WO-LT-0005

Ghazi Boys High School
Kabul, Afghanistan

Technical Specifications
(Vol. 1 of 2)

100% Design Review Submittal
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Note to Reviewer

This Technical Specification document is submitted in accordance with the requirements of the Work Order.

This submittal of the Technical Specifications represents the 100% Design Review Submission to be used for the site work and electrical, water, and wastewater utilities only.

FINAL DESIGN

GHAZI BOYS HIGH SCHOOL
KABUL, AFGHANISTAN

TABLE OF CONTENTS

DATE

VOLUME 1 OF 2

DIVISION 02 – EXISTING CONDITIONS

02 41 00	DEMOLITION	06/30/10

DIVISION 03 – CONCRETE

03 11 13.00 10	STRUCTURAL CONCRETE FORMWORK	06/30/10
03 15 13.00 10	EXPANSION JOINTS, CONTRACTION JOINTS, AND WATERSTOPS	06/30/10
03 15 14.00 10	EXPANSION, CONTRACTION AND CONSTRUCTION JOINTS IN CONCRETE FOR CIVIL WORKS	06/30/10
03 20 01.00 10	CONCRETE REINFORCEMENT	06/30/10
03 31 00.00 10	CAST-IN-PLACE STRUCTURAL CONCRETE	06/30/10

DIVISION 04 – MASONRY

04 20 00	MASONRY	06/30/10

DIVISION 05 – METALS

05 12 00	STRUCTURAL STEEL	06/30/10
05 50 13	MISCELLANEOUS METAL FABRICATIONS	06/30/10

DIVISION 07 – THERMAL AND MOISTURE PROTECTION

07 21 13	BOARD AND BLOCK INSULATION	06/30/10
07 21 16	MINERAL FIBER BLANKET INSULATION	06/30/10
07 41 13	METAL ROOF PANELS	06/30/10
07 60 00	FLASHING AND SHEET METAL	06/30/10
07 92 00	JOINT SEALANTS	06/30/10

DIVISION 08 – OPENINGS

08 11 13	STEEL DOORS AND FRAMES	06/30/10
08 34 19.10 20	ROLLING SERVICE DOORS	06/30/10
08 71 00	DOOR HARDWARE	06/30/10
08 91 00	METAL WALL LOUVERS	06/30/10

DIVISION 09 – FINISHES

09 22 00	SUPPORTS FOR PLASTER AND GYPSUM BOARD	06/30/10
09 24 23	STUCCO	06/30/10
09 29 00	GYPSUM BOARD	06/30/10
09 90 00	PAINTS AND COATINGS	06/30/10

DIVISION 13 – SPECIAL CONSTRUCTION

13 48 00	SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT	06/30/10
13 48 00.00 10	SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT	06/30/10

DIVISION 23 – HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

23 00 00	AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS	06/30/10
23 82 46	ELECTRIC UNIT HEATERS	06/30/10

DIVISION 26 – ELECTRICAL

26 00 00.00 20	BASIC ELECTRICAL MATERIALS AND METHODS	06/30/10
26 05 00.00 40	COMMON WORK RESULTS FOR ELECTRICAL	06/30/10
26 05 19.00 10	INSULATED WIRE AND CABLE	06/30/10
26 05 48.00 10	SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT	06/30/10
26 05 71.00 40	LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES	06/30/10
26 11 16	SECONDARY UNIT SUBSTATIONS	06/30/10
26 20 00	INTERIOR DISTRIBUTION SYSTEM	06/30/10
26 23 00	SWITCHBOARDS	06/30/10
26 28 01.00 10	COORDINATED POWER SYSTEM PROTECTION	06/30/10

26 32 15.00 10	DIESEL-GENERATOR SET STATIONARY 100-2500 KW, WITH AUXILIARIES	06/30/10
26 51 00.00 40	INTERIOR LIGHTING	06/30/10
26 52 00.00 40	EMERGENCY LIGHTING	06/30/10
26 53 00.00 40	EXIT SIGNS	06/30/10

VOLUME 2 OF 2

DIVISION 31 – EARTHWORK

31 00 00	EARTHWORK	06/30/10
31 05 19	GEOTEXTILE	06/30/10

DIVISION 32 – EXTERIOR IMPROVEMENTS

32 01 19	FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS	06/30/10
32 11 23	AGGREGATE BASE COURSE	06/30/10
32 13 13.06	PORTLAND CEMENT CONCRETE PAVEMENT FOR ROADS AND SITE FACILITIES	06/30/10
32 15 00	AGGREGATE SURFACE COURSE	06/30/10
32 16 13	CONCRETE SIDEWALKS AND CURBS AND GUTTERS	06/30/10
32 17 23.00 20	PAVEMENT MARKINGS	06/30/10
32 31 13	CHAIN LINK FENCES AND GATES	06/30/10

DIVISION 33 – UTILITIES

33 11 00	WATER DISTRIBUTION	07/08/10
33 20 00	WATER WELLS	06/30/10
33 30 00	SANITARY SEWERS	07/08/10
33 32 13.14	PACKAGED SEWAGE LIFT STATIONS, GRINDER PUMP TYPE	06/30/10
33 56 10	FACTORY-FABRICATED FUEL STORAGE TANKS	07/08/10
33 71 02.00 20	UNDERGROUND ELECTRICAL DISTRIBUTION	06/30/10
33 77 36.00 40	MEDIUM-VOLTAGE UTILITY FUSES	06/30/10

DIVISION 43 – PROCESS GAS AND LIQUID HANDLING, PURIFICATION, AND STORAGE EQUIPMENT

43 21 13	DOMESTIC DISTRIBUTION PUMPS	06/30/10
43 21 39	WELL PUMPS	06/30/10
43 32 76	CHLORINE FEEDING MACHINES (AUTOMATIC,	07/10/10

SEMIAUTOMATIC, AND MANUAL)

DIVISION 44 – POLUTION CONTROL EQUIPMENT

44 41 12 PACKAGED WASTEWATER TREATMENT PLANT 06/30/10

End of Table of Contents

SECTION 02 41 00

DEMOLITION

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2008) Safety and Health Requirements Manual

1.2 PROJECT DESCRIPTION

1.2.1 Demolition Plan

Prepare a Demolition Plan and submit proposed demolition, and removal procedures for approval by USAID Implementing Partner before work is started. Include in the plan procedures for coordination with other work in progress, a disconnection schedule of utility services, a detailed description of methods and equipment to be used for each operation and of the sequence of operations. Coordinate with Waste Management Plan of the Contract Documents. Provide procedures for safe conduct of the work in accordance with EM 385-1-1. Plan shall be approved by USAID Implementing Partner prior to work beginning.

1.2.2 General Requirements

Do not begin demolition or deconstruction until authorization is received from the USAID Implementing Partner. Remove rubbish and debris from the project site; do not allow accumulations. The work includes demolition of identified items and materials, and removal of resulting rubbish and debris. Remove rubbish and debris from property daily, unless otherwise directed. Store materials that cannot be removed daily in areas specified by the USAID Implementing Partner. In the interest of occupational safety and health, perform the work in accordance with EM 385-1-1, Section 23, Demolition, and other applicable Sections.

1.3 ITEMS TO REMAIN IN PLACE

Take necessary precautions to avoid damage to existing items to remain in place or to be reused. Repair or replace damaged items as approved by the USAID Implementing Partner. Coordinate the work of this section with all other work indicated. Construct and maintain shoring, bracing, and supports as required. Ensure that structural elements are not overloaded. Increase structural supports or add new supports as may be required as a result of any cutting, removal, or demolition work performed under this contract. Do not overload pavements to remain. Provide new supports and reinforcement for existing construction weakened by demolition, or removal work. Repairs, reinforcement, or structural replacement require approval by the USAID Implementing Partner prior to performing such work.

1.3.1 Existing Construction Limits and Protection

Do not disturb existing construction beyond the extent indicated or necessary for installation of new construction. Provide temporary shoring and bracing for support of building components to prevent settlement or other movement. Provide protective measures to control accumulation and migration of dust and dirt in all work areas. Remove snow, dust, dirt, and debris from work areas daily.

1.3.2 Trees

Protect trees within the project site which might be damaged during demolition and which are indicated to be left in place, by a 1.8 m high fence. Erect and secure fence a minimum of 1.5 m from the trunk of individual trees or follow the outer perimeter of branches or clumps of trees. Replace any tree designated to remain that is damaged during the work under this contract with like-kind or as approved by the USAID Implementing Partner.

1.3.3 Utility Service

Maintain existing utilities indicated to stay in service and protect against damage during demolition operations. Prior to start of work, utilities serving each area of alteration or removal will be shut off by the USAID Implementing Partner and disconnected and sealed by the Contractor.

1.3.4 Facilities

Protect electrical and mechanical services and utilities. Where removal of existing utilities and pavement is specified or indicated, provide approved barricades, temporary covering of exposed areas, and temporary services or connections for electrical and mechanical utilities. Ensure that no elements determined to be unstable are left unsupported and place and secure bracing, shoring, or lateral supports as may be required as a result of any cutting, removal, deconstruction, or demolition work performed under this contract.

1.4 BURNING

Where burning is permitted, adhere to local regulations.

1.5 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.

SD-01 Preconstruction Submittals

Existing Conditions

SD-07 Certificates

Demolition Plan
Notification

1.6 QUALITY ASSURANCE

Furnish timely notification of demolition projects to Federal, and local

authorities.

1.7 PROTECTION

1.7.1 Traffic Control Signs

a. Where pedestrian and driver safety is endangered in the area of removal work, use traffic barricades with flashing lights. Notify the USAID Implementing Partner prior to beginning such work.

1.8 EXISTING CONDITIONS

Before beginning any demolition or deconstruction work, survey the site and examine the drawings and specifications to determine the extent of the work. Record existing conditions in the presence of the USAID Implementing Partner showing the condition of structures and other facilities adjacent to areas of alteration or removal. Photographs sized 100 mm will be acceptable as a record of existing conditions. Include in the record the elevation of the top of foundation walls, finish floor elevations, possible conflicting electrical conduits, plumbing lines, alarms systems, the location and extent of existing cracks and other damage and description of surface conditions that exist prior to before starting work. It is the Contractor's responsibility to verify and document all required outages which will be required during the course of work, and to note these outages on the record document.

PART 2 PRODUCTS

2.1 FILL MATERIAL

a. Comply with excavating, backfilling, and compacting procedures for soils used as backfill material to fill basements, voids, depressions or excavations resulting from demolition or deconstruction of structures.

b. Fill material shall conform to the definition of satisfactory soil material as defined in Sections defining construction to be completed in the locations where demolition takes place.

PART 3 EXECUTION

3.1 EXISTING FACILITIES TO BE REMOVED

3.1.1 Structures

a. Remove sidewalks, curbs, gutters and street light bases as indicated on contract documents.

3.1.2 Utilities and Related Equipment

3.1.2.1 General Requirements

Do not interrupt existing utilities serving occupied or used facilities, except when authorized in writing by the USAID Implementing Partner.

3.1.2.2 Disconnecting Existing Utilities

When utility lines are encountered but are not indicated on the drawings, notify the USAID Implementing Partner prior to further work in that area.

3.1.3 Chain Link Fencing

Remove chain link fencing, gates and other related salvaged items scheduled for removal and transport to designated areas. Remove gates as whole units. Cut chain link fabric to 7 m lengths and store in rolls off the ground.

3.1.4 Paving and Slabs

Remove concrete and asphaltic concrete paving and slabs as indicated in contract documents. Provide neat sawcuts at limits of pavement removal as indicated. Pavement and slabs not to be used in this project shall be removed from the site at Contractor's expense.

3.1.5 Patching

Where removals leave holes and damaged surfaces exposed in the finished work, patch and repair these holes and damaged surfaces to match adjacent finished surfaces, using on-site materials when available. Finished surfaces of patched area shall be flush with the adjacent existing surface and shall match the existing adjacent surface as closely as possible as to texture and finish. Patching shall be as specified and indicated in contract documents, and shall include:

a. Concrete and Masonry: Completely fill holes and depressions, left as a result of removals in existing masonry, with an approved masonry patching material, applied in accordance with the manufacturer's printed instructions.

3.2 DISPOSITION OF MATERIAL

3.2.1 Title to Materials

All materials removed shall become the property of the Contractor and shall be removed from the site. Title to materials resulting from demolition is vested in the Contractor upon approval by the USAID Implementing Partner of the Contractor's demolition and removal procedures, and authorization by the USAID Implementing Partner to begin demolition. The USAID Implementing Partner will not be responsible for the condition or loss of, or damage to, such property after contract award. Showing for sale or selling materials and equipment on site is prohibited.

3.3 DISPOSAL OF REMOVED MATERIALS

3.3.1 Regulation of Removed Materials

Dispose of debris, rubbish, scrap, and other nonsalvageable materials resulting from removal operations with all applicable local regulations as contractually specified.

-- End of Section --

SECTION 03 11 13.00 10

STRUCTURAL CONCRETE FORMWORK

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACI INTERNATIONAL (ACI)

ACI 347	(2004) Guide to Formwork for Concrete

APA - THE ENGINEERED WOOD ASSOCIATION (APA)

APA PS 1	(1995) Voluntary Product Standard for Construction and Industrial Plywood

ASTM INTERNATIONAL (ASTM)

ASTM C 1077	(2009b) Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C 31/C 31M	(2009) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C 39/C 39M	(2005e1e2) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

1.2 SYSTEM DESCRIPTION

The design, engineering, and construction of the formwork is the responsibility of the Contractor. Design formwork in accordance with methodology of ACI 347 for anticipated loads, lateral pressures, and stresses, and capable of withstanding the pressures resulting from placement and vibration of concrete. Comply with the tolerances specified in Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE , paragraph CONSTRUCTION TOLERANCES. However, for surfaces with an ACI Class A surface designation, limit the allowable deflection for facing material between studs, for studs between walers and walers between bracing to 0.0025 times the span. Design the formwork as a complete system with consideration given to the effects of cementitious materials and mixture additives such as fly ash, cement type, plasticizers, accelerators, retarders, air entrainment, and others. Monitor the adequacy of formwork design and construction prior to and during concrete placement as part of the Contractor's approved Quality Control Plan.

1.3 SUBMITTALS

Contractor shall submit the following using procedures as specified in the

Contract Documents.

SD-02 Shop Drawings

Formwork

Drawings showing details of formwork, including dimensions of joints, supports, studding and shoring, and sequence of form and shoring removal. At least 30 days either before fabrication on site or before delivery of prefabricated forms.

SD-03 Product Data

Design

Design analysis and calculations for form design and methodology used in the design. At least 30 days either before fabrication on site or before delivery of prefabricated forms.

Form Materials

Manufacturer's data including literature describing form materials, accessories, and form releasing agents.

Form Releasing Agents

Manufacturer's recommendation on method and rate of application of form releasing agents.

SD-06 Test Reports

Inspection

Formwork Not Supporting Weight of Concrete

PART 2 PRODUCTS

2.1 FORM MATERIALS

2.1.1 Forms Finish

Forms for Class B finished surfaces shall be plywood panels conforming to APA PS 1, Grade B-B concrete form panels, Class I or II. Other form materials or liners may be used provided the smoothness and appearance of concrete produced will be equivalent to that produced by the plywood concrete form panels. Forms for round columns shall be the prefabricated seamless type. Steel lining on wood sheathing will not be permitted.

2.1.2 Form Ties

Form ties shall be factory-fabricated metal ties, shall be of the removable or internal disconnecting or snap-off type, and shall be of a design that will not permit form deflection and will not spall concrete upon removal. Provide solid backing for each tie. Except where removable tie rods are used, ties shall not leave holes in the concrete surface less than 6 mm nor more than 25 mm deep and not more than 25 mm in diameter. Terminate the embedded portion of metal ties not less that 50 mm from any concrete surface exposed to water. Removable tie rods shall be not more than 38 mm in diameter. Plastic snap ties may be used in locations where the surface

will not be exposed to view.

2.1.3 Form Releasing Agents

Form releasing agents shall be commercial formulations that will not bond with, stain or adversely affect concrete surfaces. Agents shall not impair subsequent treatment of concrete surfaces depending upon bond or adhesion nor impede the wetting of surfaces to be cured with water or curing compounds. If special form liners are to be used, the Contractor shall follow the recommendation of the form coating manufacturer.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Formwork

Forms shall be constructed true to the structural design and required alignment. Forms shall be mortar tight, properly aligned and adequately supported to produce concrete surfaces meeting the surface requirements specified in Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE and conforming to construction tolerance given in TABLE 1. Continuously monitor the alignment and stability of the forms during all phases to assure the finished product will meet the required surface class or classes specified. Failure of any supporting surface either due to surface texture, deflection or form collapse shall be the responsibility of the Contractor as will the replacement or correction of unsatisfactory surfaces. Where concrete surfaces are to have a Class B finish, joints in form panels shall be arranged as approved. When forms for continuous surfaces are placed in successive units, care shall be taken to fit the forms over the completed surface to obtain accurate alignment of the surface and to prevent leakage of mortar. Forms shall not be re-used if there is any evidence of defects which would impair the quality of the resulting concrete surface. All surfaces of used forms shall be cleaned of mortar and any other foreign material before reuse. Form ties that are to be completely withdrawn shall be coated with a nonstaining bond breaker.

3.2 CHAMFERING

All exposed joints, edges and external corners shall be chamfered by molding placed in the forms unless the drawings specifically state that chamfering is to be omitted or as otherwise specified. Chamfered joints shall not be permitted where earth or rockfill is placed in contact with concrete surfaces. Chamfered joints shall be terminated 300 mm outside the limit of the earth or rockfill so that the end of the chamfers will be clearly visible.

3.3 COATING

Forms for Class B finished surfaces shall be coated with a form releasing agent before the form or reinforcement is placed in final position. The coating shall be used as recommended in the manufacturer's printed or written instructions. Surplus coating on form surfaces and coating on reinforcing steel and construction joints shall be removed before placing concrete.

3.4 FORM REMOVAL

Forms shall not be removed without approval. The minimal time required for

concrete to reach a strength adequate for removal of formwork without risking the safety of workers or the quality of the concrete depends on a number of factors including, but not limited to, ambient temperature, concrete lift heights, type and amount of concrete admixture, and type and amount of cementitious material in the concrete. It is the responsibility of the Contractor to consider all applicable factors and leave the forms in place until it is safe to remove them. In any case forms shall not be removed unless the minimum time, minimum ambient temperature, and minimum compressive strength requirements below are met, except as otherwise directed or specifically authorized. When conditions are such as to justify the requirement, forms will be required to remain in place for a longer period. All removal shall be accomplished in a manner which will prevent damage to the concrete and ensure the complete safety of the structure. Where forms support more than one element, the forms shall not be removed until the form removal criteria are met by all supported elements. Form removal shall be scheduled so that all necessary repairs can be performed as specified in Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE, paragraph 3.10 Finishing Formed Surfaces. Evidence that concrete has gained sufficient strength to permit removal of forms shall be determined by tests on control cylinders. All control cylinders shall be stored in the structure or as near the structure as possible so they receive the same curing conditions and protection methods as given those portions of the structure they represent. Control cylinders shall be removed from the molds at an age of no more than 24 hours. All control cylinders shall be prepared and tested in accordance with ASTM C 31/C 31M and ASTM C 39/C 39M at the expense of the Contractor by an independent laboratory that complies with ASTM C 1077 and shall be tested within 4 hours after removal from the site.

3.4.1 Formwork Not Supporting Weight of Concrete

Formwork for walls, columns, sides of beams, gravity structures, and other vertical type formwork not supporting the weight of concrete shall not be removed in less than 24 hours after concrete placement is completed.

3.4.2 Formwork Supporting Weight of Concrete

Formwork supporting weight of concrete and shoring shall not be removed until structural members have acquired sufficient strength to safely support their own weight and any construction or other superimposed loads to which the supported concrete may be subjected. As a minimum, forms shall be left in place until control concrete test cylinders indicate evidence the concrete has attained at least 75 percent of the compressive strength required for the structure in accordance with the quality and location requirements.

3.5 INSPECTION

Forms and embedded items shall be inspected in sufficient time prior to each concrete placement in order to certify to the USAID Implementing Partner that they are ready to receive concrete. The results of each inspection shall be reported in writing.

TABLE 1 TOLERANCES FOR FORMED SURFACES	
1. Variations from the plumb:	
a. In the lines and surfaces of columns, piers, walls and in arises	6 mm in any 3 m of length Maximum for entire length -- 25 mm
b. For exposed corner columns, control-joint grooves, and other conspicuous lines	6 mm in any 6 m of length Maximum for entire length -- 13 mm
2. Variation for the level or from the grades indicated on the drawings:	
a. In slab soffits, ceilings beam soffits, and in arises,measured before removal of supporting shores	6 mm in any 3 m of length 10 mm in any bay or in any 6 m of length Maximum for entire length -- 20 mm
b. In exposed lintels, sills, parapets, horizontal grooves, and other conspicuous lines	6 mm in any bay or in any 6 m of length Maximum for entire length -- 13 mm
3. Variation of the linear building lines from established position in plan	13 mm in any 6 m 25 mm maximum
4. Variation of distance between walls, columns, partitions	6 mm per 3 m of distance, but not more than 13 mm in any one bay, and not more than 25 mm total variation
5. Variation in the sizes and locations of sleeves, floor openings, and wall opening	Minus 6 mm, Plus 13 mm
6. Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls	Minus 6 mm, Plus 13 mm
7. Footings:	

TABLE 1 TOLERANCES FOR FORMED SURFACES	
a. Variation of dimensions in plan	Minus 13 mm, plus 50 mm when formed or plus 75 mm when placed against unformed excavation
b. Misplacement of eccentricity	2 percent of the footing width in the direction of misplacement but not more than 50 mm
c. Reduction in thickness	Minus 5 percent of the specified thickness

-- End of Section --

SECTION 03 15 13.00 10

EXPANSION JOINTS, CONTRACTION JOINTS, AND WATERSTOPS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C 920	(2008) Standard Specification for Elastomeric Joint Sealants
ASTM D 2628	(1991; R 2005) Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
ASTM D 2835	(1989; R 2007) Lubricant for Installation of Preformed Compression Seals in Concrete Pavements
ASTM D 471	(2006; R 2008) Standard Test Method for Rubber Property - Effect of Liquids

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 513	(1974) Specifications for Rubber Waterstops
COE CRD-C 572	(1974) Specifications for Polyvinylchloride Waterstops

1.2 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.

SD-02 Shop Drawings

Waterstops

Shop drawings and fabrication drawings provided by the manufacturer or prepared by the Contractor.

SD-03 Product Data

Preformed Expansion Joint Filler
Sealant
Waterstops

Manufacturer's literature, including safety data sheets, for preformed fillers and the lubricants used in their installation; field-molded sealants and primers (when required by sealant

manufacturer); preformed compression seals; and waterstops. Manufacturer's recommended instructions for installing preformed fillers, field-molded sealants; preformed compression seals; and waterstops; and for splicing non-metallic waterstops.

SD-04 Samples

Lubricant for Preformed Compression Seals

Specimens identified to indicate the manufacturer, type of material, size and quantity of material, and shipment or lot represented. Each sample shall be a piece not less than 3 m of 25 mm nominal width or wider seal or a piece not less than 4 m of compression seal less than 25 mm nominal width. Provide one L of lubricant.

Field-Molded Type

Four liters of field-molded sealant and one L of primer (when primer is recommended by the sealant manufacturer) identified to indicate manufacturer, type of material, quantity, and shipment or lot represented.

Non-metallic Materials

Specimens identified to indicate manufacturer, type of material, size, quantity of material, and shipment or lot represented. Each sample shall be a piece not less than 300 mm long cut from each 61 m of finished waterstop furnished, but not less than a total of 1 m of each type, size, and lot furnished. One splice sample of each size and type for every 50 splices made in the factory and every 10 splices made at the job site. The splice samples shall be made using straight run pieces with the splice located at the mid-length of the sample and finished as required for the installed waterstop. The total length of each splice shall be not less than 300 mm long.

SD-07 Certificates

Preformed Expansion Joint Filler
Sealant
Waterstops

Certificates of compliance stating that the joint filler and sealant materials and waterstops conform to the requirements specified.

1.3 DELIVERY, STORAGE, AND HANDLING

Protect material delivered and placed in storage off the ground from moisture, dirt, and other contaminants. Deliver sealants in the manufacturer's original unopened containers. Sealants whose shelf life has expired shall be removed from the site.

PART 2 PRODUCTS

2.1 SEALANT

Joint sealant shall conform to the following:

2.1.1 Preformed Polychloroprene Elastomeric Type

ASTM D 2628.

2.1.2 Lubricant for Preformed Compression Seals

ASTM D 2835.

2.1.3 Field-Molded Type

ASTM C 920, Type M, Grade P or NS, Class 25, Use T for horizontal joints. Type M, Grade NS, Class 25, Use NT for vertical joints. Bond breaker material shall be polyethylene tape, coated paper, metal foil or similar type materials. The back-up material shall be compressible, non-shrink, nonreactive with sealant, and non-absorptive material type such as extruded butyl or polychloroprene rubber.

2.2 WATERSTOPS

Intersection and change of direction waterstops shall be shop fabricated.

2.2.1 Non-Metallic Materials`

Non-metallic waterstops shall be manufactured from a prime virgin resin; reclaimed material is not acceptable. The compound shall contain plasticizers, stabilizers, and other additives to meet specified requirements. Rubber waterstops shall conform to COE CRD-C 513. Polyvinylchloride waterstops shall conform to COE CRD-C 572. Thermoplastic elastomeric rubber waterstops shall conform to ASTM D 471.

PART 3 EXECUTION

3.1 JOINTS

Install joints at locations indicated and as authorized.

3.1.1 Contraction Joints

Contraction joints may be constructed by inserting tempered hardboard strips or rigid PVC or HIPS insert strips into the plastic concrete using a steel parting bar, when necessary, or by cutting the concrete with a saw after concrete has set. Joints shall be approximately 3 mm wide and shall extend into the slab one-fourth the slab thickness, minimum, but not less than 25 mm.

For slab subjected to heavy loading, joints shall be approximately 25 mm wide by 38 mm deep with preformed compression seal at surface and a 3 mm saw cut 75 mm deep measured from surface. See drawings for details.

3.1.1.1 Sawed Joints

Joint sawing shall be early enough to prevent uncontrolled cracking in the slab, but late enough that this can be accomplished without appreciable spalling. Use concrete sawing machines that are adequate in number and power, and with sufficient replacement blades to complete the sawing at the required rate. Cut joints to true alignment and in sequence of concrete placement. Remove sludge and cutting debris.

3.1.2 Joint Sealant

Sawed contraction joints and expansion joints in slabs shall be filled with joint sealant, unless otherwise shown. Joint surfaces shall be clean, dry, and free of oil or other foreign material which would adversely affect the bond between sealant and concrete. Joint sealant shall be applied as recommended by the manufacturer of the sealant.

3.2 WATERSTOPS, INSTALLATION AND SPLICES

Install waterstops at the locations shown to form a continuous water-tight diaphragm. Make adequate provision to support and completely protect the waterstops during the progress of the work. Any waterstop punctured or damaged shall be repaired or replaced. Protect exposed waterstops during application of form release agents to avoid being coated. Provide suitable guards to protect exposed projecting edges and ends of partially embedded waterstops from damage when concrete placement has been discontinued. Splices shall be made by certified trained personnel using approved equipment and procedures.

3.2.1 Non-Metallic

Fittings shall be shop made using a machine specifically designed to mechanically weld the waterstop. A miter guide, proper fixturing (profile dependant), and portable power saw shall be used to miter cut the ends to be joined to ensure good alignment and contact between joined surfaces. The splicing of straight lengths shall be done by squaring the ends to be joined. Continuity of the characteristic features of the cross section of the waterstop (ribs, tabular center axis, protrusions, etc.) shall be maintained across the splice.

3.2.1.1 Polyvinyl Chloride Waterstop

Make splices by heat sealing the adjacent waterstop edges together using a thermoplastic splicing iron utilizing a non-stick surface specifically designed for waterstop welding. The correct temperature shall be used to sufficiently melt without charring the plastic. The spliced area, when cooled, shall show no signs of separation, holes, or other imperfections when bent by hand in as sharp an angle as possible.

3.2.1.2 Quality Assurance

Edge welding will not be permitted. Centerbulbs shall be compressed or closed when welding to non-centerbulb type. Waterstop splicing defects which are unacceptable include, but are not limited to the following: 1) Tensile strength less than 80 percent of parent section. 2) Free lap joints. 3) Misalignment of centerbulb, ribs, and end bulbs greater than 2 mm. 4) Misalignment which reduces waterstop cross section more than 15 percent. 5) Bond failure at joint deeper than 2 mm or 15 percent of material thickness. 6) Misalignment of waterstop splice resulting in misalignment of waterstop in excess of 13 mm in 3 m. 7) Visible porosity in the weld area, including pin holes. 8) Charred or burnt material. 9) Bubbles or inadequate bonding. 10) Visible signs of splice separation when cooled splice is bent by hand at a sharp angle.

3.3 CONSTRUCTION JOINTS

Construction joints are specified in Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE except that construction joints coinciding with

expansion and contraction joints shall be treated as expansion or contraction joints as applicable.

-- End of Section --

SECTION 03 15 14.00 10

EXPANSION, CONTRACTION AND CONSTRUCTION JOINTS IN CONCRETE FOR CIVIL WORKS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C 920	(2008) Standard Specification for Elastomeric Joint Sealants
ASTM D 1751	(2004; R 2008) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D 1752	(2004a; R 2008) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
ASTM D 2628	(1991; R 2005) Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
ASTM D 2835	(1989; R 2007) Lubricant for Installation of Preformed Compression Seals in Concrete Pavements

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 513	(1974) Corps of Engineers Specifications for Rubber Waterstops
COE CRD-C 572	(1974) Corps of Engineers Specifications for Polyvinylchloride Waterstops

1.2 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.

SD-03 Product Data

Splicing Waterstops

SD-04 Samples

Field Molded Sealants and Primer
Waterstops

SD-06 Test Reports

Premolded Expansion Joint Filler Strips
Compression Seals and Lubricant

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Premolded Expansion Joint Filler Strips

Premolded expansion joint filler strips shall conform to ASTM D 1751 or ASTM D 1752, Type I, or resin impregnated fiberboard conforming to the physical requirements of ASTM D 1752. Submit certified manufacturer's test reports for premolded expansion joint filler strips, compression seals and lubricant to verify compliance with applicable specification.

2.1.2 Joint Seals and Sealants

2.1.2.1 Field Molded Sealants and Primer

Field molded sealants and primer shall conform to ASTM C 920, Type M, Grade NS or P, Class 25, Use T for horizontal joints and Type M, Grade NS, Class 25, Use NT for vertical joints. Bond breaker material shall be polyethylene tape, coated paper, metal foil or similar type materials. The back-up material shall be compressible, nonshrink, nonreactive with sealant, and nonabsorptive material type such as extruded butyl or polychloroprene foam rubber. Submit Four L of field-molded sealant and 1 L of primer (when primer is recommended by the sealant manufacturer) for testing.

2.1.2.2 Compression Seals and Lubricant

Compression seals shall conform to ASTM D 2628; lubricant for installation shall conform to ASTM D 2835.

2.1.3 Waterstops

Submit a sample of each material consisting of a piece not less than 300 mm long cut from each 60 m of finished waterstop furnished, but not less than a total of 1.2 linear meters of each type and size furnished. The spliced samples shall be made using straight run pieces with the splice located at the mid-length of the sample and finished as required for the installed waterstop. The total length of each spliced sample shall be not less than 300 mm long. Submit waterstop materials and splice samples for inspection and testing identified to indicate manufacturer, type of material, size and quantity of material and shipment represented.

2.1.3.1 Non-Metallic Waterstops

Rubber waterstops shall conform to COE CRD-C 513. Polyvinylchloride waterstops shall conform to COE CRD-C 572.

2.2 TESTS, INSPECTIONS, AND VERIFICATIONS

2.2.1 Materials Tests

2.2.1.1 Field-Molded Sealants

Samples of sealant and primer, when use of primer is recommended by the manufacturer, as required in paragraph FIELD MOLDED SEALANTS AND PRIMER, shall be tested by and at the expense of the USAID Implementing Partner for compliance with paragraph FIELD MOLDED SEALANTS AND PRIMER. If the sample fails to meet specification requirements, provide new samples and the cost of retesting will be deducted from payments due the Contractor at a rate set by USAID Implementing Partner.

2.2.1.2 Non-Metallic Waterstops

Samples of materials and splices, as required in paragraph WATERSTOPS, shall be visually inspected and tested by and at the expense of the Government for compliance with COE CRD-C 513 or COE CRD-C 572 as applicable. If a sample fails to meet the specification requirements, provide new samples and the cost of retesting will be deducted from payments due the Contractor at the rate set by USAID Implementing Partner per material sample retested and per spliced sample retested.

2.2.2 Splicing Waterstops

2.2.2.1 Procedure and Performance Qualifications

Demonstrate procedure and performance qualifications for splicing waterstops in the presence of the USAID Implementing Partner. Submit procedures for splicing waterstops for approval.

2.2.2.2 Non-Metallic Waterstops

Demonstrate procedure and performance qualifications for splicing non-metallic waterstops by the manufacturer at the factory and the Contractor at the job site by each making three spliced samples of each size and type of finished waterstop.

PART 3 EXECUTION

3.1 INSTALLATION

Joint locations and details, including materials and methods of installation of joint fillers and waterstops, shall be as specified, as shown, and as directed. In no case shall any fixed metal be continuous through an expansion or contraction joint.

3.1.1 Expansion Joints

Provide premolded filler strips with oiled wood strips secured to the top thereof and accurately positioned and secured against displacement to clean, smooth concrete surfaces. The wood strips shall be slightly tapered, dressed and of the size required to install filler strips at the desired level below the finished concrete surface and to form the groove for the joint sealant or seals to the size shown. The wood strips shall not be removed until after the concrete curing period. The groove shall be thoroughly cleaned of all curing compound, foreign materials, protrusions of hardened concrete and any dust which shall be blown out of the groove

with oil-free compressed air.

3.1.1.1 Joints With Field-Molded Sealant

Joints shall not be sealed when the sealant, air or concrete temperature is less than 4 degrees C. Immediately prior to installation of field molded sealants, clean the joint of all debris and further cleaned using water, chemical solvents or other means as recommended by the sealant manufacturer. The joints shall be dry prior to filling with sealant. Install bond breaker and back-up material where required. Joints shall be primed and filled flush with joint sealant in accordance with the manufacturer's recommendations.

3.1.1.2 Joints With Preformed Compression Seals

Install the joint seals with equipment capable of installing joint seals to the prescribed depth without cutting, nicking, twisting, or otherwise distorting or damaging the seal and with no more than five percent stretching of the seal. The sides of the joint and, if necessary, the sides of the compression seal shall be covered with a coating of lubricant, and the seal shall be installed to the depth indicated with joint installation equipment. Butt joints shall be coated with liberal applications of lubricant.

3.1.2 Contraction Joints

Joints requiring a bond breaker shall be coated with curing compound or with bituminous paint. Waterstops shall be protected during application of bond breaking material to prevent them from being coated.

3.1.3 Waterstops

Waterstops shall be carefully and correctly positioned during installation to eliminate faulty installation that may result in joint leakage. The bottom of each waterstop shall be embedded a minimum of 150 mm in firm rock or sealed to other cut-off systems. Install all waterstops so as to form a continuous watertight diaphragm in each joint. Adequate provision shall be made to support and protect the waterstops during the progress of work. Any waterstop punctured or damaged shall be replaced or repaired at the Contractor's expense. Joints in waterstops shall be spliced together by qualified splicers using the approved splicing procedures to form a continuous watertight diaphragm. Splices shall be as follows:

a. Non-Metallic Waterstops - Make all splices on a bench in a temporary shop provided at the site of the installation or at the manufacturer's plant. A miter guide and portable power saw shall be used to cut the ends to be joined to insure good alignment and contact between joined surfaces.

b. Rubber Waterstops - Splices shall be vulcanized in accordance with the approved procedure.

c. Polyvinylchloride Waterstops - Make splices by heat sealing the adjacent surfaces in accordance with the approved procedure. Use a thermostatically controlled electrical heat source to make all splices. The correct temperature at which splices should be made will differ with the material concerned but the applied heat should be sufficient to melt but not char the plastic. Waterstops shall be reformed at splices with a remolding iron with ribs or corrugations to

match the pattern of the waterstop. The spliced area, when cooled and bent by hand in as sharp an angle as possible, shall show no sign of separation.

-- End of Section --

SECTION 03 20 01.00 10

CONCRETE REINFORCEMENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACI INTERNATIONAL (ACI)

ACI 318M	(2008; Errata 2008; Errata 2009) Metric Building Code Requirements for Structural Concrete and Commentary
ACI 350/350M	(2006)Code Requirements for Environmental Engineering Concrete Structures and Commentary

AMERICAN WELDING SOCIETY (AWS)

AWS D1.4/D1.4M	(2005; Errata 2005) Structural Welding Code - Reinforcing Steel

ASTM INTERNATIONAL (ASTM)

ASTM A 185/A 185M	(2007) Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
ASTM A 53/A 53M	(2007) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 615/A 615M	(2009) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A 675/A 675M	(2003; R 2009) Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties
ASTM A 706/A 706M	(2009) Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A 767/A 767M	(2009) Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement

ASTM A 775/A 775M	(2007b) Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A 82/A 82M	(2007) Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
ASTM A 884/A 884M	(2006) Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement
ASTM A 934/A 934M	(2007) Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars

CONCRETE REINFORCING STEEL INSTITUTE (CRSI)

CRSI 10MSP	(2001; 27Ed) Manual of Standard Practice

1.2 SYSTEM DESCRIPTION

Concrete potable water tanks shall be constructed in accordance with ACI 350/350M. Concrete gray water tanks shall be constructed in accordance with ACI 318M.

1.3 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.

SD-02 Shop Drawings

Reinforcement; G

Detail drawings showing reinforcing steel placement, schedules, sizes, grades, and splicing and bending details. Drawings shall show support details including types, sizes and spacing.

SD-07 Certificates

Reinforcing Steel

Certified copies of mill reports attesting that the reinforcing steel furnished contains no less than 25 percent recycled scrap steel and meets the requirements specified herein, prior to the installation of reinforcing steel.

1.4 DELIVERY, STORAGE, AND HANDLING

Reinforcement and accessories shall be stored off the ground on platforms, skids, or other supports.

PART 2 PRODUCTS

2.1 DOWELS

Dowels shall conform to ASTM A 675/A 675M, Grade 80. Steel pipe conforming to ASTM A 53/A 53M, Schedule 80, may be used as dowels provided the ends are closed with metal or plastic inserts or with mortar.

2.2 REINFORCING STEEL

Reinforcing steel shall be deformed bars conforming to ASTM A 615/A 615M or ASTM A 706/A 706M, grades and sizes as indicated. Cold drawn wire used for spiral reinforcement shall conform to ASTM A 82/A 82M. In highly corrosive environments or when directed by the Contracting Officer, reinforcing steel shall conform to ASTM A 767/A 767M, ASTM A 775/A 775M or ASTM A 934/A 934Mas appropriate.

2.3 WELDED WIRE FABRIC

Welded wire fabric shall conform to ASTM A 185/A 185M. When directed by the Contracting Officer for special applications, welded wire fabric shall conform to ASTM A 884/A 884M.

2.4 WIRE TIES

Wire ties shall be 16 gauge or heavier black annealed steel wire.

2.5 SUPPORTS

Bar supports for formed surfaces shall be designed and fabricated in accordance with CRSI 10MSP and shall be steel or precast concrete blocks. Precast concrete blocks shall have wire ties and shall be not less than 100 by 100 mm when supporting reinforcement on ground. Precast concrete block shall have compressive strength equal to that of the surrounding concrete. Where concrete formed surfaces will be exposed to weather or where surfaces are to be painted, steel supports within 13 mm of concrete surface shall be galvanized, plastic protected or of stainless steel. Concrete supports used in concrete exposed to view shall have the same color and texture as the finish surface. For slabs on grade, supports shall be precast concrete blocks, plastic coated steel fabricated with bearing plates, or specifically designed wire-fabric supports fabricated of plastic.

PART 3 EXECUTION

3.1 REINFORCEMENT

Reinforcement shall be fabricated to shapes and dimensions shown and shall conform to the requirements of ACI 318M. Reinforcement shall be cold bent unless otherwise authorized. Bending may be accomplished in the field or at the mill. Bars shall not be bent after embedment in concrete. Safety caps shall be placed on all exposed ends of vertical concrete reinforcement bars that pose a danger to life safety. Wire tie ends shall face away from the forms.

3.1.1 Placement

Reinforcement shall be free from loose rust and scale, dirt, oil, or other deleterious coating that could reduce bond with the concrete. Reinforcement shall be placed in accordance with ACI 318M at locations shown plus or minus one bar diameter. Reinforcement shall not be continuous through expansion joints and shall be as indicated through construction or contraction joints. Concrete coverage shall be as indicated or as required by ACI 318M. If bars are moved more than one bar diameter to avoid interference with other reinforcement, conduits or embedded items, the

resulting arrangement of bars, including additional bars required to meet structural requirements, shall be approved before concrete is placed.

3.1.2 Splicing

Splices of reinforcement shall conform to ACI 318M and shall be made only as required or indicated. Splicing shall be by lapping or by mechanical or welded butt connection; except that lap splices shall not be used for bars larger than 35 mm diameter unless otherwise indicated. Welding shall conform to AWS D1.4/D1.4M. Welded butt splices shall be full penetration butt welds. Lapped bars shall be placed in contact and securely tied or spaced transversely apart to permit the embedment of the entire surface of each bar in concrete. Lapped bars shall not be spaced farther apart than one-fifth the required length of lap or 150 mm. Mechanical butt splices shall be in accordance with the recommendation of the manufacturer of the mechanical splicing device. Butt splices shall develop 125 percent of the specified minimum yield tensile strength of the spliced bars or of the smaller bar in transition splices. Bars shall be flame dried before butt splicing. Adequate jigs and clamps or other devices shall be provided to support, align, and hold the longitudinal centerline of the bars to be butt spliced in a straight line.

3.2 WELDED-WIRE FABRIC PLACEMENT

Welded-wire fabric shall be placed in slabs as indicated. Fabric placed in slabs on grade shall be continuous between expansion, construction, and contraction joints. Fabric placement at joints shall be as indicated. Lap splices shall be made in such a way that the overlapped area equals the distance between the outermost crosswires plus 50 mm. Laps shall be staggered to avoid continuous laps in either direction. Fabric shall be wired or clipped together at laps at intervals not to exceed 1.2 m. Fabric shall be positioned by the use of supports.

3.3 DOWEL INSTALLATION

Dowels shall be installed in slabs on grade at locations indicated and at right angles to joint being doweled. Dowels shall be accurately positioned and aligned parallel to the finished concrete surface before concrete placement. Dowels shall be rigidly supported during concrete placement. One end of dowels shall be coated with a bond breaker.

-- End of Section --

SECTION 03 31 00.00 10

CAST-IN-PLACE STRUCTURAL CONCRETE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACI INTERNATIONAL (ACI)

ACI 117	(2006) Standard Specifications for Tolerances for Concrete Construction and Materials
ACI 211.1	(1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 214R	(2002) Recommended Practice for Evaluation of Strength Test Results of Concrete
ACI 305R	(1999; Errata 2006) Hot Weather Concreting
ACI 318M	(2008; Errata 2008; Errata 2009) Metric Building Code Requirements for Structural Concrete and Commentary
ACI 350/350M	(2006) Code Requirements for Environmental Engineering Concrete Structures and Commentary

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182	(2005) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

ASTM INTERNATIONAL (ASTM)

ASTM C 1017/C 1017M	(2007) Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C 1059/C 1059M	(1999; R 2008) Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete
ASTM C 1064/C 1064M	(2008) Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete

ASTM C 1077	(2009b) Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C 1107/C 1107M	(2008) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM C 1240	(2005) Standard Specification for Silica Fume Used in Cementitious Mixtures
ASTM C 1260	(2007) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C 136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C 143/C 143M	(2009) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C 150/C 150M	(2009) Standard Specification for Portland Cement
ASTM C 1567	(2008) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C 171	(2007) Standard Specification for Sheet Materials for Curing Concrete
ASTM C 172	(2008) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C 192/C 192M	(2007) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 231	(2009a) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 260	(2006) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C 309	(2007) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 31/C 31M	(2009) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C 33/C 33M	(2008) Standard Specification for Concrete Aggregates
ASTM C 39/C 39M	(2005e1e2) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

ASTM C 42/C 42M	(2004) Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C 494/C 494M	(2008a) Standard Specification for Chemical Admixtures for Concrete
ASTM C 618	(2008a) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C 78	(2009) Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C 881/C 881M	(2002) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 937	(2002) Grout Fluidifier for Preplaced-Aggregate Concrete
ASTM C 94/C 94M	(2009) Standard Specification for Ready-Mixed Concrete
ASTM D 1752	(2004a; R 2008) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
ASTM D 75/D 75M	(2009) Standard Practice for Sampling Aggregates
ASTM E 1155M	(1996; R 2008) Standard Test Method for Determining Floor Flatness and Floor Levelness Numbers (Metric)
ASTM E 96/E 96M	(2005) Standard Test Methods for Water Vapor Transmission of Materials

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 44	(2007) NIST Handbook 44: Specifications, Tolerances, and other Technical Requirements for Weighing and Measuring Devices

NATIONAL READY MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA CPMB 100	(2000) Concrete Plant Standards
NRMCA QC 3	(2002) Quality Control Manual: Section 3, Plant Certifications Checklist: Certification of Ready Mixed Concrete Production Facilities
NRMCA TMMB 100	(2001) Truck Mixer, Agitator and Front Discharge Concrete Carrier Standards

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 104	(1980) Method of Calculation of the Fineness Modulus of Aggregate
COE CRD-C 400	(1963) Requirements for Water for Use in Mixing or Curing Concrete
COE CRD-C 521	(1981) Standard Test Method for Frequency and Amplitude of Vibrators for Concrete
COE CRD-C 540	(2001) Standard Specification for Nonbituminous Inserts for Contraction Joints in Portland Cement Concrete Airfield Pavements, Sawable Type
COE CRD-C 572	(1974) Specifications for Polyvinylchloride Waterstops
COE CRD-C 94	(1995) Specification for Surface Retarders

1.2 SYSTEM DESCRIPTION

Provide concrete composed of portland cement, other cementitious and pozzolanic materials as specified, aggregates, water and admixtures as specified.

Concrete potable water tanks shall be constructed in accordance with ACI 350/350M. Concrete gray water tanks shall be constructed in accordance with ACI 318M.

1.2.1 Proportioning Studies-Normal Weight Conc

Trial design batches, mixture proportions studies, and testing requirements for various classes and types of concrete specified are the responsibility of the Contractor. Except as specified for flexural strength concrete, mixture proportions shall be based on compressive strength as determined by test specimens fabricated in accordance with ASTM C 192/C 192M and tested in accordance with ASTM C 39/C 39M.

a. Samples of all materials used in mixture proportioning studies shall be representative of those proposed for use in the project and be accompanied by the manufacturer's or producer's test reports indicating compliance with these specifications.

b. Make trial mixtures having proportions, consistencies, and air content suitable for the work based on methodology described in ACI 211.1, using at least three different water-cement ratios for each type of mixture, which will produce a range of strength encompassing those required for each class and type of concrete required on the project.

c. The maximum water-cement ratios required in subparagraph Water-Cement Ratio below will be the equivalent water-cement ratio as determined by conversion from the weight ratio of water to cement plus pozzolan, silica fume, and ground granulated blast furnace slag (GGBF slag) by the weight equivalency method as described in ACI 211.1. In the case where silica fume slag is used, the weight of the silica fume shall be included in the equations in ACI 211.1 for the term P, which

is used to denote the weight of pozzolan. If pozzolan is used in the concrete mixture, the minimum pozzolan content shall be 15 percent by weight of the total cementitious material, and the maximum shall be 35 percent.

d. Design laboratory trial mixtures for maximum permitted slump and air content. Make separate sets of trial mixture studies for each combination of cementitious materials and each combination of admixtures proposed for use. No combination of either shall be used until proven by such studies, except that, if approved in writing and otherwise permitted by these specifications, an accelerator or a retarder may be used without separate trial mixture study. Separate trial mixture studies shall also be made for concrete for any conveying or placing method proposed which requires special properties and for concrete to be placed in unusually difficult placing locations.

e. Report the temperature of concrete in each trial batch. For each water-cement ratio, at least three test cylinders for each test age shall be made, cured in accordance withASTM C 192/C 192M and tested at 7 and 28 days in accordance with ASTM C 39/C 39M. From these test results, plot a curve showing the relationship between water-cement ratio and strength for each set of trial mix studies. In addition, a curve shall be plotted showing the relationship between 7 day and 28 day strengths. Design each mixture to promote easy and suitable concrete placement, consolidation and finishing, and to prevent segregation and excessive bleeding.

1.2.2 Average Compressive Strength

The mixture proportions selected during mixture design studies shall produce a required average compressive strength (f'cr) exceeding the specified compressive strength (f'c) by the amount indicated below. This required average compressive strength, f'cr, will not be a required acceptance criteria during concrete production. However, whenever the daily average compressive strength at 28 days drops below f'cr during concrete production, or daily average 7-day strength drops below a strength correlated with the 28-day f'cr, adjust the mixture, as approved, to bring the daily average back up to f'cr. During production, the required f'cr shall be adjusted, as appropriate, based on the standard deviation being attained on the job.

1.2.3 Computations from Test Records

Where a concrete production facility has test records, establish a standard deviation in accordance with the applicable provisions of ACI 214R. Test records from which a standard deviation is calculated shall represent materials, quality control procedures, and conditions similar to those expected; shall represent concrete produced to meet a specified strength or strengths (f'c) within 7 MPa of that specified for proposed work; and shall consist of at least 30 consecutive tests. A strength test shall be the average of the strengths of two cylinders made from the same sample of concrete and tested at 28 days. Required average compressive strength f'cr used as the basis for selection of concrete proportions shall be the larger of the equations that follow using the standard deviation as determined above:

$f'cr = f'c + 1.34S$ where units are in MPa

$f'cr = f'c + 2.33S - 3.45$ where units are in MPa

Where S = standard deviation

Where a concrete production facility does not have test records meeting the requirements above but does have a record based on 15 to 29 consecutive tests, a standard deviation shall be established as the product of the calculated standard deviation and a modification factor from the following table:

NUMBER OF TESTS	MODIFICATION FACTOR FOR STANDARD DEVIATION
15	1.16
20	1.08
25	1.03
30 or more	1.00

1.2.4 Computations without Previous Test Records

When a concrete production facility does not have sufficient field strength test records for calculation of the standard deviation, the required average strength f'cr shall be determined as follows:

a. If the specified compressive strength f'c is less than 20 MPa,

f'cr = f'c + 6.9 MPa

b. If the specified compressive strength f'c is 20 to 35 MPa,

f'cr = f'c + 8.3 MPa

c. If the specified compressive strength f'c is over 35 MPa,

f'cr = f'c + 9.7 MPa

1.2.5 Tolerances

Except as otherwise specified herein, tolerances for concrete batching, mixture properties, and construction as well as definition of terms and application practices shall be in accordance with ACI 117. Take level and grade tolerance measurements of slabs as soon as possible after finishing; when forms or shoring are used, the measurements shall be made prior to removal.

1.2.6 Floor Finish

For the purpose of this Section the following terminology correlation between ACI 117 and this Section shall apply:

Floor Profile Quality Classification From ACI 117	This Section
Conventional Bullfloated	Same
Conventional Straightedged	Same
Flat	Float Finish or Trowel Finish
Very Flat	Same. Use only with F-system

Levelness tolerance shall not apply where design requires floors to be

sloped to drains or sloped for other reasons.

1.2.6.1 Floors by the F-Number System

The flatness and levelness of floors shall be carefully controlled and the tolerances shall be measured by the F-Number system of Paragraph 4.8.4 of ACI 117. Furnish an approved floor profilograph or other equipment capable of measuring the floor flatness (FF) number and the floor levelness (FL) number in accordance with ASTM E 1155M. Perform the tolerance measurements within 72 hours after floor slab construction while being observed by the Contracting Officer. The tolerances of surfaces beyond the limits of ASTM E 1155M (the areas within 600 mm of embedment's and construction joints) will be acceptable to the Contracting Officer. Tolerances of all exposed floors shall meet the requirements for the Trowel finish as specified in paragraphs 4.8.4 of ACI 117. Minimum F_F shall be 25.

1.2.7 Strength Requirements

Specified compressive strength (f'c) shall be 21.0 MPa27.5 MPa at 28 days.

Concrete made with high-early strength cement shall have a 7-day strength equal to the specified 28-day strength for concrete made with Type I or II portland cement. Compressive strength shall be determined in accordance with ASTM C 39/C 39M.

a. Evaluation of Concrete Compressive Strength. Fabricate compressive strength specimens (152 by 305 mm cylinders), laboratory cure them in accordance with ASTM C 31/C 31M and test them in accordance with ASTM C 39/C 39M. The strength of the concrete will be considered satisfactory so long as the average of all sets of three consecutive test results equals or exceeds the specified compressive strength f'c and no individual test result falls below the specified strength f'c by more than 3.5 MPa. A "test" is defined as the average of two companion cylinders, or if only one cylinder is tested, the results of the single cylinder test. Additional analysis or testing, including taking cores and/or load tests may be required at the Contractor's expense when the strength of the concrete in the structure is considered potentially deficient.

b. Investigation of Low-Strength Compressive Test Results. When any strength test of standard-cured test cylinders falls below the specified strength requirement by more than 3.5 MPa or if tests of field-cured cylinders indicate deficiencies in protection and curing, take steps to assure that the load-carrying capacity of the structure is not jeopardized. When the strength of concrete in place is considered potentially deficient, cores shall be obtained and tested in accordance with ASTM C 42/C 42M. At least three representative cores shall be taken from each member or area of concrete in place that is considered potentially deficient. The location of cores will be determined by the Contracting Officer to least impair the strength of the structure. Concrete in the area represented by the core testing will be considered adequate if the average strength of the cores is equal to at least 85 percent of the specified strength requirement and if no single core is less than 75 percent of the specified strength requirement. Non-destructive tests (tests other than test cylinders or cores) shall not be used as a basis for acceptance or rejection. Perform the coring and repair the holes; cores will be

tested by the Government.

c. Load Tests. If the core tests are inconclusive or impractical to obtain or if structural analysis does not confirm the safety of the structure, load tests may be directed by the Contracting Officer in accordance with the requirements of ACI 318M. Concrete work evaluated by structural analysis or by results of a load test as being understrength shall be corrected in a manner satisfactory to the Contracting Officer. All investigations, testing, load tests, and correction of deficiencies shall be performed by and at the expense of the Contractor and approved by the Contracting Officer, except that if all concrete is found to be in compliance with the drawings and specifications, the cost of investigations, testing, and load tests will be at the expense of the Government.

1.2.8 Water-Cement Ratio

Maximum water-cement ratio (w/c) for normal weight concrete shall not exceed 0.45.

These w/c's may cause higher strengths than that required above for compressive or flexural strength. The maximum w/c required will be the equivalent w/c as determined by conversion from the weight ratio of water to cement plus pozzolan and silica fume by the weight equivalency method as described in ACI 211.1. In the case where silica fume is used, the weight of the silica fume shall be included in the equations of ACI 211.1 for the term P which is used to denote the weight of pozzolan.

1.2.9 Air Entrainment

All normal weight concrete shall be air entrained to contain between 3.5 and 4.5 percent total air, except that when the nominal maximum size coarse aggregate is 19 mm or smaller it shall be between 4 and 5 percent. Specified air content shall be attained at point of placement into the forms. Air content for normal weight concrete shall be determined in accordance with ASTM C 231.

1.2.10 Slump

Slump of the concrete, as delivered to the point of placement into the forms, shall be within the following limits. Slump shall be determined in accordance with ASTM C 143/C 143M.

Structural Element	Slump Minimum	Slump Maximum
Walls, columns and beams	50 mm	100 mm
Foundation walls, substructure walls, footings, slabs	25 mm	75 mm
Any structural concrete approved for placement by pumping:		
At pump	50 mm	150 mm
At discharge of line	25 mm	100 mm

When use of a plasticizing admixture conforming to ASTM C 1017/C 1017M or when a Type F or G high range water reducing admixture conforming to

ASTM C 494/C 494M is permitted to increase the slump of concrete, concrete shall have a slump of 50 to 100 mm before the admixture is added and a maximum slump of 200 mm at the point of delivery after the admixture is added.

1.2.11 Concrete Temperature

The temperature of the concrete as delivered shall not exceed 32 degrees C. When the ambient temperature during placing is 5 degrees C or less, or is expected to be at any time within 6 hours after placing, the temperature of the concrete as delivered shall be between 12 and 25 degrees C.

1.2.12 Size of Coarse Aggregate

Use the largest feasible nominal maximum size aggregate (NMSA), specified in paragraph AGGREGATES PART 2, in each placement. However, nominal maximum size of aggregate shall not exceed any of the following: three-fourths of the minimum cover for reinforcing bars, three-fourths of the minimum clear spacing between reinforcing bars, one-fifth of the narrowest dimension between sides of forms, or one-third of the thickness of slabs or toppings.

1.3 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.

SD-03 Product Data

Curing Materials
Joint fillers
Portland Cement
Ready-Mixed Concrete
Vapor Barrier
Latex Bonding Agent
Floor Finish
Waterstops
Chemical Admixtures
Epoxy-Resin

Manufacturer's product data, indicating VOC content. Manufacturer's catalog data for the items above, including printed instructions. Products included in other referenced Section (Ex: 07 92 00 JOINT SEALANTS) shall follow the submittals requirements for that Section.

SD-04 Samples

Surface Retarder

Sample of surface retarder material with manufacturer's instructions for application in conjunction with air-water cutting.

SD-05 Design Data

Mixture Proportions

The results of trial mixture design studies along with a statement giving the maximum nominal coarse aggregate size and the

proportions of ingredients that will be used in the manufacture of each strength or class of concrete, at least 14 days prior to commencing concrete placing operations. Aggregate weights shall be based on the saturated surface dry condition. Accompany the statement with test results from an approved independent commercial testing laboratory, showing that mixture design studies have been made with materials proposed for the project and that the proportions selected will produce concrete of the qualities indicated. No substitutions shall be made in the materials used in the mixture design studies without additional tests to show that the quality of the concrete is satisfactory.

SD-06 Test Reports

Testing and Inspection for CQC

Certified copies of laboratory test reports, including mill tests and all other test data, for portland cement, blended cement, pozzolan, ground granulated blast furnace slag, silica fume, aggregate, admixtures, and curing compound proposed for use on this project.

SD-07 Certificates

Qualifications

Written documentation for Contractor Quality Control personnel.

1.4 QUALITY ASSURANCE

Submit qualifications for Contractor Quality Control personnel assigned to concrete construction.
The foreman or lead journeyman of the flatwork finishing crew shall have similar qualifications.

1.4.1 Pre-installation Meeting

A pre-installation meeting with the USAID Implementing Partner will be required at least 10 days prior to start of construction on foundation, floors, and slab on grade placement. The Contractor is responsible for calling the meeting; the Project Superintendent and active installation personnel shall be present.

1.4.2 Special Properties and Products

Concrete may contain admixtures other than air entraining agents, such as water reducers, superplasticizers, or set retarding agents to provide special properties to the concrete, if specified or approved. Any of these materials to be used on the project shall be used in the mix design studies.

1.4.3 Technical Service for Specialized Concrete

Obtain the services of a factory trained technical representative to oversee proportioning, batching, mixing, placing, consolidating, and finishing of specialized structural concrete, such as silica fume. The technical representative shall be on the job full time until the Contracting Officer is satisfied that field controls indicate concrete of specified quality is furnished and that the Contractor's crews are capable of continued satisfactory work. The technical representative shall be

available for consultation with, and advice to, Government forces.

1.4.4 Government Assurance Inspection and Testing

Day-to day inspection and testing shall be the responsibility of the Contractor Quality Control (CQC) staff. However, representatives of the Contracting Officer can and will inspect construction as considered appropriate and will monitor operations of the Contractor's CQC staff. Government inspection or testing will not relieve the Contractor of any CQC responsibilities.

1.4.4.1 Materials

The Government will sample and test aggregates, cementitious materials, other materials, and concrete to determine compliance with the specifications as considered appropriate. Provide facilities and labor as may be necessary for procurement of representative test samples. Samples of aggregates will be obtained at the point of batching in accordance with ASTM D 75/D 75M. Other materials will be sampled from storage at the jobsite or from other locations as considered appropriate. Samples may be placed in storage for later testing when appropriate.

1.4.4.2 Fresh Concrete

Fresh concrete will be sampled as delivered in accordance with ASTM C 172 and tested in accordance with these specifications, as considered necessary.

1.4.4.3 Hardened Concrete

Tests on hardened concrete will be performed by the Government when such tests are considered necessary.

1.4.4.4 Inspection

Concrete operations may be tested and inspected by the Government as the project progresses. Failure to detect defective work or material will not prevent rejection later when a defect is discovered nor will it obligate the Government for final acceptance.

1.5 DELIVERY, STORAGE, AND HANDLING

Store cement and other cementitious materials in weathertight buildings, bins, or silos which will exclude moisture and contaminants and keep each material completely separated. Aggregate stockpiles shall be arranged and used in a manner to avoid excessive segregation and to prevent contamination with other materials or with other sizes of aggregates. Aggregate shall not be stored directly on ground unless a sacrificial layer is left undisturbed. Store reinforcing bars and accessories above the ground on platforms, skids or other supports. Other materials shall be stored in such a manner as to avoid contamination and deterioration. Admixtures which have been in storage at the project site for longer than 6 months or which have been subjected to freezing shall not be used unless retested and proven to meet the specified requirements. Materials shall be capable of being accurately identified after bundles or containers are opened.

PART 2 PRODUCTS

2.1 CEMENTITIOUS MATERIALS

Cementitious Materials shall be portland cement in combination with pozzolan, silica fume conforming to appropriate specifications listed below. Restrict usage of cementitious materials in concrete that will have surfaces exposed in the completed structure so there is no change in color, source, or type of cementitious material.

2.1.1 Portland Cement

ASTM C 150/C 150M, Type II.

2.1.2 Pozzolan (Fly Ash)

Pozzolan shall conform to ASTM C 618, Class C or F, including low alkali and moderate sulfate resistance requirements in Table 3 of ASTM C 618. If pozzolan is used, it shall never be less than 15 percent nor more than 35 percent by weight of the total cementitious material.

2.1.3 Silica Fume

Silica fume shall conform to ASTM C 1240. Silica fume shall consist of not less than 7.0 percent of the cementitious material by mass and no more than 9.0 percent.

2.2 AGGREGATES

Fine and coarse aggregates shall "be tested and evaluated for alkali-aggregate reactivity in accordance with ASTM C 1260. The fine and coarse aggregates shall be evaluated separately and in combination, which matches the Contractor's proposed mix design proportioning. All results of the separate and combination testing shall have a measured expansion less than 0.10 (0.08) percent at 16 days after casting. Should the test data indicate an expansion of 0.10 (0.08) percent or greater, the aggregate(s) shall be rejected or additional testing using ASTM C 1260 and ASTM C 1567 shall be performed. The additional testing using ASTM C 1260 and ASTM C 1567 shall be performed using the low alkali portland cement in combination with Class F fly ash. Class F fly ash shall be used in the range of 25 to 40 percent of the total cementitious material by mass." conform to the following.

2.2.1 Fine Aggregate

Fine aggregate shall conform to the quality and gradation requirements of ASTM C 33/C 33M.

2.2.2 Coarse Aggregate

Coarse aggregate shall conform to ASTM C 33/C 33M, Class 5S.

2.3 CHEMICAL ADMIXTURES

Chemical admixtures, when required or permitted, shall conform to the appropriate specification listed. Admixtures shall be furnished in liquid form and of suitable concentration for easy, accurate control of dispensing.

2.3.1 Air-Entraining Admixture

ASTM C 260 and shall consistently entrain the air content in the specified ranges under field conditions.

2.3.2 Accelerating Admixture

ASTM C 494/C 494M, Type C or E, except that calcium chloride or admixtures containing calcium chloride shall not be used.

2.3.3 Water-Reducing or Retarding Admixture

ASTM C 494/C 494M, Type A, B, or D, except that the 6-month and 1-year compressive and flexural strength tests are waived.

2.3.4 High-Range Water Reducer

ASTM C 494/C 494M, Type F or G, except that the 6-month and 1-year strength requirements are waived.

2.3.5 Surface Retarder

COE CRD-C 94.

2.3.6 Expanding Admixture

Aluminum powder type expanding admixture conforming to ASTM C 937.

2.3.7 Other Chemical Admixtures

Chemical admixtures for use in producing flowing concrete shall comply with ASTM C 1017/C 1017M, Type I or II. These admixtures shall be used only when approved in writing, such approval being contingent upon particular mixture control as described in the Contractor's Quality Control Plan and upon performance of separate mixture design studies.

2.4 CURING MATERIALS

2.4.1 Impervious-Sheet

Impervious-sheet materials shall conform to ASTM C 171, type optional, except, that polyethylene sheet shall not be used.

2.4.2 Membrane-Forming Compound

Membrane-Forming curing compound shall conform to ASTM C 309, Type 1-D or 2, except that only a styrene acrylate or chlorinated rubber compound meeting Class B requirements shall be used for surfaces that are to be painted or are to receive bituminous roofing, or waterproofing. The curing compound selected shall be compatible with any subsequent paint, roofing, or waterproofing specified. Nonpigmented compound shall contain a fugitive dye, and shall have the reflective requirements in ASTM C 309 waived.

2.4.3 Burlap and Cotton Mat

Burlap and cotton mat used for curing shall conform to AASHTO M 182.

2.5 WATER

Water for mixing and curing shall be fresh, clean, potable, and free of injurious amounts of oil, acid, salt, or alkali, except that non-potable water may be used if it meets the requirements of COE CRD-C 400.

2.6 NONSHRINK GROUT

Nonshrink grout shall conform to ASTM C 1107/C 1107M, and shall be a commercial formulation suitable for the proposed application.

2.7 LATEX BONDING AGENT

Latex agents for bonding fresh to hardened concrete shall conform to ASTM C 1059/C 1059M.

2.8 EPOXY RESIN

Epoxy resins for use in repairs shall conform to ASTM C 881/C 881M, Type V, Grade 2. Class as appropriate to the existing ambient and surface temperatures.

2.9 EMBEDDED ITEMS

Embedded items shall be of the size and type indicated or as needed for the application. Dovetail slots shall be galvanized steel. Inserts for shelf angles and bolt hangers shall be of malleable iron or cast or wrought steel.

2.10 VAPOR BARRIER

Vapor barrier shall be polyethylene sheeting with a minimum thickness of 0. 25 mm (10 mils) or other equivalent material having a vapor permeance rating not exceeding 30 nanograms per Pascal per second per square meter as determined in accordance with ASTM E 96/E 96M.

2.11 JOINT MATERIALS

2.11.1 Joint Fillers, Sealers, and Waterstops

Expansion joint fillers shall be preformed materials conforming to ASTM D 1752. Materials for waterstops shall be in accordance with Section 03 15 13.00 10 EXPANSION JOINTS, CONTRACTION JOINTS, AND WATERSTOPS. Materials for and sealing of joints shall conform to the requirements of Section 07 92 00 JOINT SEALANTS.

2.11.2 Contraction Joints in Slabs

Sawable type contraction joint inserts shall conform to COE CRD-C 540. Contraction joints as detailed on the drawings are sawable type, if the Contractor chooses to provide nonsawable joint inserts, the inserts shall have sufficient stiffness to permit placement in plastic concrete without undue deviation from a straight line and shall conform to the physical requirements of COE CRD-C 540, with the exception of Section 3.4 "Resistance to Sawing". Plastic inserts shall be polyvinyl chloride conforming to the materials requirements of COE CRD-C 572.

2.12 Access Hatch Cover

Provide aluminum access hatch cover as indicated. Include lifting

mechanism, automatic hold open arm, slam lock with handle, and flush lift handle with red vinyl grip. Use automatic hold open arm that locks in the 90 degree position. Use cover that is 6 mm diamond plate with 6 mm channel frame and continuous anchor flange. Use access hatch cover capable of withstanding a live load of 1500 kg/sq meter. Provide stainless steel cylinder lock with two keys per lock. Key all the locks the same.

PART 3 EXECUTION

3.1 PREPARATION FOR PLACING

Before commencing concrete placement, perform the following: Surfaces to receive concrete shall be clean and free from frost, ice, mud, and water. Forms shall be in place, cleaned, coated, and adequately supported, in accordance with Section 03 11 13.00 10 STRUCTURAL CONCRETE FORMWORK. Reinforcing steel shall be in place, cleaned, tied, and adequately supported, in accordance with Section 03 20 01.00 10 CONCRETE REINFORCEMENT. Transporting and conveying equipment shall be in-place, ready for use, clean, and free of hardened concrete and foreign material. Equipment for consolidating concrete shall be at the placing site and in proper working order. Equipment and material for curing and for protecting concrete from weather or mechanical damage shall be at the placing site, in proper working condition and in sufficient amount for the entire placement. When hot, windy conditions during concreting appear probable, equipment and material shall be at the placing site to provide windbreaks, shading, fogging, or other action to prevent plastic shrinkage cracking or other damaging drying of the concrete.

3.1.1 Foundations

3.1.1.1 Concrete on Earth Foundations

Earth (subgrade, base, or subbase courses) surfaces upon which concrete is to be placed shall be clean, damp, and free from debris, frost, ice, and standing or running water. Prior to placement of concrete, the foundation shall be well drained and shall be satisfactorily graded and uniformly compacted.

3.1.1.2 Excavated Surfaces in Lieu of Forms

Concrete for footings may be placed directly against the soil provided the earth or rock has been carefully trimmed, is uniform and stable, and meets the compaction requirements of Section 31 00 00 EARTHWORK. Place the concrete without becoming contaminated by loose material, and outlined within the specified tolerances.

3.1.2 Waste Disposal

The method used in disposing of waste water employed in cutting, washing, and rinsing of concrete surfaces shall be such that the waste water does not stain, discolor, or affect exposed surfaces of the structures, or damage the environment of the project area. The method of disposal shall be subject to approval.

3.1.3 Vapor Barrier

Provide vapor barrier beneath the interior on-grade concrete floor slabs. Use the greatest widths and lengths practicable to eliminate joints wherever possible. Joints shall be lapped a minimum of 300 mm. Torn,

punctured, or damaged vapor barrier material shall be removed and new vapor barrier shall be provided prior to placing concrete. For minor repairs, patches may be made using laps of at least 300 mm. Lapped joints shall be sealed and edges patched with pressure-sensitive adhesive or tape not less than 50 mm wide and compatible with the membrane. Place vapor barrier directly on underlying subgrade, base course, or capillary water barrier, unless it consists of crushed material or large granular material which could puncture the vapor barrier. In this case, a thin layer of approximately 13 mm of fine graded material should be rolled or compacted over the fill before installation of the vapor barrier to reduce the possibility of puncture. Control concrete placement so as to prevent damage to the vapor barrier.

3.1.4 Embedded Items

Before placement of concrete, determine that all embedded items are firmly and securely fastened in place as indicated on the drawings, or required. Conduit and other embedded items shall be clean and free of oil and other foreign matter such as loose coatings or rust, paint, and scale. The embedding of wood in concrete will be permitted only when specifically authorized or directed. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable materials to prevent the entry of concrete into voids. Welding shall not be performed on embedded metals within 300 mm of the surface of the concrete. Tack welding shall not be performed on or to embedded items.

3.2 CONCRETE PRODUCTION

3.2.1 General Requirements

Concrete shall either be batched and mixed onsite or shall be furnished from a ready-mixed concrete plant. Ready-mixed concrete shall be batched, mixed, and transported in accordance with ASTM C 94/C 94M, except as otherwise specified. Truck mixers, agitators, and nonagitating transporting units shall comply with NRMCA TMMB 100. Ready-mix plant equipment and facilities shall be certified in accordance with NRMCA QC 3. Approved batch tickets shall be furnished for each load of ready-mixed concrete. Site-mixed concrete shall conform to the following subparagraphs.

3.2.2 Batching Plant

Locate the batching plant offsite close to the project. The batching, mixing and placing system shall have a capacity to meet the demands of the project construction schedule and quantity. The batching plant shall conform to the requirements of NRMCA CPMB 100 and as specified; however, rating plates attached to batch plant equipment are not required.

3.2.3 Batching Equipment

The batching controls shall be semiautomatic or automatic, as defined in NRMCA CPMB 100. Provide a semiautomatic batching system with interlocks such that the discharge device cannot be actuated until the indicated material is within the applicable tolerance. Equip the batching system with accurate recorder or recorders that meet the requirements of NRMCA CPMB 100. Record the weight of water and admixtures if batched by weight. Provide separate bins or compartments for each size group of aggregate and type of cementitious material, to prevent intermingling at any time. Aggregates shall be weighed either in separate weigh batchers with individual scales or, provided the smallest size is batched first,

cumulatively in one weigh batcher on one scale. Aggregate shall not be weighed in the same batcher with cementitious material. If both portland cement and other cementitious material are used, they may be batched cumulatively, provided that the portland cement is batched first, except that silica fume shall always be batched separately. Water may be measured by weight or volume. Water shall not be weighed or measured cumulatively with another ingredient. Filling and discharging valves for the water metering or batching system shall be so interlocked that the discharge valve cannot be opened before the filling valve is fully closed. Piping for water and for admixtures shall be free from leaks and shall be properly valved to prevent backflow or siphoning. Furnish admixtures as a liquid of suitable concentration for easy control of dispensing. Provide an adjustable, accurate, mechanical device for measuring and dispensing each admixture. Each admixture dispenser shall be interlocked with the batching and discharging operation of the water so that each admixture is separately batched and individually discharged automatically in a manner to obtain uniform distribution throughout the water as it is added to the batch in the specified mixing period. When use of truck mixers makes this requirement impractical, the admixture dispensers shall be interlocked with the sand batchers. Different admixtures shall not be combined prior to introduction in water and shall not be allowed to intermingle until in contact with the cement. Admixture dispensers shall have suitable devices to detect and indicate flow during dispensing or have a means for visual observation. Arrange the plant so as to facilitate the inspection of all operations at all times. Provide suitable facilities for obtaining representative samples of aggregates from each bin or compartment, and for sampling and calibrating the dispensing of cementitious material, water, and admixtures. Filling ports for cementitious materials bins or silos shall be clearly marked with a permanent sign stating the contents.

3.2.4 Scales

The weighing equipment shall conform to the applicable requirements of CPMB Concrete Plant Standard, and of NIST HB 44, except that the accuracy shall be plus or minus 0.2 percent of scale capacity. Provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring devices. Perform the tests at the specified frequency in the presence of a Government inspector. Arrange the weighing equipment so that the plant operator can conveniently observe all dials or indicators.

3.2.5 Batching Tolerances

(A) Tolerances with Weighing Equipment

MATERIAL	PERCENT OF REQUIRED WEIGHT
Cementitious materials	0 to plus 2
Aggregate	plus or minus 2
Water	plus or minus 1
Chemical admixture	0 to plus 6

(B) Tolerances with Volumetric Equipment

For volumetric batching equipment used for water and admixtures, the following tolerances shall apply to the required volume of material being batched:

MATERIAL	PERCENT OF REQUIRED MATERIAL
Water:	plus or minus 1 percent
Chemical admixtures:	0 to plus 6 percent

3.2.6 Moisture Control

Provide a plant capable of ready adjustment to compensate for the varying moisture content of the aggregates and to change the weights of the materials being batched.

3.2.7 Concrete Mixers

Mixers shall be stationary mixers or truck mixers capable of combining the materials into a uniform mixture and of discharging this mixture without segregation. The mixers shall not be charged in excess of the capacity recommended by the manufacturer. Operate the mixers at the drum or mixing blade speed designated by the manufacturer. The mixers shall be maintained in satisfactory operating condition, and the mixer drums shall be kept free of hardened concrete. Should any mixer at any time produce unsatisfactory results, its use shall be promptly discontinued until it is repaired.

3.2.8 Stationary Mixers

Concrete plant mixers shall be drum-type mixers of tilting, nontilting, horizontal-shaft, or vertical-shaft type, or pug mill type provided with an acceptable device to lock the discharge mechanism until the required mixing time has elapsed. The mixing time and uniformity shall conform to all the requirements in ASTM C 94/C 94M applicable to central-mixed concrete.

3.2.9 Truck Mixers

Truck mixers, the mixing of concrete therein, and concrete uniformity shall conform to the requirements of ASTM C 94/C 94M. A truck mixer may be used either for complete mixing (transit-mixed) or to finish the partial mixing done in a stationary mixer (shrink-mixed). Each truck shall be equipped with two counters from which it is possible to determine the number of revolutions at mixing speed and the number of revolutions at agitating speed. Water shall not be added at the placing site unless specifically approved; and in no case shall it exceed the specified w/c. Any such water shall be injected at the base of the mixer, not at the discharge end.

3.3 TRANSPORTING CONCRETE TO PROJECT SITE

Transport concrete to the placing site in truck mixers.

3.4 CONVEYING CONCRETE ONSITE

Convey concrete from mixer or transporting unit to forms as rapidly as possible and within the time interval specified by methods which will prevent segregation or loss of ingredients using following equipment. Conveying equipment shall be cleaned before each placement.

3.4.1 Buckets

The interior hopper slope shall be not less than 58 degrees from the horizontal, the minimum dimension of the clear gate opening shall be at

least 5 times the nominal maximum-size aggregate, and the area of the gate opening shall not be less than 0.2 square meters. The maximum dimension of the gate opening shall not be greater than twice the minimum dimension. The bucket gates shall be essentially grout tight when closed and may be manually, pneumatically, or hydraulically operated except that buckets larger than 1.5 cubic meters shall not be manually operated. The design of the bucket shall provide means for positive regulation of the amount and rate of deposit of concrete in each dumping position.

3.4.2 Transfer Hoppers

Concrete may be charged into nonagitating hoppers for transfer to other conveying devices. Transfer hoppers shall be capable of receiving concrete directly from delivery vehicles and shall have conical-shaped discharge features. Equip the transfer hopper with a hydraulically operated gate and with a means of external vibration to effect complete discharge. Concrete shall not be held in nonagitating transfer hoppers more than 30 minutes.

3.4.3 Trucks

Truck mixers operating at agitating speed or truck agitators used for transporting plant-mixed concrete shall conform to the requirements of ASTM C 94/C 94M. Use nonagitating equipment only for transporting plant-mixed concrete over a smooth road and when the hauling time is less than 15 minutes. Bodies of nonagitating equipment shall be smooth, watertight, metal containers specifically designed to transport concrete, shaped with rounded corners to minimize segregation, and equipped with gates that will permit positive control of the discharge of the concrete.

3.4.4 Chutes

When concrete can be placed directly from a truck mixer, agitator, or nonagitating equipment, the chutes normally attached to this equipment by the manufacturer may be used. Use a discharge deflector when required by the Contracting Officer. Separate chutes and other similar equipment will not be permitted for conveying concrete.

3.4.5 Belt Conveyors

Design and operate belt conveyors to assure a uniform flow of concrete from mixer to final place of deposit without segregation of ingredients or loss of mortar and provided with positive means, such as discharge baffle or hopper , for preventing segregation of the concrete at the transfer points and the point of placing. Construct belt conveyors such that the idler spacing does not exceed 900 mm. The belt speed shall be a minimum of 90 meters per minute and a maximum of 225 meters per minute. If concrete is to be placed through installed horizontal or sloping reinforcing bars, the conveyor shall discharge concrete into a pipe or elephant truck that is long enough to extend through the reinforcing bars.

3.4.6 Concrete Pumps

Concrete may be conveyed by positive displacement pump when approved. The pumping equipment shall be piston or squeeze pressure type; pneumatic placing equipment shall not be used. The pipeline shall be rigid steel pipe or heavy-duty flexible hose. The inside diameter of the pipe shall be at least 3 times the nominal maximum-size coarse aggregate in the concrete mixture to be pumped but not less than 100 mm. Aluminum pipe shall not be used.

3.5 PLACING CONCRETE

Discharge mixed concrete within 1.5 hours or before the mixer drum has revolved 300 revolutions, whichever comes first after the introduction of the mixing water to the cement and aggregates. When the concrete temperature exceeds 30 degrees C, reduce the time to 45 minutes. Place concrete within 15 minutes after it has been discharged from the transporting unit. Concrete shall be handled from mixer or transporting unit to forms in a continuous manner until the approved unit of operation is completed. Provide adequate scaffolding, ramps and walkways so that personnel and equipment are not supported by in-place reinforcement. Placing will not be permitted when the sun, heat, wind, or limitations of facilities prevent proper consolidation, finishing and curing. Provide sufficient placing capacity so that concrete can be kept free of cold joints.

3.5.1 Depositing Concrete

Deposit concrete as close as possible to its final position in the forms, and with no vertical drop greater than 1.5 meters except where suitable equipment is provided to prevent segregation and where specifically authorized. Depositing of the concrete shall be so regulated that it will be effectively consolidated in horizontal layers not more than 300 mm thick, except that all slabs shall be placed in a single lift. Concrete to receive other construction shall be screeded to the proper level. Concrete shall be deposited continuously in one layer or in layers so that fresh concrete is deposited on in-place concrete that is still plastic. Fresh concrete shall not be deposited on concrete that has hardened sufficiently to cause formation of seams or planes of weakness within the section. Concrete that has surface dried, partially hardened, or contains foreign material shall not be used. When temporary spreaders are used in the forms, the spreaders shall be removed as their service becomes unnecessary. Concrete shall not be placed in slabs over columns and walls until concrete in columns and walls has been in-place at least two hours or until the concrete begins to lose its plasticity. Place concrete for beams, girders, brackets, column capitals, haunches, and drop panels at the same time as concrete for adjoining slabs.

3.5.2 Consolidation

Immediately after placing, consolidate each layer of concrete by internal vibrators, except for slabs 100 mm thick or less. The vibrators shall at all times be adequate in effectiveness and number to properly consolidate the concrete; keep a spare vibrator at the jobsite during all concrete placing operations. The vibrators shall have a frequency of not less than 10,000 vibrations per minute, an amplitude of at least 0.6 mm, and the head diameter shall be appropriate for the structural member and the concrete mixture being placed. Insert vibrators vertically at uniform spacing over the area of placement. The distance between insertions shall be approximately 1.5 times the radius of action of the vibrator so that the area being vibrated will overlap the adjacent just-vibrated area by a reasonable amount. The vibrator shall penetrate rapidly to the bottom of the layer and at least 150 mm into the preceding layer if there is such. Vibrator shall be held stationary until the concrete is consolidated and then vertically withdrawn slowly while operating. Form vibrators shall not be used unless specifically approved and unless forms are constructed to withstand their use. Vibrators shall not be used to move concrete within the forms. Slabs 100 mm and less in thickness shall be consolidated by

properly designed vibrating screeds or other approved technique. Frequency and amplitude of vibrators shall be determined in accordance with COE CRD-C 521. Grate tampers ("jitterbugs") shall not be used.

3.5.3 Cold Weather Requirements

Use special protection measures, approved by the Contracting Officer, if freezing temperatures are anticipated before the expiration of the specified curing period. The ambient temperature of the air where concrete is to be placed and the temperature of surfaces to receive concrete shall be not less than 5 degrees C. The temperature of the concrete when placed shall be not less than 10 degrees C nor more than 25 degrees C. Heating of the mixing water or aggregates will be required to regulate the concrete placing temperature. Materials entering the mixer shall be free from ice, snow, or frozen lumps. Salt, chemicals or other materials shall not be incorporated in the concrete to prevent freezing. Upon written approval, an accelerating admixture conforming to ASTM C 494/C 494M, Type C or E may be used, provided it contains no calcium chloride. Calcium chloride shall not be used.

3.5.4 Hot Weather Requirements

When the ambient temperature during concrete placing is expected to exceed 30 degrees C, the concrete shall be placed and finished with procedures previously submitted and as specified herein. The concrete temperature at time of delivery to the forms shall not exceed the temperature shown in the table below when measured in accordance with ASTM C 1064/C 1064M. Cooling of the mixing water or aggregates or placing concrete in the cooler part of the day may be required to obtain an adequate placing temperature. A retarder may be used, as approved, to facilitate placing and finishing. Steel forms and reinforcements shall be cooled as approved prior to concrete placement when steel temperatures are greater than 49 degrees C. Conveying and placing equipment shall be cooled if necessary to maintain proper concrete-placing temperature.

Maximum Allowable Concrete Placing Temperature

Relative Humidity, Percent, During Time of Concrete Placement	Maximum Allowable Concrete Temperature Degrees
Greater than 60	33 C
40-60	30 C
Less than 40	27 C

3.5.5 Prevention of Plastic Shrinkage Cracking

During hot weather with low humidity, and particularly with appreciable wind, as well as interior placements when space heaters produce low humidity, the Contractor shall be alert to the tendency for plastic shrinkage cracks to develop and shall institute measures to prevent this. Take particular care if plastic shrinkage cracking is potentially imminent and especially if it has developed during a previous placement. Periods of high potential for plastic shrinkage cracking can be anticipated by use of Fig. 2.1.5 of ACI 305R. In addition the concrete placement shall be further protected by erecting shades and windbreaks and by applying fog sprays of water, sprinkling, ponding or wet covering. Plastic shrinkage cracks that occur shall be filled by injection of epoxy resin as directed, after the concrete hardens. Plastic shrinkage cracks shall never be

troweled over or filled with slurry.

3.5.6 Placing Concrete in Congested Areas

Use special care to ensure complete filling of the forms, elimination of all voids, and complete consolidation of the concrete when placing concrete in areas congested with reinforcing bars, embedded items, waterstops and other tight spacing. An appropriate concrete mixture shall be used, and the nominal maximum size of aggregate (NMSA) shall meet the specified criteria when evaluated for the congested area. Vibrators with heads of a size appropriate for the clearances available shall be used, and the consolidation operation shall be closely supervised to ensure complete and thorough consolidation at all points. Where necessary, splices of reinforcing bars shall be alternated to reduce congestion. Where two mats of closely spaced reinforcing are required, the bars in each mat shall be placed in matching alignment to reduce congestion.

3.6 JOINTS

Locate and construct joints as indicated or approved. Joints not indicated on the drawings shall be located and constructed to minimize the impact on the strength of the structure. Joints shall be perpendicular to the main reinforcement. All reinforcement shall be continued across joints; except that reinforcement or other fixed metal items shall not be continuous through expansion joints, or through construction or contraction joints in slabs on grade. Reinforcement shall be 50 mm clear from each joint. Except where otherwise indicated, construction joints between interior slabs on grade and vertical surfaces shall consist of 1.5 kg per square meter asphalt-saturated felt, extending for the full depth of the slab. The perimeters of the slabs shall be free of fins, rough edges, spalling, or other unsightly appearance. Reservoir for sealant for construction and contraction joints in slabs shall be formed to the dimensions shown on the drawings by removing snap-out joint-forming inserts, by sawing sawable inserts, or by sawing to widen the top portion of sawed joints. Joints to be sealed shall be cleaned and sealed as indicated and in accordance with Section 07 92 00 JOINT SEALANTS.

3.6.1 Construction Joints

For concrete other than slabs on grade, locate construction joints so that the unit of operation does not exceed 18 meters. Concrete shall be placed continuously so that each unit is monolithic in construction. Fresh concrete shall not be placed against adjacent hardened concrete until it is at least 24 hours old. Locate construction joints as indicated or approved. Where concrete work is interrupted by weather, end of work shift or other similar type of delay, location and type of construction joint shall be subject to approval of the Contracting Officer. Unless otherwise indicated and except for slabs on grade, extend reinforcing steel through construction joints. Construction joints in slabs on grade shall be keyed or doweled as shown. Concrete columns, walls, or piers shall be in place at least 2 hours, or until the concrete begins to lose its plasticity, before placing concrete for beams, girders, or slabs thereon. In walls having door or window openings, terminate lifts at the top and bottom of the opening. Other lifts shall terminate at such levels as to conform to structural requirements or architectural details. Where horizontal construction joints in walls or columns are required, a strip of 25 mm square-edge lumber, bevelled and oiled to facilitate removal, shall be tacked to the inside of the forms at the construction joint. Place concrete to a point 25 mm above the underside of the strip. The strip

shall be removed 1 hour after the concrete has been placed, and any irregularities in the joint line shall be leveled off with a wood float, and all laitance shall be removed. Prior to placing additional concrete, horizontal construction joints shall be prepared as specified in paragraph Previously Placed Concrete above.

3.6.2 Contraction Joints in Slabs on Grade

Contraction joints shall be located and detailed as shown on the drawings. Produce contraction joints by forming a weakened plane in the concrete slab by use of rigid inserts impressed in the concrete during placing operations use of snap-out plastic joint forming inserts or sawing a continuous slot with a concrete saw. Regardless of method used to produce the weakened plane, it shall be 1/4 the depth of the slab thickness and between 3 and 5 mm wide. For saw-cut joints, cutting shall be timed properly with the set of the concrete. Cutting shall be started as soon as the concrete has hardened sufficiently to prevent ravelling of the edges of the saw cut. Cutting shall be completed before shrinkage stresses become sufficient to produce cracking. Form reservoir for joint sealant as previously specified. For slabs subjected to heavy loads, contraction joints have a wider saw cut near the surface and a 3 mm sawcut 75 mm deep measured from the surface of the slab. See drawings for details.

3.6.3 Waterstops

Install waterstops in conformance with the locations and details shown on the drawings using materials and procedures specified in Section 03 15 13.00 10 EXPANSION JOINTS, CONTRACTION JOINTS, AND WATERSTOPS.

3.6.4 Dowels and Tie Bars

Install dowels and tie bars at the locations shown on the drawings and to the details shown, using materials and procedures specified in Section 03 20 01.00 10 CONCRETE REINFORCEMENT and herein. Conventional smooth "paving" dowels shall be installed in slabs using approved methods to hold the dowel in place during concreting within a maximum alignment tolerance of 1 mm in 100 mm. "Structural" type deformed bar dowels, or tie bars, shall be installed to meet the specified tolerances. Care shall be taken during placing adjacent to and around dowels and tie bars to ensure there is no displacement of the dowel or tie bar and that the concrete completely embeds the dowel or tie bar and is thoroughly consolidated.

3.7 FINISHING FORMED SURFACES

Forms, form materials, and form construction are specified in Section 03 11 13.00 10 STRUCTURAL CONCRETE FORMWORK. Finishing of formed surfaces shall be as specified herein. Unless another type of architectural or special finish is specified, surfaces shall be left with the texture imparted by the forms except that defective surfaces shall be repaired. Unless painting of surfaces is required, maintain uniform color of the concrete by use of only one mixture without changes in materials or proportions for any structure or portion of structure that requires a Class B finish. Except for major defects, as defined hereinafter, repair surface defects as specified herein within 24 hours after forms are removed. Repairs of the so-called "plaster-type" will not be permitted in any location. Tolerances of formed surfaces shall conform to the requirements of ACI 117. These tolerances apply to the finished concrete surface, not to the forms themselves; forms shall be set true to line and grade. Form tie holes requiring repair and other defects whose depth is at least as

great as their surface diameter shall be repaired as specified in paragraph Damp-Pack Mortar Repair below. Defects whose surface diameter is greater than their depth shall be repaired as specified in paragraph Repair of Major Defects below. Repairs shall be finished flush with adjacent surfaces and with the same surface texture. The cement used for all repairs shall be a blend of job cement with white cement proportioned so that the final color after curing and aging will be the same as the adjacent concrete. Concrete with excessive honeycomb, or other defects which affect the strength of the member, will be rejected. Repairs shall be demonstrated to be acceptable and free from cracks or loose or drummy areas at the completion of the contract and, for Class B Finishes, shall be inconspicuous. Repairs not meeting these requirements will be rejected and shall be replaced.

3.7.1 Class B Finish

Class B finish is required where indicated on the drawings. Remove fins, ravelings, and loose material, all surface defects over 12 mm in diameter or more than 12 mm deep, shall be repaired and, except as otherwise indicated or as specified in Section 03 11 13.00 10 STRUCTURAL CONCRETE FORMWORK, holes left by removal of form ties shall be reamed and filled. Defects more than 12 mm in diameter shall be cut back to sound concrete, but in all cases at least 25 mm deep. Prepare a sample panel for approval (as specified in PART 1) before commencing repair, showing that the surface texture and color match will be attained.

3.8 REPAIRS

3.8.1 Damp-Pack Mortar Repair

Form tie holes requiring repair and other defects, whose depth is at least as great as their surface diameter but not over 100 mm, shall be repaired by the damp-pack mortar method. Form tie holes shall be reamed and other similar defects shall be cut out to sound concrete. The void shall then be thoroughly cleaned, thoroughly wetted, brush-coated with a thin coat of neat cement grout and filled with mortar. Mortar shall be a stiff mix of 1 part portland cement to 2 parts fine aggregate passing the 1.18 mm sieve, and minimum amount of water. Use only sufficient water to produce a mortar which, when used, will stick together on being molded into a ball by a slight pressure of the hands and will not exude water but will leave the hands damp. Mortar shall be mixed and allowed to stand for 30 to 45 minutes before use with remixing performed immediately prior to use. Mortar shall be thoroughly tamped in place in thin layers using a hammer and hardwood block. Holes passing entirely through walls shall be completely filled from the inside face by forcing mortar through to the outside face. All holes shall be packed full. Damp-pack repairs shall be moist cured for at least 48 hours.

3.8.2 Repair of Major Defects

Major defects will be considered to be those more than 12 mm deep or, for Class A and B finishes, more than 12 mm in diameter and, for Class C and D finishes, more than 50 mm in diameter. Also included are any defects of any kind whose depth is over 100 mm or whose surface diameter is greater than their depth. Repair major defects as specified below.

3.8.2.1 Surface Application of Mortar Repair

Defective concrete shall be removed, and removal shall extend into

completely sound concrete. Use approved equipment and procedures which will not cause cracking or microcracking of the sound concrete. If reinforcement is encountered, remove concrete so as to expose the reinforcement for at least 50 mm on all sides. All such defective areas greater than 7800 square mm shall be outlined by saw cuts at least 25 mm deep. Defective areas less than 7800 square mm shall be outlined by a 25 mm deep cut with a core drill in lieu of sawing. All saw cuts shall be straight lines in a rectangular pattern in line with the formwork panels. After concrete removal, the surface shall be thoroughly cleaned by high pressure washing to remove all loose material. Keep surfaces continually saturated for the first 12 of the 24 hours immediately before placing mortar and shall be damp but not wet at the time of commencing mortar placement. The Contractor, as an option, may use either hand-placed mortar or mortar placed with a mortar gun. If hand-placed mortar is used, the edges of the cut shall be perpendicular to the surface of the concrete. The prepared area shall be brush-coated with a thin coat of neat cement grout. The repair shall then be made using a stiff mortar, preshrunk by allowing the mixed mortar to stand for 30 to 45 minutes and then remixed, thoroughly tamped into place in thin layers. If hand-placed mortar is used, test each repair area for drumminess by firm tapping with a hammer and inspecting for cracks, both in the presence of the Contracting Officer, immediately before completion of the contract, and replacing any showing drumminess or cracking. If mortar placed with a mortar gun is used, the gun shall be a small compressed air-operated gun to which the mortar is slowly hand fed and which applies the mortar to the surface as a high-pressure stream, as approved. Repairs made using shotcrete equipment will not be accepted. The mortar used shall be the same mortar as specified for damp-pack mortar repair. If gun-placed mortar is used, the edges of the cut shall be beveled toward the center at a slope of 1:1. All surface applied mortar repairs shall be continuously moist cured for at least 7 days. Moist curing shall consist of several layers of saturated burlap applied to the surface immediately after placement is complete and covered with polyethylene sheeting, all held closely in place by a sheet of plywood or similar material rigidly braced against it. Keep burlap continually wet.

3.9 FINISHING UNFORMED SURFACES

The finish of all unformed surfaces shall meet the requirements of paragraph Tolerances in PART 1, when tested as specified herein.

3.9.1 General

The ambient temperature of spaces adjacent to unformed surfaces being finished and of the base on which concrete will be placed shall be not less than 10 degrees C. In hot weather all requirements of paragraphs Hot Weather Requirements and Prevention of Plastic Shrinkage Cracking above shall be met. Unformed surfaces that are not to be covered by additional concrete or backfill shall have a float finish, with additional finishing as specified below, and shall be true to the elevation shown on the drawings. Surfaces to receive additional concrete or backfill shall be brought to the elevation shown on the drawings, properly consolidated, and left true and regular. Unless otherwise shown on the drawings, exterior surfaces shall be sloped for drainage, as directed. Where drains are provided, interior floors shall be evenly sloped to the drains. Joints shall be carefully made with a jointing or edging tool. The finished surfaces shall be protected from stains or abrasions. Grate tampers or "jitterbugs" shall not be used for any surfaces. The dusting of surfaces with dry cement or other materials or the addition of any water during

finishing shall not be permitted. If bleedwater is present prior to finishing, the excess water shall be carefully dragged off or removed by absorption with porous materials such as burlap. During finishing operations, extreme care shall be taken to prevent over finishing or working water into the surface; this can cause "crazing" (surface shrinkage cracks which appear after hardening) of the surface. Any slabs with surfaces which exhibit significant crazing shall be removed and replaced. During finishing operations, surfaces shall be checked with a 10 foot straightedge, applied in both directions at regular intervals while the concrete is still plastic, to detect high or low areas.

3.9.2 Troweled Finish

All exposed slabs shall be given a trowel finish. After floating is complete and after the surface moisture has disappeared, unformed surfaces shall be steel-troweled to a smooth, even, dense finish, free from blemishes including trowel marks. In lieu of hand finishing, an approved power finishing machine may be used in accordance with the directions of the machine manufacturer. Additional trowelings shall be performed, either by hand or machine until the surface has been troweled 3 times, with waiting period between each. Care shall be taken to prevent blistering and if such occurs, troweling shall immediately be stopped and operations and surfaces corrected. A final hard steel troweling shall be done by hand, with the trowel tipped, and using hard pressure, when the surface is at a point that the trowel will produce a ringing sound. The finished surface shall be thoroughly consolidated and shall be essentially free of trowel marks and be uniform in texture and appearance. The concrete mixture used for troweled finished areas shall be adjusted, if necessary, in order to provide sufficient fines (cementitious material and fine sand) to finish properly.

3.10 EXTERIOR SLAB AND RELATED ITEMS

3.10.1 Pits and Trenches

Construct pits and trenches as indicated on the drawings. Bottoms and walls shall be placed monolithically or waterstops and keys, shall be provided as approved.

3.11 CURING AND PROTECTION

3.11.1 General

Concrete shall be cured by an approved method for the period of time of 7 days.

Immediately after placement, protect concrete from premature drying, extremes in temperatures, rapid temperature change, mechanical injury and damage from rain and flowing water for the duration of the curing period. Maintain air and forms in contact with concrete at a temperature above 10 degrees C for the first 3 days and at a temperature above 0 degrees C for the remainder of the specified curing period. Exhaust fumes from combustion heating units shall be vented to the outside of the enclosure, and heaters and ducts shall be placed and directed so as not to cause areas of overheating and drying of concrete surfaces or to create fire hazards. Materials and equipment needed for adequate curing and protection shall be available and at the site prior to placing concrete. No fire or excessive heat, including welding, shall be permitted near or in direct contact with the concrete at any time. Moist curing shall be provided for any areas to

receive any paint or other applied coating, or to which other concrete is to be bonded. Concrete containing silica fume shall be initially cured by fog misting during finishing, followed immediately by continuous moist curing. Except for plastic coated burlap, impervious sheeting alone shall not be used for curing.

3.11.2 Moist Curing

Maintain concrete, to be moist-cured, continuously wet for the entire curing period, commencing immediately after finishing. If water or curing materials used stain or discolor concrete surfaces which are to be permanently exposed, the concrete surfaces shall be cleaned as approved. When wooden forms are left in place during curing, they shall be kept wet at all times. If steel forms are used in hot weather, nonsupporting vertical forms shall be broken loose from the concrete soon after the concrete hardens and curing water continually applied in this void. If the forms are removed before the end of the curing period, curing shall be carried out as on unformed surfaces, using suitable materials. Surfaces shall be cured by ponding, by continuous sprinkling, by continuously saturated burlap or cotton mats, or by continuously saturated plastic coated burlap. Burlap and mats shall be clean and free from any contamination and shall be completely saturated before being placed on the concrete. Provide an approved work system to ensure that moist curing is continuous 24 hours per day.

3.11.3 Impervious Sheeting

The following concrete surfaces may be cured using impervious sheets in the wash station ramps. However, except for plastic coated burlap, impervious sheeting alone shall not be used for curing. Use impervious-sheet curing only on horizontal or nearly horizontal surfaces. Surfaces shall be thoroughly wetted and be completely covered with the sheeting. Sheeting shall be at least 450 mm wider than the concrete surface to be covered. Covering shall be laid with light-colored side up. Covering shall be lapped not less than 300 mm and securely weighted down or shall be lapped not less than 100 mm and taped to form a continuous cover with completely closed joints. The sheet shall be weighted to prevent displacement so that it remains in contact with the concrete during the specified length of curing. Coverings shall be folded down over exposed edges of slabs and secured by approved means. Sheets shall be immediately repaired or replaced if tears or holes appear during the curing period.

3.11.4 Cold Weather Curing and Protection

When the daily ambient low temperature is less than 0 degrees C maintain the temperature of the concrete above 5 degrees C for the first seven days after placing. During the period of protection removal, control the air temperature adjacent to the concrete surfaces so that concrete near the surface will not be subjected to a temperature differential of more than 13 degrees C as determined by suitable temperature measuring devices furnished by the Contractor, as required, and installed adjacent to the concrete surface and 50 mm inside the surface of the concrete. Perform the installation of the thermometers as directed.

3.12 SETTING BASE PLATES AND BEARING PLATES

After being properly positioned, column base plates, bearing plates for beams and similar structural members, and machinery and equipment base plates shall be set to the proper line and elevation with damp-pack bedding

mortar, except where nonshrink grout is indicated. The thickness of the mortar or grout shall be approximately 1/24 the width of the plate, but not less than 19 mm. Concrete and metal surfaces in contact with grout shall be clean and free of oil and grease, and concrete surfaces in contact with grout shall be damp and free of laitance when grout is placed. Use nonshrink grout for all Pre Engineered Building base plates.

3.12.1 Damp-Pack Bedding Mortar

Damp-pack bedding mortar shall consist of 1 part cement and 2-1/2 parts fine aggregate having water content such that a mass of mortar tightly squeezed in the hand will retain its shape but will crumble when disturbed. The space between the top of the concrete and bottom of the bearing plate or base shall be packed with the bedding mortar by tamping or ramming with a bar or rod until it is completely filled.

3.12.2 Nonshrink Grout

Nonshrink grout shall be a ready-mixed material requiring only the addition of water. Water content shall be the minimum that will provide a flowable mixture and completely fill the space to be grouted without segregation, bleeding, or reduction of strength.

3.12.2.1 Mixing and Placing of Nonshrink Grout

Mixing and placing shall be in conformance with the material manufacturer's instructions and as specified therein. Ingredients shall be thoroughly dry-mixed before adding water. After adding water, mix the batch for 3 minutes. Batches shall be of size to allow continuous placement of freshly mixed grout. Discard grout not used within 30 minutes after mixing. The space between the top of the concrete or machinery-bearing surface and the plate shall be filled solid with the grout. Forms shall be of wood or other equally suitable material for completely retaining the grout on all sides and on top and shall be removed after the grout has set. The placed grout shall be carefully worked by rodding or other means to eliminate voids; however, overworking and breakdown of the initial set shall be avoided. Grout shall not be retempered or subjected to vibration from any source. Where clearances are unusually small, placement shall be under pressure with a grout pump. Temperature of the grout, and of surfaces receiving the grout, shall be maintained at 18 to 30 degrees C until after setting.

3.12.2.2 Treatment of Exposed Surfaces

For metal-oxidizing nonshrink grout, exposed surfaces shall be cut back 25 mm and immediately covered with a parge coat of mortar consisting of 1 part portland cement and 2-1/2 parts fine aggregate by weight, with sufficient water to make a plastic mixture. The parge coat shall have a smooth finish. For other mortars or grouts, exposed surfaces shall have a smooth-dense finish and be left untreated. Curing shall comply with paragraph CURING AND PROTECTION above.

3.13 TESTING AND INSPECTION FOR CQC

Perform the inspection and tests described below and, based upon the results of these inspections and tests, take the action required and submit specified reports. When, in the opinion of the Contracting Officer, the concreting operation is out of control, cease concrete placement and correct the operation. The laboratory performing the tests shall be onsite

and shall conform with ASTM C 1077. Materials may be subjected to check testing by the Government from samples obtained at the manufacturer, at transfer points, or at the project site. The Government will inspect the laboratory, equipment, and test procedures prior to start of concreting operations and at least once per month thereafter for conformance with ASTM C 1077.

3.13.1 Grading and Corrective Action

3.13.1.1 Fine Aggregate

At least once during each shift when the concrete plant is operating, there shall be one sieve analysis and fineness modulus determination in accordance with ASTM C 136 and COE CRD-C 104 for the fine aggregate or for each fine aggregate if it is batched in more than one size or classification. The location at which samples are taken may be selected by the Contractor as the most advantageous for control. However, the Contractor is responsible for delivering fine aggregate to the mixer within specification limits. When the amount passing on any sieve is outside the specification limits, the fine aggregate shall be immediately resampled and retested. If there is another failure on any sieve, the fact shall be immediately reported to the Contracting Officer, concreting shall be stopped, and immediate steps taken to correct the grading.

3.13.1.2 Coarse Aggregate

At least once during each shift in which the concrete plant is operating, there shall be a sieve analysis in accordance with ASTM C 136 for each size of coarse aggregate. The location at which samples are taken may be selected by the Contractor as the most advantageous for production control. However, the Contractor shall be responsible for delivering the aggregate to the mixer within specification limits. A test record of samples of aggregate taken at the same locations shall show the results of the current test as well as the average results of the five most recent tests including the current test. The Contractor may adopt limits for control coarser than the specification limits for samples taken other than as delivered to the mixer to allow for degradation during handling. When the amount passing any sieve is outside the specification limits, the coarse aggregate shall be immediately resampled and retested. If the second sample fails on any sieve, that fact shall be reported to the Contracting Officer. Where two consecutive averages of 5 tests are outside specification limits, the operation shall be considered out of control and reported to the Contracting Officer. Concreting shall be stopped and immediate steps shall be taken to correct the grading.

3.13.2 Quality of Aggregates

Thirty days prior to the start of concrete placement, perform all tests for aggregate quality required by ASTM C 33/C 33M. In addition, after the start of concrete placement, perform tests for aggregate quality at least every three months, and when the source of aggregate or aggregate quality changes. Samples tested after the start of concrete placement shall be taken immediately prior to entering the concrete mixer.

3.13.3 Scales, Batching and Recording

Check the accuracy of the scales by test weights prior to start of concrete operations and at least once every three months. Such tests shall also be made as directed whenever there are variations in properties of the fresh

concrete that could result from batching errors. Once a week the accuracy of each batching and recording device shall be checked during a weighing operation by noting and recording the required weight, recorded weight, and the actual weight batched. At the same time, test and ensure that the devices for dispensing admixtures are operating properly and accurately. When either the weighing accuracy or batching accuracy does not comply with specification requirements, the plant shall not be operated until necessary adjustments or repairs have been made. Discrepancies in recording accuracies shall be corrected immediately.

3.13.4 Batch-Plant Control

Continuously control the measurement of concrete materials, including cementitious materials, each size of aggregate, water, and admixtures. Adjust the aggregate weights and amount of added water as necessary to compensate for free moisture in the aggregates. The amount of air-entraining agent shall be adjusted to control air content within specified limits. Prepare a report indicating type and source of cement used, type and source of pozzolan or slag used, amount and source of admixtures used, aggregate source, the required aggregate and water weights per cubic meter amount of water as free moisture in each size of aggregate, and the batch aggregate and water weights per cubic meter for each class of concrete batched during each day's plant operation.

3.13.5 Concrete Mixture

a. Air Content Testing. Perform air content tests when test specimens are fabricated. In addition, at least two tests for air content shall be made on randomly selected batches of each separate concrete mixture produced during each 8-hour period of concrete production. Perform additional tests when excessive variation in workability is reported by the placing foreman or Government inspector. Tests shall be made in accordance with ASTM C 231 for normal weight concrete. Plot test results on control charts which shall at all times be readily available to the Government and submitted weekly. Keep copies of the current control charts in the field by testing crews and results plotted as tests are made. When a single test result reaches either the upper or lower action limit, perform a second test immediately. The results of the two tests shall be averaged and this average used as the air content of the batch to plot on both the air content and the control chart for range, and for determining need for any remedial action. The result of each test, or average as noted in the previous sentence, shall be plotted on a separate control chart for each mixture on which an "average line" is set at the midpoint of the specified air content range from paragraph Air Entrainment in PART 1. Set an upper warning limit and a lower warning limit line 1.0 percentage point above and below the average line, respectively. An upper action limit and a lower action limit line shall be set 1.5 percentage points above and below the average line, respectively. The range between each two consecutive tests shall be plotted on a secondary control chart for range where an upper warning limit is set at 2.0 percentage points and an upper action limit is set at 3.0 percentage points. Samples for air content may be taken at the mixer, however, the Contractor is responsible for delivering the concrete to the placement site at the stipulated air content. If the Contractor's materials or transportation methods cause air content loss between the mixer and the placement, correlation samples shall be taken at

the placement site as required by the Contracting Officer, and the air content at the mixer controlled as directed.

b. Air Content Corrective Action. Whenever points on the control chart for percent air reach either warning limit, an adjustment shall immediately be made in the amount of air-entraining admixture batched. As soon as practical after each adjustment, another test shall be made to verify the result of the adjustment. Whenever a point on the secondary control chart for range reaches the warning limit, the admixture dispenser shall be recalibrated to ensure that it is operating accurately and with good reproducibility. Whenever a point on either control chart reaches an action limit line, the air content shall be considered out of control and the concreting operation shall immediately be halted until the air content is under control. Additional air content tests shall be made when concreting is restarted.

c. Slump Testing. In addition to slump tests which are made when test specimens are fabricated, at least four slump tests shall be made on randomly selected batches in accordance with ASTM C 143/C 143M for each separate concrete mixture produced during each 8-hour or less period of concrete production each day. Also, additional tests shall be made when excessive variation in workability is reported by the placing foreman or Government inspector. Plot test results on control charts which shall at all times be readily available to the Government and submitted weekly. Keep copies of the current control charts in the field by testing crews and results plotted as tests are made. When a single slump test reaches or goes beyond either the upper or lower action limit, immediately perform a second test. The results of the two tests shall be averaged and this average used as the slump of the batch to plot on both the control charts for slump and the chart for range, and for determining need for any remedial action. Set limits on separate control charts for slump for each type of mixture. The upper warning limit shall be set at 12.5 mm below the maximum allowable slump specified in paragraph Slump in PART 1 for each type of concrete and an upper action limit line and lower action limit line shall be set at the maximum and minimum allowable slumps, respectively, as specified in the same paragraph. The range between each consecutive slump test for each type of mixture shall be plotted on a single control chart for range on which an upper action limit is set at 50 mm. Take samples for slump at the mixer. However, the Contractor is responsible for delivering the concrete to the placement site at the stipulated slump. If the Contractor's materials or transportation methods cause slump loss between the mixer and the placement, take correlation samples at the placement site as required by the Contracting Officer, and the slump at the mixer controlled as directed.

d. Slump Corrective Action. Whenever points on the control charts for slump reach the upper warning limit, make an adjustment immediately in the batch weights of water and fine aggregate. The adjustments are to be made so that the total water content does not exceed that amount allowed by the maximum w/c ratio specified, based on aggregates which are in a saturated surface dry condition. When a single slump reaches the upper or lower action limit, no further concrete shall be delivered to the placing site until proper adjustments have been made. Immediately after each

adjustment, another test shall be made to verify the correctness of the adjustment. Whenever two consecutive individual slump tests, made during a period when there was no adjustment of batch weights, produce a point on the control chart for range at or above the upper action limit, halt the concreting operation immediately, and take appropriate steps to bring the slump under control. Additional slump tests shall be made as directed.

e. Temperature. Measure the temperature of the concrete when compressive strength specimens are fabricated in accordance with ASTM C 1064/C 1064M. Report the temperature along with the compressive strength data.

f. Strength Specimens. Perform at least one set of test specimens, for compressive or flexural strength as appropriate, on each different concrete mixture placed during the day for each 380 cubic meters or portion thereof of that concrete mixture placed each day. Perform additional sets of test specimens, as directed by the Contracting Officer, when the mixture proportions are changed or when low strengths have been detected. Develop a truly random (not haphazard) sampling plan for approval by the Contracting Officer prior to the start of construction. The plan shall ensure that sampling is done in a completely random and unbiased manner. A set of test specimens for concrete with a 28-day specified strength in accordance with paragraph Strength Requirements in PART 1 shall consist of four specimens, two to be tested at 7 days and two at 28 days. Test specimens shall be molded and cured in accordance with ASTM C 31/C 31M and tested in accordance with ASTM C 39/C 39M for test cylinders and ASTM C 78 for test beams. Results of all strength tests shall be reported immediately to the Contracting Officer. Quality control charts shall be kept for individual strength "tests", ("test" as defined in paragraph Strength Requirements in PART 1) moving average of last 3 "tests" for strength, and moving average for range for the last 3 "tests" for each mixture. The charts shall be similar to those found in ACI 214R.

3.13.6 Inspection Before Placing

Inspect foundations, construction joints, forms, and embedded items in sufficient time prior to each concrete placement in order to certify to the Contracting Officer that they are ready to receive concrete. Report the results of each inspection in writing.

3.13.7 Placing

The placing foreman shall supervise placing operations, shall determine that the correct quality of concrete or grout is placed in each location as specified and as directed by the Contracting Officer, and shall be responsible for measuring and recording concrete temperatures and ambient temperature hourly during placing operations, weather conditions, time of placement, volume placed, and method of placement. The placing foreman shall not permit batching and placing to begin until it has been verified that an adequate number of vibrators in working order and with competent operators are available. Placing shall not be continued if any pile of concrete is inadequately consolidated. If any batch of concrete fails to meet the temperature requirements, immediate steps shall be taken to improve temperature controls.

3.13.8 Vibrators

Determine the frequency and amplitude of each vibrator in accordance with COE CRD-C 521 prior to initial use and at least once a month when concrete is being placed. Perform additional tests as directed when a vibrator does not appear to be adequately consolidating the concrete. The frequency shall be determined while the vibrator is operating in concrete with the tachometer being held against the upper end of the vibrator head while almost submerged and just before the vibrator is withdrawn from the concrete. Determine the amplitude with the head vibrating in air. Take two measurements, one near the tip and another near the upper end of the vibrator head, and these results averaged. Report the make, model, type, and size of the vibrator and frequency and amplitude results in writing. Any vibrator not meeting the requirements of paragraph Consolidation above, shall be immediately removed from service and repaired or replaced.

3.13.9 Curing Inspection

a. Moist Curing Inspections. At least once each shift, and not less than twice per day on both work and non-work days, an inspection shall be made of all areas subject to moist curing. The surface moisture condition shall be noted and recorded.

b. Moist Curing Corrective Action. When a daily inspection report lists an area of inadequate curing, immediate corrective action shall be taken, and the required curing period for those areas shall be extended by 1 day.

c. Membrane Curing Inspection. No curing compound shall be applied until the Contractor has verified that the compound is properly mixed and ready for spraying. At the end of each operation, estimate the quantity of compound used by measurement of the container and the area of concrete surface covered, compute the rate of coverage in square meters/L, and note whether or not coverage is uniform.

d. Membrane Curing Corrective Action. When the coverage rate of the curing compound is less than that specified or when the coverage is not uniform, the entire surface shall be sprayed again.

e. Sheet Curing Inspection. At least once each shift and once per day on non-work days, an inspection shall be made of all areas being cured using impervious sheets. The condition of the covering and the tightness of the laps and tapes shall be noted and recorded.

f. Sheet Curing Corrective Action. When a daily inspection report lists any tears, holes, or laps or joints that are not completely closed, the tears and holes shall promptly be repaired or the sheets replaced, the joints closed, and the required curing period for those areas shall be extended by 1 day.

3.13.10 Cold-Weather Protection

At least once each shift and once per day on non-work days, an inspection shall be made of all areas subject to cold-weather protection. Any deficiencies shall be noted, corrected, and reported.

3.13.11 Mixer Uniformity

a. Stationary Mixers. Prior to the start of concrete placing and once every 6 months when concrete is being placed, or once for every 60,000 cubic meters of concrete placed, whichever results in the shortest time interval, uniformity of concrete mixing shall be determined in accordance with ASTM C 94/C 94M.

b. Truck Mixers. Prior to the start of concrete placing and at least once every 6 months when concrete is being placed, uniformity of concrete mixing shall be determined in accordance with ASTM C 94/C 94M. Select the truck mixers randomly for testing. When satisfactory performance is found in one truck mixer, the performance of mixers of substantially the same design and condition of the blades may be regarded as satisfactory.

c. Mixer Uniformity Corrective Action. When a mixer fails to meet mixer uniformity requirements, either the mixing time shall be increased, batching sequence changed, batch size reduced, or adjustments shall be made to the mixer until compliance is achieved.

3.13.12 Reports

Report all results of tests or inspections conducted, informally as they are completed and in writing daily. Prepare a weekly report for the updating of control charts covering the entire period from the start of the construction season through the current week. During periods of cold-weather protection, reports of pertinent temperatures shall be made daily. These requirements do not relieve the Contractor of the obligation to report certain failures immediately as required in preceding paragraphs. Such reports of failures and the action taken shall be confirmed in writing in the routine reports. The Contracting Officer has the right to examine all contractor quality control records.

-- End of Section --

SECTION 04 20 00

MASONRY

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACI INTERNATIONAL (ACI)

ACI 530/530.1	(2008; Errata 2008; Errata 2009) Building Code Requirements and Specification for Masonry Structures and Related Commentaries
ACI SP-66	(2004) ACI Detailing Manual

ASTM INTERNATIONAL (ASTM)

ASTM A 153/A 153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 615/A 615M	(2009b) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A 641/A 641M	(2009a) Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A 82/A 82M	(2007) Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
ASTM C 1019	(2009) Standard Test Method for Sampling and Testing Grout
ASTM C 270	(2008a) Standard Specification for Mortar for Unit Masonry
ASTM C 476	(2009) Standard Specification for Grout for Masonry
ASTM C 494/C 494M	(2008a) Standard Specification for Chemical Admixtures for Concrete
ASTM C 593	(2006) Fly Ash and Other Pozzolans for Use with Lime for Soil Stabilization
ASTM C 780	(2009) Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry
ASTM C 90	(2009) Loadbearing Concrete Masonry Units

ASTM C 94/C 94M	(2009a) Standard Specification for Ready-Mixed Concrete
ASTM D 2000	(2008) Standard Classification System for Rubber Products in Automotive Applications
ASTM D 2240	(2005) Standard Test Method for Rubber Property - Durometer Hardness
ASTM D 2287	(1996; R 2001) Nonrigid Vinyl Chloride Polymer and Copolymer Molding and Extrusion Compounds

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2009; Errata First Printing) International Building Code

1.2 SYSTEM DESCRIPTION

1.2.1 Design Requirements

1.2.1.1 Unit Strength Method

Compute compressive strength of masonry system "Unit Strength Method", ACI 530/530.1. Submit calculations and certifications of unit and mortar strength.

1.2.1.2 Seismic Requirement

In addition to design requirements of ICC IBC, provide additional seismic reinforcement as detailed on the drawings. The total minimum reinforcing percentage for structural walls shall be 0.20 percent.

1.2.1.3 Masonry Strength

Determine masonry strength in accordance with ACI 530/530.1; submit test reports on three prisms as specified in ACI 530/530.1. The cost of testing shall be paid by the Contractor.

1.2.2 Additional Requirements

a. Maintain at least one spare vibrator on site at all times.

b. Provide bracing and scaffolding necessary for masonry work. Design bracing to resist wind pressure as required by local code.

1.3 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.

SD-02 Shop Drawings

Detail Drawings

SD-03 Product Data

Concrete Masonry Units (CMU)
Cement

Cold Weather Installation

SD-04 Samples

Concrete Masonry Units (CMU)
Anchors, Ties, and Bar Positioners
Expansion-Joint Materials

SD-05 Design Data

Pre-mixed Mortar
Unit Strength Method

SD-06 Test Reports

Prism tests

SD-07 Certificates

Concrete Masonry Units (CMU)
Anchors, Ties, and Bar Positioners
Expansion-Joint Materials
Reinforcing Steel Bars and Rods
Masonry Cement
Precast Concrete Items

SD-08 Manufacturer's Instructions

Masonry Cement

SD-10 Operation and Maintenance Data

Plastic Identification

1.4 QUALITY ASSURANCE

1.4.1 Detail Drawings

Submit detail drawings showing bar splice locations. Bent bars shall be identified on a bending diagram and shall be referenced and located on the drawings. Wall dimensions, bar clearances, and wall openings greater than one masonry unit in area shall be shown. Shop drawings shall include all openings, including those for mechanical and electrical service, are shown. The minimum scale for wall elevations shall be 1 to 50. Reinforcement bending details shall conform to the requirements of ACI SP-66. Submit drawings including plans, elevations, and details of wall reinforcement; details of reinforcing bars at corners and wall intersections; offsets; tops, bottoms, and ends of walls; control and expansion joints; lintels; and wall openings.

1.5 DELIVERY, STORAGE, AND HANDLING

Materials shall be delivered, stored, handled, and protected to avoid chipping, breakage, and contact with soil or contaminating material. Store and prepare materials in already disturbed areas to minimize project site disturbance and size of project site.

1.5.1 Masonry Units

Cover and protect concrete masonry units and cementitious materials from precipitation. Conform to all handling and storage requirements of ASTM C 90.

1.5.2 Reinforcement, Anchors, and Ties

Steel reinforcing bars, coated anchors, and ties shall be stored above the ground. Steel reinforcing bars and uncoated ties shall be free of loose mill scale and rust.

1.5.3 Cementitious Materials, Sand and Aggregates

Cementitious and other packaged materials shall be delivered in unopened containers, plainly marked and labeled with manufacturers' names and brands. Cementitious material shall be stored in dry, weathertight enclosures or be completely covered. Cement shall be handled in a manner that will prevent the inclusion of foreign materials and damage by water or dampness. Store sand and aggregates in a manner to prevent contamination or segregation.

1.6 PROJECT/SITE CONDITIONS

Conform to ACI 530/530.1 for hot and cold weather masonry erection.

1.6.1 Hot Weather Installation

Take the following precautions if masonry is erected when the ambient air temperature is more than 37 degrees C in the shade and the relative humidity is less than 50 percent or the ambient air temperature exceeds 32 degrees C and the wind velocity is more than 13 km/h. All masonry materials shall be shaded from direct sunlight; mortar beds shall be spread no more than 1.2 m ahead of masonry; masonry units shall be set within one minute of spreading mortar; and after erection, masonry shall be protected from direct exposure to wind and sun for 48 hours.

1.6.2 Cold Weather Installation

Before erecting masonry when ambient temperature or mean daily air temperature falls below 4 degrees C or temperature of masonry units is below 4 degrees C, submit a written statement of proposed cold weather construction procedures for approval.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

The source of materials which will affect the appearance of the finished work shall not be changed after the work has started except with USAID Implementing Partner's approval. Submit test reports from an approved independent laboratory. Test reports on a previously tested material shall be certified as the same as that proposed for use in this project. Submit certificates of compliance stating that the materials meet the specified requirements.

2.2 CONCRETE MASONRY UNITS (CMU)

Cement shall have a low alkali content and be of one brand. Units shall be of modular dimensions and air, water, or steam cured. Surfaces of units which are to be plastered or stuccoed shall be sufficiently rough to provide bond.

a. Hollow Load-Bearing Units: ASTM C 90, made with normal weight aggregate. Provide load-bearing units for exterior walls, foundation walls, load-bearing walls, and shear walls.

2.3 PRECAST CONCRETE ITEMS

Splashblocks shall be factory-made units from a plant regularly engaged in producing precast concrete units. Unless otherwise indicated, concrete shall be 28 MPa minimum conforming to Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE using 13 mm to No. 4 nominal-size coarse aggregate, and minimum reinforcement shall be the reinforcement required for handling of the units. Clearance of 19 mm shall be maintained between reinforcement and faces of units. Unless precast-concrete items have been subjected during manufacture to saturated-steam pressure of at least 827 kPa for at least 5 hours, the items, after casting, shall be either damp-cured for 24 hours or steam-cured and shall then be aged under cover for 28 days or longer. Cast-concrete members weighing over 35 kg shall have built-in loops of galvanized wire or other approved provisions for lifting and anchoring. Units shall have beds and joints at right angles to the face, with sharp true arises and shall be cast with drip grooves on the underside where units overhang walls. Exposed-to-view surfaces shall be free of surface voids, spalls, cracks, and chipped or broken edges. Precast units exposed-to-view shall be of uniform appearance and color. Unless otherwise specified, units shall have a smooth dense finish. Prior to use, each item shall be wetted and inspected for crazing. Items showing evidence of dusting, spalling, crazing, or having surfaces treated with a protective coating will be rejected.

2.3.1 Splash Blocks

Splash blocks shall be as detailed. Reinforcement shall be the manufacturer's standard.

2.4 MORTAR FOR STRUCTURAL MASONRY

ASTM C 270, Type S. Strength (f'm) as indicated. Test in accordance with ASTM C 780. Use Type I portland cement. Do not use admixtures containing chlorides. When structural reinforcement is incorporated, maximum air-content shall be 12 percent in cement-lime mortar and 18 percent in masonry cement mortar. Use up to 40 percent Class F fly ash with type IP cement in cement-lime mortar. Fly ash shall comply with ASTM C 593.

2.5 GROUT AND READY-MIXED GROUT

Grout shall conform to ASTM C 476, fine. Cement used in grout shall have a low alkali content. Grout slump shall be between 200 and 250 mm. Minimum grout strength shall be 14 MPa in 28 days, as tested by ASTM C 1019. Grout shall be used subject to the limitations of Table III. Proportions shall not be changed and materials with different physical or chemical characteristics shall not be used in grout for the work unless additional evidence is furnished that the grout meets the specified requirements. Ready-Mixed grout shall conform to ASTM C 94/C 94M.

2.5.1 Admixtures for Grout

In cold weather, a non-chloride based accelerating admixture may be used subject to approval; accelerating admixture shall be non-corrosive, shall contain less than 0.2 percent chlorides, and shall conform to ASTM C 494/C 494M, Type C. In general, air-entrainment, anti-freeze or chloride admixtures shall not be used except as approved by the USAID Implementing Partner.

2.5.2 Grout Barriers

Grout barriers for vertical cores shall consist of fine mesh wire, fiberglass, or expanded metal.

2.6 TIES, AND BAR POSITIONERS

Ties shall be fabricated without drips or crimps and shall be zinc-coated in accordance with ASTM A 153/A 153M, Class B-2. Steel wire used for anchors and ties shall be fabricated from steel wire conforming to ASTM A 82/A 82M. Wire ties in exterior walls shall conform to ASTM A 641/A 641M. Ties shall be sized to provide a minimum of 16 mm mortar cover from either face. Submit two anchors, ties and bar positioners of each type used, as samples.

2.6.1 Wall Ties

Wall ties shall be rectangular-shaped or Z-shaped fabricated of 5 mm diameter zinc-coated steel wire. Rectangular wall ties shall be no less than 100 mm wide. Adjustable type wall ties, if approved for use, shall consist of two essentially U-shaped elements fabricated of 5 mm diameter zinc-coated steel wire. Adjustable ties shall be of the double pintle to eye type and shall allow a maximum of 13 mm eccentricity between each element of the tie. Play between pintle and eye opening shall be not more than 2 mm. The pintle and eye elements shall be formed so that both can be in the same plane.

2.6.2 Bar Positioners

Bar positioners, used to prevent displacement of reinforcing bars during the course of construction, shall be factory fabricated from 9 gauge steel wire or equivalent, and coated with a hot-dip galvanized finish. Not more than one wire shall cross the cell.

2.7 REINFORCING STEEL BARS AND RODS

Reinforcing steel bars and rods shall conform to ASTM A 615/A 615M, Grade 60.

2.8 CONTROL JOINT KEYS

Control joint keys shall be a factory fabricated solid section of natural or synthetic rubber (or combination thereof) conforming to ASTM D 2000or polyvinyl chloride conforming to ASTM D 2287. The material shall be resistant to oils and solvents. The control joint key shall be provided with a solid shear section not less than 16 mm thick and 10 mm thick flanges, with a tolerance of plus or minus 2 mm. The control joint key shall fit neatly, but without forcing, in masonry unit jamb sash grooves. The control joint key shall be flexible at a temperature of minus 34

degrees C after five hours exposure, and shall have a durometer hardness of not less than 70 when tested in accordance with ASTM D 2240.

2.9 EXPANSION-JOINT MATERIALS

Backer rod and sealant shall be adequate to accommodate joint compression equal to 50 percent of the width of the joint. The backer rod shall be compressible rod stock of polyethylene foam, polyurethane foam, butyl rubber foam, or other flexible, nonabsorptive material as recommended by the sealant manufacturer. Sealant shall conform to Section 07 92 00 JOINT SEALANTS, and shall be penetrating. Submit one piece of each type of material used.

PART 3 EXECUTION

3.1 PREPARATION

Prior to start of work, masonry inspector shall verify the applicable conditions as set forth in ACI 530/530.1, inspection. The Contracting Officer will serve as inspector or will select a masonry inspector.

3.1.1 Protection

Ice or snow formed on the masonry bed shall be thawed by the application of heat. Heat shall be applied carefully until the top surface of the masonry is dry to the touch. Sections of masonry deemed frozen and damaged shall be removed before continuing construction of those sections.

a. Air Temperature 4 to 0 degrees C. Sand or mixing water shall be heated to produce mortar temperatures between 4 and 49 degrees C

b. Air Temperature 0 to minus 4 degrees C. Sand and mixing water shall be heated to produce mortar temperatures between 4 and 49 degrees C. Temperature of mortar on boards shall be maintained above freezing.

c. Air Temperature minus 4 to minus 7 degrees C. Sand and mixing water shall be heated to provide mortar temperatures between 4 and 49 degrees C. Temperature of mortar on boards shall be maintained above freezing. Sources of heat shall be used on both sides of walls under construction. Windbreaks shall be employed when wind is in excess of 24 km/hour.

d. Air Temperature minus 7 degrees C and below. Sand and mixing water shall be heated to provide mortar temperatures between 4 and 49 degrees C. Enclosure and auxiliary heat shall be provided to maintain air temperature above 0 degrees C. Temperature of units when laid shall not be less than minus 7 degrees C.

3.1.2 Completed Masonry and Masonry Not Being Worked On

a. Mean daily air temperature 4 to 0 degrees C. Masonry shall be protected from rain or snow for 24 hours by covering with weather-resistive membrane.

b. Mean daily air temperature 0 to minus 4 degrees C. Masonry shall be completely covered with weather-resistant membrane for 24 hours.

c. Mean Daily Air Temperature minus 4 to minus 7 degrees C. Masonry shall be completely covered with insulating blankets or equally

protected for 24 hours.

d. Mean Daily Temperature minus 7 degrees C and Below. Masonry temperature shall be maintained above 0 degrees C for 24 hours by enclosure and supplementary heat, by electric heating blankets, infrared heat lamps, or other approved methods.

3.1.3 Stains

Protect exposed surfaces from mortar and other stains. When mortar joints are tooled, remove mortar from exposed surfaces with fiber brushes and wooden paddles. Protect base of walls from splash stains by covering adjacent ground with sand, sawdust, or polyethylene.

3.1.4 Loads

Do not apply uniform loads for at least 12 hours or concentrated loads for at least 72 hours after masonry is constructed. Provide temporary bracing as required.

3.1.5 Surfaces

Surfaces on which masonry is to be placed shall be cleaned of laitance, dust, dirt, oil, organic matter, or other foreign materials and shall be slightly roughened to provide a surface texture with a depth of at least 3 mm. Sandblasting shall be used, if necessary, to remove laitance from pores and to expose the aggregate.

3.2 LAYING MASONRY UNITS

a. Coordinate masonry work with the work of other trades to accommodate built-in items and to avoid cutting and patching. Masonry units shall be laid in running bond pattern. Facing courses shall be level with back-up courses, unless the use of adjustable ties has been approved in which case the tolerances shall be plus or minus 13 mm. Each unit shall be adjusted to its final position while mortar is still soft and plastic.

b. Units that have been disturbed after the mortar has stiffened shall be removed, cleaned, and relaid with fresh mortar. Air spaces, cavities, chases, expansion joints, and spaces to be grouted shall be kept free from mortar and other debris. Units used in exposed masonry surfaces shall be selected from those having the least amount of chipped edges or other imperfections detracting from the appearance of the finished work. Vertical joints shall be kept plumb.

c. Units being laid and surfaces to receive units shall be free of water film and frost. Solid units shall be laid in a nonfurrowed full bed of mortar. Mortar for veneer wythes shall be beveled and sloped toward the center of the wythe from the cavity side. Units shall be shoved into place so that the vertical joints are tight. Vertical joints of brick and the vertical face shells of concrete masonry units, except where indicated at control, expansion, and isolation joints, shall be completely filled with mortar. Mortar will be permitted to protrude up to 13 mm into the space or cells to be grouted. Means shall be provided to prevent mortar from dropping into the space below.

d. In double wythe construction, the inner wythe may be brought up not more than 400 mm ahead of the outer wythe. Collar joints shall be

filled with mortar or grout during the laying of the facing wythe, and filling shall not lag the laying of the facing wythe by more than 200 m.

3.2.1 Forms and Shores

Provide bracing and scaffolding as required. Design bracing to resist wind pressure as required by local codes. Forms and shores shall be sufficiently rigid to prevent deflections which may result in cracking or other damage to supported masonry and sufficiently tight to prevent leakage of mortar and grout. Supporting forms and shores shall not be removed in less than 10 days.

3.2.2 Reinforced Concrete Masonry Units Walls

Where vertical reinforcement occurs, fill cores solid with grout. Lay units in such a manner as to preserve the unobstructed vertical continuity of cores to be filled. Embed the adjacent webs in mortar to prevent leakage of grout. Remove mortar fins protruding from joints before placing grout. Minimum clear dimensions of vertical cores shall be 50 by 75 mm. Position reinforcing accurately as indicated before placing grout. As masonry work progresses, secure vertical reinforcing in place at vertical intervals not to exceed 160 bar diameters. Use puddling rod or vibrator to consolidate the grout. Minimum clear distance between masonry and vertical reinforcement shall be not less than 13 mm. Unless indicated or specified otherwise, form splices by lapping bars not less than 40 bar diameters and wire tying them together.

3.2.3 Concrete Masonry Units

Units in piers, pilasters, columns, starting courses on footings, solid foundation walls, lintels, and beams, and where cells are to be filled with grout shall be full bedded in mortar under both face shells and webs. Other units shall be full bedded under both face shells. Head joints shall be filled solidly with mortar for a distance in from the face of the unit not less than the thickness of the face shell. Foundation walls below grade shall be grouted solid. Jamb units shall be of the shapes and sizes to conform with wall units. Solid units may be incorporated in the masonry work where necessary to fill out at corners, gable slopes, and elsewhere as approved. Double walls shall be stiffened at wall-mounted plumbing fixtures by use of strap anchors, two above each fixture and two below each fixture, located to avoid pipe runs, and extending from center to center of the double wall. Walls and partitions shall be adequately reinforced for support of wall-hung plumbing fixtures when chair carriers are not specified.

3.2.4 Tolerances

Masonry shall be laid plumb, true to line, with courses level. Bond pattern shall be kept plumb throughout. Corners shall be square unless noted otherwise. Except for walls constructed of prefaced concrete masonry units, masonry shall be laid within the following tolerances (plus or minus unless otherwise noted):

TABLE II

TOLERANCES

Variation from the plumb in the lines
and surfaces of columns, walls and arises

TOLERANCES

In adjacent masonry units	3 mm
In 3 m	6 mm
In 6 m	10 mm
In 12 m or more	13 mm
Variations from the plumb for external corners, expansion joints, and other conspicuous lines	
In 6 m	6 mm
In 12 m or more	13 mm
Variations from the level for exposed lintels, sills, parapets, horizontal grooves, and other conspicuous lines	
In 6 m	6 mm
In 12 m or more	13 mm
Variation from level for bed joints and top surfaces of bearing walls	
In 3 m	6 mm
In 12 m or more	13 mm
Variations from horizontal lines	
In 3 m	6 mm
In 6 m	10 mm
In 12 m or more	13 mm
Variations in cross sectional dimensions of columns and in thickness of walls	
Minus	6 mm
Plus	13 mm

3.2.5 Cutting and Fitting

Full units of the proper size shall be used wherever possible, in lieu of cut units. Cutting and fitting, including that required to accommodate the work of others, shall be done by masonry mechanics using power masonry saws. Concrete masonry units may be wet or dry cut. Wet cut units, before being placed in the work, shall be dried to the same surface-dry appearance as uncut units being laid in the wall. Cut edges shall be clean, true and sharp. Openings in the masonry shall be made carefully so that wall plates, cover plates or escutcheons required by the installation will completely conceal the openings and will have bottoms parallel with the masonry bed joints. Reinforced masonry lintels shall be provided above openings over 300 mm wide for pipes, ducts, cable trays, and other wall penetrations, unless steel sleeves are used.

3.2.6 Jointing

Joints shall be tooled when the mortar is thumbprint hard. Horizontal joints shall be tooled last. Joints shall be brushed to remove all loose and excess mortar. Mortar joints shall be finished as follows:

3.2.6.1 Flush Joints

Joints in concealed masonry surfaces and joints at electrical outlet boxes in wet areas shall be flush cut. Flush cut joints shall be made by cutting off the mortar flush with the face of the wall. Joints in unparged masonry walls below grade shall be pointed tight. Flush joints for architectural units, such as fluted units, shall completely fill both the head and bed joints.

3.2.6.2 Tooled Joints

Joints in exposed exterior and interior masonry surfaces shall be tooled slightly concave. Joints shall be tooled with a jointer slightly larger than the joint width so that complete contact is made along the edges of the unit. Tooling shall be performed so that the mortar is compressed and the joint surface is sealed. Jointer of sufficient length shall be used to obtain a straight and true mortar joint.

3.2.6.3 Door and Window Frame Joints

On the exposed interior side of exterior frames, joints between frames and abutting masonry walls shall be raked to a depth of 10 mm. On the exterior side of exterior frames, joints between frames and abutting masonry walls shall be raked to a depth of 10 mm.

3.2.7 Joint Widths

Joint widths shall be as follows:

3.2.7.1 Concrete Masonry Units

Concrete masonry units shall have 10 mm joints.

3.2.8 Embedded Items

Spaces around built-in items shall be filled with mortar. Openings around flush-mount electrical outlet boxes in wet locations shall be pointed with mortar. Anchors, ties, wall plugs, accessories, flashing, pipe sleeves and other items required to be built-in shall be embedded as the masonry work progresses. Anchors, ties and joint reinforcement shall be fully embedded in the mortar. Cells receiving anchor bolts and cells of the first course below bearing plates shall be filled with grout.

3.2.9 Unfinished Work

Unfinished work shall be stepped back for joining with new work. Toothing may be resorted to only when specifically approved. Loose mortar shall be removed and the exposed joints shall be thoroughly cleaned before laying new work.

3.2.10 Masonry Wall Intersections

Each course shall be masonry bonded at corners and elsewhere as shown. Masonry walls shall be anchored or tied together at corners and intersections with bond beam reinforcement and prefabricated corner or tee pieces of joint reinforcement as shown.

3.3 MORTAR MIX

Mortar shall be mixed in a mechanically operated mortar mixer for at least 3 minutes, but not more than 5 minutes. Measurement of ingredients for mortar shall be by volume. Ingredients not in containers, such as sand, shall be accurately measured by the use of measuring boxes. Water shall be mixed with the dry ingredients in sufficient amount to provide a workable mixture which will adhere to the vertical surfaces of masonry units. Mortar that has stiffened because of loss of water through evaporation shall be retempered by adding water to restore the proper consistency and workability. Mortar that has reached its initial set or that has not been used within 2.5 hours after mixing shall be discarded.

3.4 REINFORCING STEEL

Reinforcement shall be cleaned of loose, flaky rust, scale, grease, mortar, grout, or other coating which might destroy or reduce its bond prior to placing grout. Bars with kinks or bends not shown on the drawings shall not be used. Reinforcement shall be placed prior to grouting. Unless otherwise indicated, vertical wall reinforcement shall extend to within 50 mm of tops of walls.

3.4.1 Positioning Bars

Vertical bars shall be accurately placed within the cells at the positions indicated on the drawings. A minimum clearance of 13 mm shall be maintained between the bars and masonry units. Minimum clearance between parallel bars shall be one diameter of the reinforcement. Vertical reinforcing may be held in place using bar positioners located near the ends of each bar and at intermediate intervals of not more than 192 diameters of the reinforcement. Column and pilaster ties shall be wired in position around the vertical steel. Ties shall be in contact with the vertical reinforcement and shall not be placed in horizontal bed joints.

3.4.2 Splices

Bars shall be lapped a minimum of 48 diameters of the reinforcement. Welded or mechanical connections shall develop at least 125 percent of the specified yield strength of the reinforcement.

3.5 PLACING GROUT

Cells containing reinforcing bars shall be filled with grout. Hollow masonry units in walls or partitions supporting plumbing, heating, or other mechanical fixtures, voids at door and window jambs, and other indicated spaces shall be filled solid with grout. Cells under lintel bearings on each side of openings shall be filled solid with grout for full height of openings. Walls below grade, lintels, and bond beams shall be filled solid with grout. Units other than open end units may require grouting each course to preclude voids in the units. Grout not in place within 1-1/2 hours after water is first added to the batch shall be discarded. Sufficient time shall be allowed between grout lifts to preclude

displacement or cracking of face shells of masonry units. If blowouts, flowouts, misalignment, or cracking of face shells should occur during construction, the wall shall be torn down and rebuilt.

3.5.1 Vertical Grout Barriers for Fully Grouted Walls

Grout barriers shall be provided not more than 10 m apart, or as required, to limit the horizontal flow of grout for each pour.

3.5.2 Horizontal Grout Barriers

Grout barriers shall be embedded in mortar below cells of hollow units receiving grout.

3.5.3 Grout Holes and Cleanouts

3.5.3.1 Grout Holes

Grouting holes shall be provided in slabs, spandrel beams, and other in-place overhead construction. Holes shall be located over vertical reinforcing bars or as required to facilitate grout fill in bond beams. Additional openings spaced not more than 400 mm on centers shall be provided where grouting of all hollow unit masonry is indicated. Openings shall not be less than 100 mm in diameter or 75 by 100 mm in horizontal dimensions. Upon completion of grouting operations, grouting holes shall be plugged and finished to match surrounding surfaces.

3.5.3.2 Cleanouts for Hollow Unit Masonry Construction

Cleanout holes shall be provided at the bottom of every pour in cores containing vertical reinforcement when the height of the grout pour exceeds 1.5 m. Where all cells are to be grouted, cleanout courses shall be constructed using bond beam units in an inverted position to permit cleaning of all cells. Cleanout holes shall be provided at a maximum spacing of 800 mm where all cells are to be filled with grout. A new series of cleanouts shall be established if grouting operations are stopped for more than 4 hours. Cleanouts shall not be less than 75 by 100 mm openings cut from one face shell. Manufacturer's standard cutout units may be used at the Contractor's option. Cleanout holes shall not be closed until masonry work, reinforcement, and final cleaning of the grout spaces have been completed and inspected. For walls which will be exposed to view, cleanout holes shall be closed in an approved manner to match surrounding masonry.

3.5.4 Grouting Equipment

3.5.4.1 Grout Pumps

Pumping through aluminum tubes will not be permitted. Pumps shall be operated to produce a continuous stream of grout without air pockets, segregation, or contamination. Upon completion of each day's pumping, waste materials and debris shall be removed from the equipment, and disposed of outside the masonry.

3.5.4.2 Vibrators

Internal vibrators shall maintain a speed of not less than 5,000 impulses per minute when submerged in the grout. At least one spare vibrator shall be maintained at the site at all times. Vibrators shall be applied at

uniformly spaced points not further apart than the visible effectiveness of the machine. Duration of vibration shall be limited to time necessary to produce satisfactory consolidation without causing segregation.

3.5.5 Grout Placement

Masonry shall be laid to the top of a pour before placing grout. Grout shall not be placed in two-wythe solid unit masonry cavity until mortar joints have set for at least 3 days during hot weather and 5 days during cold damp weather. Grout shall not be placed in hollow unit masonry until mortar joints have set for at least 24 hours. Grout shall be placed using a hand bucket, concrete hopper, or grout pump to completely fill the grout spaces without segregation of the aggregates. Vibrators shall not be inserted into lower pours that are in a semi-solidified state. The height of grout pours and type of grout used shall be limited by the dimensions of grout spaces as indicated in Table III. Low-lift grout methods may be used on pours up to and including 1.5 m in height. High-lift grout methods shall be used on pours exceeding 1.5 m in height.

3.5.5.1 Low-Lift Method

Grout shall be placed at a rate that will not cause displacement of the masonry due to hydrostatic pressure of the grout. Mortar protruding more than 13 mm into the grout space shall be removed before beginning the grouting operation. Grout pours 300 mm or less in height shall be consolidated by mechanical vibration or by puddling. Grout pours over 300 mm in height shall be consolidated by mechanical vibration and reconsolidated by mechanical vibration after initial water loss and settlement has occurred. Vibrators shall not be inserted into lower pours that are in a semi-solidified state. Low-lift grout shall be used subject to the limitations of Table III.

3.5.5.2 High-Lift Method

Mortar droppings shall be cleaned from the bottom of the grout space and from reinforcing steel. Mortar protruding more than 6 mm into the grout space shall be removed by dislodging the projections with a rod or stick as the work progresses. Reinforcing, bolts, and embedded connections shall be rigidly held in position before grouting is started. CMU units shall not be pre-wetted. Grout, from the mixer to the point of deposit in the grout space shall be placed as rapidly as practical by pumping and placing methods which will prevent segregation of the mix and cause a minimum of grout splatter on reinforcing and masonry surfaces not being immediately encased in the grout lift. The individual lifts of grout shall be limited to 1.2 m in height. The first lift of grout shall be placed to a uniform height within the pour section and vibrated thoroughly to fill all voids. This first vibration shall follow immediately behind the pouring of the grout using an approved mechanical vibrator. After a waiting period sufficient to permit the grout to become plastic, but before it has taken any set, the succeeding lift shall be poured and vibrated 300 to 450 mm into the preceding lift. If the placing of the succeeding lift is going to be delayed beyond the period of workability of the preceding, each lift shall be reconsolidated by reworking with a second vibrator as soon as the grout has taken its settlement shrinkage. The waiting, pouring, and reconsolidation steps shall be repeated until the top of the pour is reached. The top lift shall be reconsolidated after the required waiting period. The high-lift grouting of any section of wall between vertical grout barriers shall be completed to the top of a pour in one working day unless a new series of cleanout holes is established and the resulting

horizontal construction joint cleaned. High-lift grout shall be used subject to the limitations in Table III.

TABLE III

POUR HEIGHT AND TYPE OF GROUT FOR VARIOUS GROUT SPACE DIMENSIONS

Maximum Grout Pour Height (m) (4)	Grout Type	Grouting Procedure	Minimum Dimensions of the Total Clear Areas Within Grout Spaces and Cells (mm) (1,2) Multiwythe Masonry (3)	Hollow-unit Masonry
0.3	Fine	Low Lift	20	40 x 50
1.5	Fine	Low Lift	50	50 x 75
2.4	Fine	High Lift	50	50 x 75
3.6	Fine	High Lift	65	65 x 75
7.3	Fine	High Lift	75	75 x 75

Notes:

(1) The actual grout space or cell dimension shall be larger than the sum of the following items:

a) The required minimum dimensions of total clear areas given in the table above;

b) The width of any mortar projections within the space;

c) The horizontal projections of the diameters of the horizontal reinforcing bars within a cross section of the grout space or cell.

(2) The minimum dimensions of the total clear areas shall be made up of one or more open areas, with at least one area being 20 mm or greater in width.

(3) For grouting spaces between masonry wythes.

(4) Where only cells of hollow masonry units containing reinforcement are grouted, the maximum height of the pour shall not exceed the distance between horizontal bond beams.

3.6 CONTROL JOINTS

Control joints shall be provided as indicated and shall be constructed by using in accordance with the details shown on the drawings. Sash jamb units shall have a 19 by 19 mm groove near the center at end of each unit. The vertical mortar joint at control joint locations shall be continuous, including through all bond beams. This shall be accomplished by utilizing half blocks in alternating courses on each side of the joint. The control joint key shall be interrupted in courses containing continuous bond beam steel. In single wythe exterior masonry walls, the exterior control joints shall be raked to a depth of 19 mm; backer rod and sealant shall be installed in accordance with Section 07 92 00 JOINT SEALANTS. Exposed interior control joints shall be raked to a depth of 6 mm. Concealed control joints shall be flush cut.

3.7 SPLASH BLOCKS

Splash blocks shall be located as shown.

3.8 POINTING AND CLEANING

After mortar joints have attained their initial set, but prior to hardening, completely remove mortar and grout daubs or splashings from masonry-unit surfaces that will be exposed or painted. Before completion of the work, defects in joints of masonry to be exposed or painted shall be raked out as necessary, filled with mortar, and tooled to match existing joints. Immediately after grout work is completed, scum and stains which have percolated through the masonry work shall be removed using a high pressure stream of water and a stiff bristled brush. Masonry surfaces shall not be cleaned, other than removing excess surface mortar, until mortar in joints has hardened. Masonry surfaces shall be left clean, free of mortar daubs, dirt, stain, and discoloration, including scum from cleaning operations, and with tight mortar joints throughout. Metal tools and metal brushes shall not be used for cleaning.

3.8.1 Dry-Brushing

a. Exposed concrete masonry unit

b. shall be dry-brushed at the end of each day's work and after any required pointing, using stiff-fiber bristled brushes.

3.9 PROTECTION

Protect facing materials against staining. Cover top of walls with nonstaining waterproof covering or membrane when work is not in progress. Covering of the top of the unfinished walls shall continue until the wall is waterproofed with a complete roof or parapet system. Covering shall extend a minimum of 600 mm down on each side of the wall and shall be held securely in place. Before starting or resuming, top surface of masonry in place shall be cleaned of loose mortar and foreign material.

3.10 TEST REPORTS

3.10.1 Prism Tests

Perform at least one prism test sample for each 465 square meters of wall but not less than three such samples shall be made for any building. Three prisms will be used in each sample. Prisms shall be tested in accordance with ACI 530/530.1. Seven-day tests may be used provided the relationship between the 7- and 28-day strengths of the masonry is established by the tests of the materials used. Compressive strength shall not be less than 13.8 MPa at 28 days. If the compressive strength of any prism falls below the specified value by more than 3.5 MPa, steps shall be taken to assure that the load-carrying capacity of the structure is not jeopardized. If the likelihood of low-strength masonry is confirmed and computations indicate that the load-carrying capacity may have been significantly reduced, tests of cores drilled, or prisms sawed, from the area in question may be required. In such case, three specimens shall be taken for each prism test more than 3.5 MPa below the specified value. Masonry in the area in question shall be considered structurally adequate if the average compressive strength of three specimens is equal to at least 85 percent of the specified value, and if the compressive strength of no single specimen is less than 75 percent of the specified value. Additional testing of specimens extracted from locations represented by erratic core or prism strength test results will be permitted.

-- End of Section --

SECTION 05 12 00

STRUCTURAL STEEL

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 201	(2006) AISC Certification Program for Structural Steel Fabricators
AISC 325	(2005) Steel Construction Manual
AISC 326	(2009) Detailing for Steel Construction
ANSI/AISC 341	(2005; Suppl No. 1 2005) Seismic Provisions for Structural Steel Buildings
ANSI/AISC 360	(2005) Specification for Structural Steel Buildings, with Commentary

AMERICAN WELDING SOCIETY (AWS)

AWS A2.4	(2007) Standard Symbols for Welding, Brazing and Nondestructive Examination
AWS D1.1/D1.1M	(2008; Errata 2008) Structural Welding Code - Steel

ASME INTERNATIONAL (ASME)

ASME B46.1	(2002) Surface Texture, Surface Roughness, Waviness and Lay

ASTM INTERNATIONAL (ASTM)

ASTM A 307	(2007b) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A 325M	(2009a) Standard Specification for Structural Bolts, Steel, Heat Treated, 830 MPa Minimum Tensile Strength (Metric)
ASTM A 36/A 36M	(2008) Standard Specification for Carbon Structural Steel
ASTM A 490M	(2009a) Standard Specification for High-Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints (Metric)

ASTM A 500/A 500M	(2009) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A 501	(2007) Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
ASTM A 53/A 53M	(2007) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 563	(2007a) Standard Specification for Carbon and Alloy Steel Nuts
ASTM A 563M	(2007) Standard Specification for Carbon and Alloy Steel Nuts (Metric)
ASTM A 6/A 6M	(2009) Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
ASTM C 1107/C 1107M	(2008) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM C 827	(2001a; R 2005) Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixtures
ASTM F 1554	(2007a) Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength
ASTM F 436M	(2009) Hardened Steel Washers (Metric)
ASTM F 844	(2007a) Washers, Steel, Plain (Flat), Unhardened for General Use
ASTM F 959M	(2007) Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners (Metric)

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC PA 1	(2000; E 2004) Shop, Field, and Maintenance Painting of Steel
SSPC PS 13.01	(1982; E 2004) Epoxy Polyamide Painting System
SSPC Paint 25	(1997; E 2004) Zinc Oxide, Alkyd, Linseed Oil Primer for Use Over Hand Cleaned Steel, Type I and Type II
SSPC SP 3	(1982; E 2004) Power Tool Cleaning
SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

1.2 SYSTEM DESCRIPTION

Provide the structural steel system, including shop primer, complete and ready for use. Structural steel systems including design, materials, installation, workmanship, fabrication, assembly, erection, inspection, quality control, and testing shall be provided in accordance with ANSI/AISC 360 and ANSI/AISC 341 except as modified in this contract.

1.3 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.:

SD-02 Shop Drawings

Fabrication drawings including description of connections

SD-03 Product Data

Shop primer

Welding electrodes and rods

Load indicator washers

Non-Shrink Grout

Include test report for Class B primer.

SD-06 Test Reports

Class B coating

Bolts, nuts, and washers

Supply the certified manufacturer's mill reports which clearly show the applicable ASTM mechanical and chemical requirements together with the actual test results for the supplied fasteners.

SD-07 Certificates

Steel

Bolts, nuts, and washers

1.4 SEISMIC PROVISIONS

The structural steel system shall be provided in accordance with ANSI/AISC 341.

1.5 QUALITY ASSURANCE

1.5.1 Drawing Requirements

Submit fabrication drawings for approval prior to fabrication. Prepare in accordance with AISC 326 and AISC 325. Fabrication drawings shall not be reproductions of contract drawings. Include complete information for the fabrication and erection of the structure's components, including the

location, type, and size of bolts, welds, member sizes and lengths, connection details, blocks, copes, and cuts. Double connections that require an erection seat to comply with OSHA 1926.756(c)(1) shall be shown on the shop drawings, reviewed and approved by the structural engineer of record. Use AWS A2.4 standard welding symbols. Member substitutions of details shown on the contract drawings shall be clearly highlighted on the fabrication drawings. Explain the reasons for any deviations from the contract drawings.

1.5.2 Certifications

1.5.2.1 Welding Procedures and Qualifications

Conform to all requirements specified in AWS D1.1/D1.1M.

PART 2 PRODUCTS

2.1 STEEL

2.1.1 Structural Steel

ASTM A 36/A 36M.

2.1.2 Structural Steel Tubing

ASTM A 500/A 500M, Grade B; ASTM A 501.

2.1.3 Steel Pipe

ASTM A 53/A 53M, Type E or S, Grade B, weight class STD (Standard).

2.2 BOLTS, NUTS, AND WASHERS

Provide the following unless indicated otherwise.

2.2.1 Structural Steel , Steel Pipe

2.2.1.1 Bolts

ASTM A 307, Grade A; ASTM A 325M, Type 1, ASTM A 490M, Type 1. The bolt heads and the nuts of the supplied fasteners must be marked with the manufacturer's identification mark, the strength grade and type specified by ASTM specifications.

2.2.1.2 Nuts

ASTM A 563M, Grade A, heavy hex style, except nuts under M36 may be provided in hex style.

2.2.1.3 Washers

ASTM F 844 washers for ASTM A 307 bolts, and ASTM F 436M washers for ASTM A 325M and ASTM A 490M bolts.

2.2.2 Foundation Anchorage

2.2.2.1 Anchor Bolts

ASTM F 1554.

2.2.2.2 Anchor Nuts

ASTM A 563, Grade A, hex style.

2.2.2.3 Anchor Washers

ASTM F 844.

2.2.2.4 Anchor Plate Washers

ASTM A 36/A 36M.

2.2.3 Load Indicator Washers

ASTM F 959M.

2.3 STRUCTURAL STEEL ACCESSORIES

2.3.1 Welding Electrodes and Rods

AWS D1.1/D1.1M.

2.3.2 Non-Shrink Grout

ASTM C 1107/C 1107M, with no ASTM C 827 shrinkage. Grout shall be nonmetallic.

2.4 SHOP PRIMER

SSPC Paint 25, (alkyd primer) or SSPC PS 13.01 epoxy-polyamide, green primer (Form 150) type 1, except provide a Class B coating in accordance with AISC 325 for slip critical joints. Primer shall conform to Federal, State, and local VOC regulations. If flash rusting occurs, re-clean the surface prior to application of primer.

2.5 FABRICATION

2.5.1 Markings

Prior to erection, members shall be identified by a painted erection mark. Connecting parts assembled in the shop for reaming holes in field connections shall be match marked with scratch and notch marks. Do not locate erection markings on areas to be welded. Do not locate match markings in areas that will decrease member strength or cause stress concentrations.

2.5.2 Shop Primer

Shop prime structural steel, except as modified herein, in accordance with SSPC PA 1. Do not prime steel surfaces embedded in concrete, or surfaces within 13 mm of the toe of the welds prior to welding (except surfaces on which metal decking is to be welded). Slip critical surfaces shall be primed with a Class B coating. Prior to assembly, prime surfaces which will be concealed or inaccessible after assembly. Do not apply primer in foggy or rainy weather; when the ambient temperature is below 7 degrees C or over 35 degrees C; or when the primer may be exposed to temperatures below 4 degrees C within 48 hours after application, unless approved otherwise by the Contracting Officer.

2.5.2.1 Cleaning

SSPC SP 6/NACE No.3, except steel exposed in spaces above ceilings, attic spaces, furred spaces, and chases that will be hidden to view in finished construction may be cleaned to SSPC SP 3 when recommended by the shop primer manufacturer. Maintain steel surfaces free from rust, dirt, oil, grease, and other contaminants through final assembly.

2.5.2.2 Primer

Apply primer to a minimum dry film thickness of 0.05 mm except provide the Class B coating for slip critical joints in accordance with the coating manufacturer's recommendations. Repair damaged primed surfaces with an additional coat of primer.

PART 3 EXECUTION

3.1 FABRICATION

Fabrication shall be in accordance with the applicable provisions of AISC 325. Fabrication and assembly shall be done in the shop to the greatest extent possible.

Compression joints depending on contact bearing shall have a surface roughness not in excess of 13 micrometer as determined by ASME B46.1, and ends shall be square within the tolerances for milled ends specified in ASTM A 6/A 6M.

Structural steelwork, except surfaces of steel to be encased in concrete, surfaces to be field welded, surfaces to be fireproofed, and contact surfaces of friction-type high-strength bolted connections shall be prepared for painting in accordance with endorsement "P" of AISC 201 and primed with the specified paint.

Shop splices of members between field splices will be permitted only where indicated on the Contract Drawings. Splices not indicated require the approval of the Contracting Officer.

3.2 ERECTION

3.2.1 STORAGE

Material shall be stored out of contact with the ground in such manner and location as will minimize deterioration.

3.3 CONNECTIONS

Except as modified in this section, connections not detailed shall be designed in accordance with ANSI/AISC 360. Build connections into existing work. Do not tighten anchor bolts set in concrete with impact torque wrenches. Punch, subpunch and ream, or drill bolt and pin holes perpendicular to the surface of the member. Holes shall not be cut or enlarged by burning. Bolts, nuts, and washers shall be clean of dirt and rust, and lubricated immediately prior to installation.

3.3.1 Common Grade Bolts

ASTM A 307 bolts shall be tightened to a "snug tight" fit. "Snug tight" is

the tightness that exists when plies in a joint are in firm contact. If firm contact of joint plies cannot be obtained with a few impacts of an impact wrench, or the full effort of a man using a spud wrench, contact the USAID Implementing Partner for further instructions.

3.4 GAS CUTTING

Use of gas-cutting torch in the field for correcting fabrication errors will not be permitted on any major member in the structural framing. Use of a gas cutting torch will be permitted on minor members not under stress only after approval has been obtained from the USAID Implementing Partner.

3.5 WELDING

Field welding will not be permitted without written authorization from the USAID Implementing Partner.AWS D1.1/D1.1M. Grind exposed welds smooth as indicated. Provide AWS D1.1/D1.1M qualified welders, welding operators, and tackers.

The Contractor shall develop and submit the Welding Procedure Specifications (WPS) for all welding, including welding done using prequalified procedures. Prequalified procedures may be submitted for information only; however, procedures that are not prequalified shall be submitted for approval.

3.5.1 Removal of Temporary Welds, Run-Off Plates, and Backing Strips

Remove only from finished areas.

3.6 SHOP PRIMER REPAIR

Repair shop primer in accordance with the paint manufacturer's recommendation for surfaces damaged by handling, transporting, cutting, welding, or bolting.

3.6.1 Field Priming

Field priming of steel exposed to the weather, or located in building areas without HVAC for control of relative humidity. After erection, the field bolt heads and nuts, field welds, and any abrasions in the shop coat shall be cleaned and primed with paint of the same quality as that used for the shop coat.

3.7 FIELD QUALITY CONTROL

Perform field tests, and provide labor, equipment, and incidentals required for testing, except that electric power for field tests will be furnished as set forth in Division 1. The Contracting Officer shall be notified in writing of defective welds, bolts, nuts, and washers within 7 working days of the date of weld inspection.

3.7.1 Welds

3.7.1.1 Visual Inspection

AWS D1.1/D1.1M. Furnish the services of AWS-certified welding inspectors for fabrication and erection inspection and testing and verification inspections. Welding inspectors shall visually inspect and mark welds, including fillet weld end returns.

3.7.1.2 Nondestructive Testing

AWS D1.1/D1.1M. Test locations shall be selected by the USAID Implementing Partner.

Testing frequency: Provide the following types and number of tests:

Test Type	Number of Tests
Dye Penetrant	1 per 25 welds or less

3.7.2 Load Indicator Washers

3.7.2.1 Load Indicator Washer Compression

Load indicator washers shall be tested in place to verify that they have been compressed sufficiently to provide the 0.38 mm gap when the load indicator washer is placed under the bolt head and the nut is tightened, and to provide the 0.13 mm gap when the load indicator washer is placed under the turned element, as required by ASTM F 959M.

-- End of Section --

SECTION 05 50 13

MISCELLANEOUS METAL FABRICATIONS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ALUMINUM ASSOCIATION (AA)

AA 46	(1978) Standards for Anodized Architectural Aluminum
AA DAF-45	(2003) Designation System for Aluminum Finishes

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 303	(2005) Code of Standard Practice for Steel Buildings and Bridges

AMERICAN SOCIETY OF SAFETY ENGINEERS (ASSE/SAFE)

ASSE/SAFE A10.3	(2006) Operations - Safety Requirements for Powder Actuated Fastening Systems

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2008; Errata 2008) Structural Welding Code - Steel

ASME INTERNATIONAL (ASME)

ASME B18.2.1	(1996; R 2005) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(1987; R 2005) Standard for Square and Hex Nuts
ASME B18.21.2M	(1999; R 2005) Lock Washers (Metric Series)
ASME B18.22M	(1981; R 2005) Metric Plain Washers
ASME B18.6.2	(1998; R 2005) Slotted Head Cap Screws, Square Head Set Screws, and Slotted Headless Set Screws: Inch Series
ASME B18.6.3	(2003; R 2008) Machine Screws and Machine Screw Nuts

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M	(2009) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153/A 153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 307	(2007b) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A 36/A 36M	(2008) Standard Specification for Carbon Structural Steel
ASTM A 47/A 47M	(1999; R 2009) Standard Specification for Steel Sheet, Aluminum-Coated, by the Hot-Dip Process
ASTM A 500/A 500M	(2009) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A 53/A 53M	(2007) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 653/A 653M	(2009a) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A 687	(1993) Standard Specification for High-Strength Nonheaded Steel Bolts and Studs
ASTM A 780/A 780M	(2009) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A 924/A 924M	(2009a) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B 108/B 108M	(2008) Standard Specification for Aluminum-Alloy Permanent Mold Castings
ASTM B 209M	(2007) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B 221M	(2007) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)
ASTM B 26/B 26M	(2009) Standard Specification for Aluminum-Alloy Sand Castings

ASTM C 1513	(2004; E 2009; R 2009) Standard Specification for Steel Tapping Screws for Cold-Formed Steel Framing Connections
ASTM D 1187	(1997; R 2002e1) Asphalt-Base Emulsions for Use as Protective Coatings for Metal
ASTM E 488	(1996; R 2003) Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements

MASTER PAINTERS INSTITUTE (MPI)

MPI 79	(Oct 2009) Alkyd Anti-Corrosive Metal Primer

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 3	(1982; E 2004) Power Tool Cleaning
SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

1.2 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.

SD-02 Shop Drawings

Embedded angles and plates, installation drawings

Roof hatch

Submit fabrication drawings showing layout(s), connections to structural system, and anchoring details as specified in AISC 303.

Submit templates, erection and installation drawings indicating thickness, type, grade, class of metal, and dimensions. Show construction details, reinforcement, anchorage, and installation with relation to the building construction.

SD-03 Product Data

Roof hatch

1.3 QUALIFICATION OF WELDERS

Qualify welders in accordance with AWS D1.1/D1.1M. Use procedures, materials, and equipment of the type required for the work.

1.4 DELIVERY, STORAGE, AND PROTECTION

Protect from corrosion, deformation, and other types of damage. Store items in an enclosed area free from contact with soil and weather. Remove and replace damaged items with new items.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Structural Carbon Steel

ASTM A 36/A 36M.

2.1.2 Structural Tubing

ASTM A 500/A 500M.

2.1.3 Steel Pipe

ASTM A 53/A 53M, Type E or S, Grade B.

2.1.4 Fittings for Steel Pipe

Standard malleable iron fittings ASTM A 47/A 47M.

2.1.5 Anchor Bolts

ASTM A 307. Where exposed, shall be of the same material, color, and finish as the metal to which applied.

2.1.5.1 Expansion Anchors

Provide 6 mm diameter expansion anchors. Minimum masonry embedment shall be 29 mm. Design values listed shall be as tested according to ASTM E 488.

a. Minimum allowable pullout value shall be 1.3 kN.

b. Minimum allowable shear value shall be 2.4 kN.

2.1.5.2 Lag Screws and Bolts

ASME B18.2.1, type and grade best suited for the purpose.

2.1.5.3 Toggle Bolts

ASME B18.2.1.

2.1.5.4 Bolts, Nuts, Studs and Rivets

ASME B18.2.2 and ASTM A 687 or ASTM A 307.

2.1.5.5 Powder Actuated Fasteners

Follow safety provisions of ASSE/SAFE A10.3.

2.1.5.6 Screws

ASME B18.2.1, ASME B18.6.2, ASME B18.6.3 and ASTM C 1513.

2.1.5.7 Washers

Provide plain washers to conform toASME B18.22M. Provide beveled washers for American Standard beams and channels, square or rectangular, tapered in thickness, and smooth. Provide lock washers to conform to ASME B18.21.2M.

2.1.6 Aluminum Alloy Products

Conform to ASTM B 209M for sheet plate, ASTM B 221M for extrusions and ASTM B 26/B 26M or ASTM B 108/B 108M for castings, as applicable. Provide aluminum extrusions at least 3 mm thick and aluminum plate or sheet at least 1.3 mm thick.

2.2 FABRICATION FINISHES

2.2.1 Galvanizing

Hot-dip galvanize items specified to be zinc-coated, after fabrication where practicable. Galvanizing: ASTM A 123/A 123M, ASTM A 153/A 153M, ASTM A 653/A 653M or ASTM A 924/A 924M, Z275, as applicable.

2.2.2 Galvanize

Anchor bolts, grating fasteners, washers, and parts or devices necessary for proper installation, unless indicated otherwise.

2.2.3 Repair of Zinc-Coated Surfaces

Repair damaged surfaces with galvanizing repair method and paint conforming to ASTM A 780/A 780M or by application of stick or thick paste material specifically designed for repair of galvanizing, as approved by Contracting Officer. Clean areas to be repaired and remove slag from welds. Heat surfaces to which stick or paste material is applied, with a torch to a temperature sufficient to melt the metallics in stick or paste; spread molten material uniformly over surfaces to be coated and wipe off excess material.

2.2.4 Shop Cleaning and Painting

2.2.4.1 Surface Preparation

Blast clean surfaces in accordance with SSPC SP 6/NACE No.3. Surfaces that will be exposed in spaces above ceiling or in attic spaces, crawl spaces, furred spaces, and chases may be cleaned in accordance with SSPC SP 3 in lieu of being blast cleaned. Wash cleaned surfaces which become contaminated with rust, dirt, oil, grease, or other contaminants with solvents until thoroughly clean. Steel to be embedded in concrete shall be free of dirt and grease. Do not paint or galvanize bearing surfaces, including contact surfaces within slip critical joints, but coat with rust preventative applied in the shop.

2.2.4.2 Pretreatment, Priming and Painting

Apply pretreatment, primer, and paint in accordance with manufacturer's printed instructions. On surfaces concealed in the finished construction or not accessible for finish painting, apply an additional prime coat to a minimum dry film thickness of 0.03 mm. Tint additional prime coat with a small amount of tinting pigment.

2.2.5 Nonferrous Metal Surfaces

Protect by plating, anodic, or organic coatings.

2.2.6 Aluminum Surfaces

2.2.6.1 Surface Condition

Before finishes are applied, remove roll marks, scratches, rolled-in scratches, kinks, stains, pits, orange peel, die marks, structural streaks, and other defects which will affect uniform appearance of finished surfaces.

2.2.6.2 Aluminum Finishes

Unexposed sheet, plate and extrusions may have mill finish as fabricated. Sandblast castings' finish, medium, AA DAF-45, or AA 46. Unless otherwise specified, provide all other aluminum items with a standard mill finish. Provide a coating thickness not less than that specified for protective and decorative type finishes for items used in interior locations or architectural Class I type finish for items used in exterior locations in AA DAF-45. Provide a polished satin finish on items to be anodized.

2.3 GUARD POSTS (BOLLARDS/PIPE GUARDS)

Provide 100 mm prime coated, standard weight steel pipe as specified in ASTM A 53/A 53M. Anchor posts in concrete as indicated and fill solidly with concrete with minimum compressive strength of 21 MPa.

2.4 MISCELLANEOUS PLATES AND SHAPES

Provide for items that do not form a part of the structural steel framework, such as lintels, sill angles, miscellaneous mountings and frames.

Provide angles and plates, ASTM A 36/A 36M, for embedment as indicated. Galvanize embedded items exposed to the elements according to ASTM A 123/A 123M.

2.5 DOWNSPOUT BOOTS

Provide cast iron downspout boots with receiving bells sized to fit downspouts.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

Install items at locations indicated, according to manufacturer's instructions. Verify all measurements and take all field measurements necessary before fabrication. Exposed fastenings shall be compatible materials, shall generally match in color and finish, and harmonize with the material to which fastenings are applied. Include materials and parts necessary to complete each item, even though such work is not definitely shown or specified. Poor matching of holes for fasteners shall be cause for rejection. Conceal fastenings where practicable. Thickness of metal and details of assembly and supports shall provide strength and stiffness. Form joints exposed to the weather shall be formed to exclude water. Items listed below require additional procedures.

3.2 WORKMANSHIP

Provide miscellaneous metalwork that is well formed to shape and size, with sharp lines and angles and true curves. Drilling and punching shall

produce clean true lines and surfaces. Provide continuous welding along the entire area of contact except where tack welding is permitted. Do not tack weld exposed connections of work in place and ground smooth. Provide a smooth finish on exposed surfaces of work in place and unless otherwise approved, flush exposed riveting. Mill joints where tight fits are required. Corner joints shall be coped or mitered, well formed, and in true alignment. Accurately set work to established lines and elevations and securely fastened in place. Install in accordance with manufacturer's installation instructions and approved drawings, cuts, and details.

3.3 ANCHORAGE, FASTENINGS, AND CONNECTIONS

Provide anchorage where necessary for fastening miscellaneous metal items securely in place. Include for anchorage not otherwise specified or indicated slotted inserts, expansion shields, and powder-driven fasteners, when approved for concrete; toggle bolts and through bolts for masonry; machine and carriage bolts for steel; through bolts, lag bolts, and screws for wood. Do not use wood plugs in any material. Provide non-ferrous attachments for non-ferrous metal. Make exposed fastenings of compatible materials, generally matching in color and finish, to which fastenings are applied. Conceal fastenings where practicable.

3.4 BUILT-IN WORK

Form for anchorage metal work built-in with concrete or masonry, or provide with suitable anchoring devices as indicated or as required. Furnish metal work in ample time for securing in place as the work progresses.

3.5 WELDING

Perform welding, welding inspection, and corrective welding, in accordance with AWS D1.1/D1.1M. Use continuous welds on all exposed connections. Grind visible welds smooth in the finished installation.

3.6 FINISHES

3.6.1 Dissimilar Materials

Where dissimilar metals are in contact, protect surfaces with a coat conforming to MPI 79 to prevent galvanic or corrosive action. Where aluminum is in contact with concrete, plaster, mortar, masonry, wood, or absorptive materials subject to wetting, protect with ASTM D 1187, asphalt-base emulsion.

3.6.2 Field Preparation

Remove rust preventive coating just prior to field erection, using a remover approved by the rust preventive manufacturer. Surfaces, when assembled, shall be free of rust, grease, dirt and other foreign matter.

3.6.3 Environmental Conditions

Do not clean or paint surface when damp or exposed to foggy or rainy weather, when metallic surface temperature is less than minus 15 degrees C above the dew point of the surrounding air, or when surface temperature is below 7 degrees C or over 35 degrees C, unless approved by the Contracting Officer.

3.7 ROOF HATCH (SCUTTLES)

Provide zinc-coated steel sheets not less than 1.9 mm, with 75 mm beaded flange, welded and ground at corner. Provide a minimum clear opening of 760 by 900 mm. Construction and accessories as follows:

a. Insulate cover and curb with 25 mm thick rigid fiberboard insulation covered and protected by zinc-coated steel liner not less than 0.45 mm with 300 mm high curb, formed with 75 mm mounting flange with holes provided for securing to the roof deck. Equip the curb with an integral metal cap flashing of the same gage and metal as the curb, full welded and ground at corners for weather tightness.

b. Provide hatch completely assembled with pintle hinges, compression spring operators enclosed in telescopic tubes, positive snap latch with turn handles on inside and outside, and neoprene draft seal. Provide fasteners for padlocking on the inside. Equip the cover with an automatic hold-open arm complete with grip handle to permit one-hand release. Cover action shall be smooth through its entire range with an operating pressure of approximately 130 N.

3.8 INSTALLATION OF GUARD POSTS (BOLLARDS/PIPE GUARDS)

Set pipe guards vertically in concrete piers. Construct piers of, and the hollow cores of the pipe filled with, concrete having a compressive strength of 21 MPa.

3.9 INSTALLATION OF DOWNSPOUT BOOTS

Secure downspouts to building through integral lips with appropriate fasteners.

-- End of Section --

SECTION 07 21 13

BOARD AND BLOCK INSULATION

PART 1 GENERAL

1.1 SUBMITTALS

Submit for approval samples of board and block insulation and accessories.

SD-03 Product Data

Block or board insulation
Vapor retarder
Pressure sensitive tape
Accessories

SD-08 Manufacturer's Instructions

Block or Board Insulation

1.2 DELIVERY, STORAGE, AND HANDLING

1.2.1 Delivery

Deliver materials to the site in original sealed wrapping bearing manufacturer's name and brand designation, specification number, type, grade, R-value, and class. Store and handle to protect from damage. Do not allow insulation materials to become wet, soiled, crushed, or covered with ice or snow. Comply with manufacturer's recommendations for handling, storing, and protecting of materials before and during installation.

1.2.2 Storage

Inspect materials delivered to the site for damage; unload and store out of weather in manufacturer's original packaging. Store only in dry locations, not subject to open flames or sparks, and easily accessible for inspection and handling.

1.3 SAFETY PRECAUTIONS

1.3.1 Safety Considerations

Consider safety concerns and measures.

PART 2 PRODUCTS

2.1 BLOCK OR BOARD INSULATION

Provide only thermal insulating materials recommended by manufacturer for type of application indicated. Provide board or block thermal insulation conforming to the following standards and the physical properties listed below:

a. Extruded Preformed Cellular Polystyrene:

2.1.1 Thermal Resistance

As indicated.

2.1.2 Prohibited Materials

Do not provide materials containing more than one percent of asbestos.

2.2 VAPOR RETARDER

2.2.1 Vapor Retarder in Frame Walls and Roofs

a. 0.15 mm thick polyethylene sheeting

2.2.2 Vapor Retarder under Floor Slab

a. 0.15 mm thick polyethylene sheeting.

2.3 PRESSURE SENSITIVE TAPE

As recommended by manufacturer of vapor retarder.

2.4 ACCESSORIES

2.4.1 Mechanical Fasteners

Corrosion resistant fasteners as recommended by the insulation manufacturer.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Insulation Board

Install and handle insulation in accordance with the manufacturer's installation instructions. Keep material dry and free of extraneous materials. Observe safe work practices.

3.1.2 Electrical Wiring

Do not install insulation in a manner that would sandwich electrical wiring between two layers of insulation.

3.1.3 Cold Climate Requirement

Place insulation to the outside of pipes.

3.1.4 Continuity of Insulation

Butt tightly against adjoining boards, studs, rafters, joists, sill plates, headers and obstructions. Provide continuity and integrity of insulation at corners, wall to ceiling joint, roof, and floor. Avoid creating any thermal bridges or voids.

3.2 INSTALLATION ON WALLS

3.2.1 Installation using Furring Strips

Install insulation between members as recommended by insulation

manufacturer.

3.2.2 Installation on Masonry Walls

Apply board directly to masonry with fasteners as recommended by the insulation manufacturer. Fit between obstructions without impaling board on ties or anchors. Apply in parallel courses with joints breaking midway over course below. Put ends in moderate contact with adjoining insulation without forcing. Cut and shape as required to fit around wall penetrations, projections or openings to accommodate conduit or other services. Seal around cut-outs with sealant.

3.3 VAPOR RETARDER

Apply a continuous vapor retarder as indicated. Overlap all joints at least 150 mm and seal with pressure sensitive tape. Seal at utility penetrations. Repair punctures or tears with pressure sensitive tape.

-- End of Section --

SECTION 07 21 16

MINERAL FIBER BLANKET INSULATION

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D 4397	(2009) Standard Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications
ASTM E 96/E 96M	(2005) Standard Test Methods for Water Vapor Transmission of Materials

1.2 SUBMITTALS

Submit for aproval samples of blanket installation and accessories.

SD-03 Product Data

Blanket insulation
Vapor retarder
Pressure sensitive tape
Accessories

SD-08 Manufacturer's Instructions

Insulation

1.3 DELIVERY, STORAGE, AND HANDLING

1.3.1 Delivery

Deliver materials to site in original sealed wrapping bearing manufacturer's name and brand designation, specification number, type, grade, R-value, and class. Store and handle to protect from damage. Do not allow insulation materials to become wet, soiled, crushed, or covered with ice or snow. Comply with manufacturer's recommendations for handling, storing, and protecting of materials before and during installation.

1.3.2 Storage

Inspect materials delivered to the site for damage; unload and store out of weather in manufacturer's original packaging. Store only in dry locations, not subject to open flames or sparks, and easily accessible for inspection and handling.

1.4 SAFETY PRECAUTIONS

1.4.1 Respirators

Provide installers with dust/mist respirators, training in their use, and protective clothing, in accordance with NIOSH requirements.

1.4.2 Smoking

Do not smoke during installation of blanket thermal insulation.

PART 2 PRODUCTS

2.1 BLANKET INSULATION

Glass fiber blankets without membrane coverings.

2.1.1 Thermal Resistance Value (R-VALUE)

As indicated.

2.1.2 Prohibited Materials

Do not provide asbestos-containing materials.

2.2 BLOCKING

Metal blocking.

2.3 VAPOR RETARDER

a. 0.25 mm thick polyethylene sheeting conforming to ASTM D 4397 and having a water vapor permeance of 5.72 by 10-8g/Pa.s.m2 or less when tested in accordance with ASTM E 96/E 96M.

2.4 PRESSURE SENSITIVE TAPE

As recommended by the vapor retarder manufacturer and having a water vapor permeance rating equivalent to Vapor Retarder.

2.5 ACCESSORIES

2.5.1 Adhesive

As recommended by the insulation manufacturer.

2.5.2 Mechanical Fasteners

Corrosion resistant fasteners as recommended by the insulation manufacturer.

2.5.3 Wire Mesh

Corrosion resistant and as recommended by the insulation manufacturer.

PART 3 EXECUTION

3.1 EXISTING CONDITIONS

Before installing insulation, ensure that areas that will be in contact

with the insulation are dry and free of projections which could cause voids, compressed insulation, or punctured vapor retarders. If moisture or other conditions are found that do not allow the workmanlike installation of the insulation, do not proceed but notify USAID Implementing Partner of such conditions.

3.2 PREPARATION

3.2.1 Blocking at Vents

Prior to installation of insulation, install permanent blocking to prevent insulation from slipping over, clogging, or restricting air flow through soffit vents at eaves.

3.3 INSTALLATION

3.3.1 Insulation

Install and handle insulation in accordance with manufacturer's instructions. Keep material dry and free of extraneous materials. Ensure personal protective clothing and respiratory equipment is used as required. Observe safe work practices.

3.3.1.1 Electrical wiring

Do not install insulation in a manner that would sandwich electrical wiring between two layers of insulation.

3.3.1.2 Continuity of Insulation

Install blanket insulation to butt tightly against adjoining blankets and to studs, rafters, joists, sill plates, headers and any obstructions. Where insulation required is thicker than depth of joist, provide full width blankets to cover across top of joists. Provide continuity and integrity of insulation at corners, wall to ceiling joints, roof, and floor. Avoid creating thermal bridges.

3.3.1.3 Installation at Bridging and Cross Bracing

Insulate at bridging and cross bracing by splitting blanket vertically at center and packing one half into each opening. Butt insulation at bridging and cross bracing; fill in bridged area with loose or scrap insulation.

3.3.1.4 Cold Climate Requirement

Place insulation to the outside of pipes.

3.3.1.5 Insulation without Affixed Vapor Retarder

Provide snug friction fit to hold insulation in place. Stuff pieces of insulation into cracks between joists and other framing.

3.3.1.6 Sizing of Blankets

Provide only full width blankets when insulating between trusses, joists, or studs. Size width of blankets for a snug fit where trusses, joists or studs are irregularly spaced.

3.3.1.7 Special Requirements for Ceilings

Place insulation under electrical wiring occurring across joists. Pack insulation into narrowly spaced framing. Do not block flow of air through soffit vents.

3.3.2 Installation of Separate Vapor Retarder

Apply continuous vapor retarder. Overlap joints at least 150 mm and seal with pressure sensitive tape. Seal at header, windows, doors and utility penetrations. Repair punctures or tears with pressure sensitive tape.

-- End of Section --

SECTION 07 41 13
METAL ROOF PANELS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE/SEI 7-05	(2005; R 2006) Minimum Design Loads for Buildings and Other Structures

ASTM INTERNATIONAL (ASTM)

ASTM A 1008/A 1008M	(2009a) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardened
ASTM A 123/A 123M	(2009) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 36/A 36M	(2008) Standard Specification for Carbon Structural Steel
ASTM D 522	(1993a; R 2008) Mandrel Bend Test of Attached Organic Coatings
ASTM E 1592	(2005) Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference
ASTM E 2140	(2001) Standard Test Method for Water Penetration of Metal Roof Panel Systems by Static Water Pressure Head

UNDERWRITERS LABORATORIES (UL)

UL 580	(2006; R 2009) Standard for Tests for Uplift Resistance of Roof Assemblies

1.2 DESCRIPTION OF METAL ROOF SYSTEM

1.2.1 Performance Requirements

Steel panels and accessory components must conform to the following standards:

ASTM A 1008/A 1008M
ASTM A 123/A 123M
ASTM A 36/A 36M

ASTM D 522 for applied coatings

1.2.1.1 Hydrostatic Head Resistance

No water penetration when tested according to ASTM E 2140. Submit leakage test report upon completion of installation.

1.2.1.2 Wind Uplift Resistance

Provide metal roof panel system that conform to the requirements of ASTM E 1592 and UL 580. Uplift force due to wind action governs the design for panels. Submit wind uplift test report prior to commencing installation.

Roof system and attachments must resist the wind loads as determined by ASCE/SEI 7-05, in pounds per square foot.

1.3 SUBMITTALS

Submit for approval, prior to material delivery to site, sample metal, roof panels, attachment hardware, chimney flashing unit, and other metal roof flashing materials.

1.4 QUALITY ASSURANCE

1.4.1 Qualification of Manufacturer

1.4.1.1 Single Source

Roofing panels, clips, closures, and other accessories must be standard products of the same manufacturer, and the most recent design of the manufacturer to operate as a complete system for the intended use.

1.4.2 Pre-roofing Conference

Before performing roofing system installation work, hold a pre-roofing conference to review the following:

a. Drawings, specifications, and submittals related to the roof work.

b. Roof system components installation;

c. Contractor's plan for coordination of the work of the various trades involved in providing the roofing system and other components secured to the roofing; and

d. Quality control plan for the roof system installation;

e. Safety requirements.

1.5 DELIVERY, HANDLING, AND STORAGE

Deliver, store, and handle panel materials, bulk roofing products, accessories, and other manufactured items in a manner to prevent damage and deformation, as recommended by the manufacturer, and as specified.

1.5.1 Delivery

Package and deliver materials to the site in undamaged condition. Provide

adequate packaging to protect materials during shipment. Do not uncrate materials until ready for use, except for inspection. Immediately upon arrival of materials at jobsite, inspect materials for damage, deformation, dampness, and staining. Remove affected materials from the site and immediately replace. Remove moisture from wet materials not otherwise affected, restack and protect from further moisture exposure.

1.5.2 Handling

Handle materials in a manner to avoid damage. Select and operate material handling equipment so as not to damage materials or applied roofing.

1.5.3 Storage

Stack materials stored on site on platforms or pallets, and cover with tarpaulins or other weathertight covering which prevents trapping of water or condensation under the covering. Store roof panels so that water which may have accumulated during transit or storage will drain off. Do not store panels in contact with materials that might cause staining. Secure coverings and stored items to protect from wind displacement.

1.6 PROJECT CONDITIONS

Weather Limitations: Proceed with installation only when existing and forecast weather conditions permit metal roof panel work to be performed according to manufacturer's written instructions and specified safety requirements.

1.7 FABRICATION

Fabricate and finish metal roof panels and accessories per manufacturer's standard procedures and processes, and as necessary to fulfill indicated performance requirements. Comply with indicated profiles, dimensional and structural requirements.

Provide panel profile, as indicated on drawings for full length of panel.

1.7.1 Finishes

Finish quality and application processes must conform to the related standards specified within this section. Noticeable variations within the same piece are not acceptable.

1.7.2 Accessories

Fabricate flashing and trim as applicable to the design, dimensions, metal, and other characteristics of the item indicated.

a. Form exposed sheet metal accessories which are free from excessive oil canning, buckling, and tool marks, and are true to line and levels indicated, with exposed edges folded back to form hems.

b. Fabricate cleats and attachments devices of size and metal thickness recommended by SMACNA or by metal roof panel manufacturer for application, but not less than the thickness of the metal being secured.

PART 2 PRODUCTS

2.1 ROOF PANELS

2.1.1 Steel Sheet Panels

Roll-form steel sheet roof panels to the specified profile, with fy = 275 MPa ,24 gauge and depth as indicated.

Material must be plumb and true, and within the tolerances listed:

a. Galvanized steel sheet.

b. Individual panels to have continuous length sufficient to cover the entire length of any unbroken roof slope with no joints or seams and formed without warping, waviness, or ripples that are not a part of the panel profile and free from damage to the finish coating system.

c. Provide panels with thermal expansion and contraction consistent with the type of system specified, and with the profile shown on the Drawings.

2.2 FACTORY FINISH AND COLOR PERFORMANCE REQUIREMENTS

All panels are to receive a factory applied Kynar 500/Hylar 5000 finish consisting of a baked topcoat with a manufacturer's recommended prime coat conforming to the following:

a. Metal Preparation: All metal is to have the surfaces carefully prepared for painting on a continuous process coil coating line by alkali cleaning, hot water rinsing, application of chemical conversion coating, cold water rinsing, sealing with an acid rinse, and thorough drying.

b. Prime Coating: A base coat of epoxy paint, specifically formulated to interact with the top-coat, is to be applied to the prepared surfaces by roll coating. The prime coat must be oven cured prior to application of the finish coat.

c. Exterior Finish Coating: Apply the exterior finish coating over the primer by roll coating. The exterior finish coat must be oven-cured.

d. Interior finish coating: Apply a wash coat on the reverse side over primer by roll coating. The wash coat must be oven cured.

e. Color: The exterior finish chosen from the manufacturer's standard color chart.

2.3 MISCELLANEOUS METAL FRAMING

2.3.1 Fasteners and Miscellaneous Metal Framing

Provide compatible type, corrosion resistant, of sufficient size and length to penetrate the supporting element a minimum of 25 mm with other required properties to fasten miscellaneous metal framing members to substrates in accordance with the roof panel manufacturer's space fasteners at 300 mm O.C., typical.

2.3.1.1 Exposed Fasteners

Fasteners for roof panels must be corrosion resistant nylon capped steel, compatible with the sheet panel or flashing material and of the type and size recommended by the manufacturer to meet the performance requirements and design loads. Fasteners for accessories must be the manufacturer's standard. Provide an integral metal washer, matching the color of attached material with compressible sealing EPDM gasket.

2.3.1.2 Screws

Provide corrosion resistant screws, of the type and size recommended by the manufacturer to meet the performance requirements.

2.4 ACCESSORIES

Accessories must be compatible with the metal roof panels. Sheet metal flashing, trim, metal closure strips, caps, and similar metal accessories must be not less than the minimum thicknesses specified for roof panels. Provide exposed metal accessories to match the panels furnished except as otherwise indicated. Molded foam rib, ridge and other closure strips must be closed-cell or solid-cell synthetic rubber or neoprene premolded to match configuration of the panels and not absorb or retain water.

2.4.1 Pre-Manufactured Accessories

Pre-manufactured accessories must be manufacturer's standard for intended purpose, compatible with the metal roof system and approved for use by the metal roof panel manufacturer. Construct curbs to match roof slope.

2.4.2 Metal Closure Strips

Provide factory fabricated steel closure strips of the same gauge, color, finish and profile as the specified roof panel.

2.4.3 Rubber Closure Strips

Provide closed-cell, expanded cellular rubber closure strips extruded or molded to the configuration of the specified roof panel profile and in lengths supplied by roof panel manufacturer.

2.5 JOINT SEALANTS

2.5.1 Sealants

Sealants are to be an approved gun type for use in hand or air pressure caulking guns at temperatures above 4 degrees C (or frost-free application at temperatures above minus 12 degrees C) with a minimum solid content of 85 percent of the total volume. Sealant must dry with a tough, durable surface skin which permits it to remain soft and pliable underneath, providing a weather tight joint. No migratory staining, is permitted on painted or unpainted metal.

Prime all joints to receive sealants with a compatible one-component or two-component primer as recommended by the roof panel manufacturer.

2.5.1.1 Shop Applied Sealants

Sealant for shop-applied caulking must be an approved gun grade, non-sag

one-component polysulfide or silicone with a curing time which ensures the sealants plasticity at the time of field erection. Color to match panel color.

2.5.1.2 Field Applied Sealants

Sealants for field-applied caulking must be an approved gun grade, non-sag on-component polysulfide or two component polyurethane. Color to match panel color.

2.5.1.3 Tape Sealants

Provide pressure sensitive, 100 percent solid tape sealant with a release paper backing; permanently elastic, non-sagging, non-toxic and non-staining as approved by the roof panel manufacturer.

2.5.2 Sheet Metal Flashing and Trim

2.5.2.1 Fabrication, General

Custom fabricate sheet metal flashing and trim to comply with the characteristics of design indicated. Shop fabricate items to the greatest extent possible. Obtain and verify field measurements for accurate fit prior to shop fabrication. Fabricate flashing and trim without excessive oil canning, buckling, and tool marks, true to line and levels indicated, with exposed edges folded back to form hems.

2.5.2.2 Roof Drainage Sheet Metal Fabrications

Gutters: Fabricate to cross section indicated, with riveted and soldered joints, complete with end pieces, outlet tubes, and other special accessories as required. Fabricate in minimum 2500 mm long sections. Fabricate expansion joints and accessories from the same metal as gutters, unless otherwise indicated.

Downspouts: Fabricate rectangular downspouts complete with mitered elbows. Furnish with metal hangars of same material as downspouts and anchors.

2.6 FINISH REPAIR MATERIAL

Repair paint for color finish enameled roofing must be compatible paint of the same formula and color as the specified finish furnished by the manufacturer.

PART 3 EXECUTION

3.1 EXAMINATION

Examine substrates, areas, and conditions, with installer present, for compliance with requirements for installation tolerances, metal roof panel supports, and other conditions affecting performance of the work. Ensure surfaces are suitable, dry and free of defects and projections which might affect the installation.

Examine primary and secondary roof framing to verify that rafters, purlins, angels, channels, and other structural support members for panels and anchorages have been installed within alignment tolerances required by metal roof panel manufacturer, UL, ASTM, and applicable seismic

requirements.

Examine rough-in for components and systems penetrating metal roof panels to verify actual locations of penetrations relative to seam locations of panels prior to installation.

Proceed with installation only after defects have been corrected.

3.2 INSTALLATION

Installation must meet specified requirements and be in accordance with the manufacturer's installation instructions. Do not install damaged materials. Dissimilar materials which are not compatible when contacting each other must be insulated by means of gaskets or sealing/insulating compounds. Keep all exposed surfaces and edges clean and free from sealant, metal cuttings, hazardous burrs, and other foreign material. Remove stained, discolored, or damaged materials from the site.

3.2.1 Preparation

Clean all substrate substances which may be harmful to roof panels including removing projections capable of interfering with with roof panel attachment.

3.3 PROTECTION OF APPLIED MATERIALS

Do not permit storing, walking, wheeling, and trucking directly on applied roofing/insulation materials. Provide temporary walkways, runways, and platforms of smooth clean boards or planks as necessary to avoid damage to applied roofing/insulation materials, and to distribute weight to conform to indicated live load limits of roof construction.

3.4 FASTENER INSTALLATION

Anchor metal roof panels and other components of the Work securely in place, using approved fasteners according to manufacturer's written instructions.

3.5 FLASHING, TRIM, AND CLOSURE INSTALLATION

3.5.1 General Requirements

Comply with performance requirements, manufacturer's written installation instructions. Provide concealed fasteners where possible. Set units true to line and level as indicated. Install work with laps, joints, and seams that will be permanently water tight and weather resistant. Work is to be accomplished to form weather tight construction without waves, warps, buckles, fastening stresses or distortion, and to allow for expansion and contraction. Cutting, fitting, drilling, and other operations in connection with sheet metal required to accomplish the work must conform to the manufacturers written instructions.

3.5.2 Metal Flashing

Install exposed metal flashing at building corners, rakes, eaves, junctions between metal siding and roofing, valleys and changes of slope or direction in metal roofing, building expansion joints and gutters.

Exposed metal flashing must be the same material, color, and finish as the

specified metal roofing panels. Furnish flashing in minimum 2.5 m lengths. Exposed flashing must have 25 mm locked and blind soldered end joints, with expansion joints at intervals of no greater than 5.0 m.

Fasten flashing at not more than 100 mm on center for roofs, except where flashing is held in place by the same screws used to secure panels. Exposed flashing and flashing subject to rain penetration must be bedded in specified joint sealant. Flashing which is in contact with dissimilar metals must be isolated by means of the specified asphalt mastic material to prevent electrolytic deterioration.

Form drips to the profile indicated, with the edge folded back 13 mm to form a reinforced drip edge.

3.6 ROOF PANEL INSTALLATION

Provide metal roof panels of full length from eave to ridge or eave to wall as indicated, unless otherwise indicated or restricted by shipping limitations. Anchor metal roof panels or other components of the Work securely in place, with provisions for thermal and structural movement.

Steel Roof Panels: Use galvanized fasteners.

Metal Protection: Where dissimilar metals contact each other or possibly corrosive substrates, protect against galvanic action by coating contact surfaces with a bituminous coating.

Joint Sealers: Install gaskets, joint fillers, and sealants where indicated and required for weatherproof performance of metal roof panel system. Provide types of gaskets, fillers, and sealants indicated or, if not indicated, types recommended by metal roof panel manufacturer.

3.6.1 Handling and Erection

Erect roofing system in accordance with the printed instructions and safety precautions of the manufacturer.

Do not subject panels to overloading, abuse, or undue impact. Do not apply bent, chipped, or defective panels. Damaged panels must be replaced and removed from the site at the contractors expense. Erect panels true, plumb, and in exact alignment with the horizontal and vertical edges of the building, securely anchored, and with indicated rake, eave, and curb overhang. Allow for thermal movement of the roofing, movement of the building structure, and provide permanent freedom from noise due to wind pressure.

Do not permit storage, walking, wheeling or trucking directly on applied roofing materials. Provide temporary walkways, runways, and platforms of smooth clean boards or planks as necessary to avoid damage to the installed roofing materials, and to distribute weight to conform to the indicated live load limits of the roof construction.

Roof panels must be laid with corrugations in the direction of the roof slope. End laps of exterior roofing must not be less than 200 mm; side laps of standard exterior corrugated panels must not be less than 2-1/2 corrugations.

Field cutting of metal roof panels by torch is not permitted. Field cut only as recommended by manufacturer's written instructions.

3.6.2 Closure Strips

Install metal closure strips at open ends of metal ridge rolls; open ends of corrugated or ribbed pattern roofs, and at intersection of wall and roof, unless open ends are concealed with formed eave flashing; rake of metal roof unless open end has a formed flashing member; and in other required areas.

Install closure strips at intersection of the wall with metal roofing; top and bottom of metal siding; heads of wall openings; and in other required locations.

3.6.3 Workmanship

Make lines, arises, and angles sharp and true. Free exposed surfaces from any visible wave, warp, buckle and tool marks. Fold back exposed edges neatly to form a 13 mm hem on the concealed side. Make sheet metal exposed to the weather watertight with provisions for expansion and contraction.

Make surfaces to receive sheet metal plumb and true, clean, even, smooth, dry, and free of defects and projections which might affect the application. Provide sheet metal flashing in the angles formed where roof decks abut walls, curbs, ventilators, pipes, or other vertical surfaces and wherever indicated and as necessary to make the work watertight.

3.7 ACCEPTANCE PROVISIONS

3.7.1 Erection Tolerances

Erect metal roofing straight and true with plumb vertical lines correctly lapped and secured in accordance with the manufacturer's written instructions.

3.7.2 Leakage Tests

Finished application of metal roofing is to be subject to inspection and test for leakage.

Inspection and testing is to be made promptly after erection to permit correction of defects and removal/replacement of defective materials.

3.7.3 Repairs to Finish

Scratches, abrasions, and minor surface defects of finish may be repaired with the specified repair materials and as recommended by the metal roof panel manufacturer. Finished repaired surfaces must be uniform and free from variations of color and surface texture. Repaired metal surfaces that are not acceptable to the project requirements are to be immediately removed and replaced with new material.

3.8 CLEAN UP AND DISPOSAL

Clean exposed sheet metal work at completion of installation. Remove metal shavings, filings, nails, bolts, and wires from roofs. Remove grease and oil films, excess sealants, handling marks, contamination from steel wool, fittings and drilling debris and scrub the work clean. Exposed metal surfaces must be free of dents, creases, waves, scratch marks, solder or weld marks, and damage to the finish coating. Touch up scratches in panel

finish with manufacturer supplied touch-up paint system to match panel finish.

Collect all scrap/waste materials and place in containers. Promptly dispose of demolished and scrap materials. Do not allow scrap/waste materials to accumulate on-site; transport immediately from the government property and legally dispose of them.

-- End of Section --

SECTION 07 60 00

FLASHING AND SHEET METAL

PART 1 GENERAL

1.1 GENERAL REQUIREMENTS

Finished sheet metalwork will be accomplished to form a weathertight construction without waves, warps, buckles, fastening stresses or distortion, and shall allow for expansion and contraction. Sheet metal mechanic is responsible for cutting, fitting, drilling, and other operations in connection with sheet metal required to accommodate the work of other trades. Coordinate installation of sheet metal items used in conjunction with roofing with roofing work to permit continuous roofing operations.

1.2 SUBMITTALS

Submit for approval samples of expansion joint materials, cleats, and all flashing prior to delivery of materials to the site.

1.3 DELIVERY, HANDLING, AND STORAGE

Package and protect materials during shipment. Uncrate and inspect materials for damage, dampness, and wet-storage stains upon delivery to the job site. Handle sheet metal items to avoid damage to surfaces, edges, and ends. Store materials in dry, weather-tight, ventilated areas until immediately before installation.

PART 2 PRODUCTS

2.1 MATERIALS

Do not use galvanized steel. Any material listed by ASTM, DIN, B5, or EN standards for a particular item may be used, unless otherwise specified or indicated. Materials shall conform to the requirements specified below and to the thickness and configurations established in ASTM, DIN, BS, or EN standards. Different items need not be of the same metal, except that if copper is selected for any exposed item, all exposed items must be copper.

Furnish sheet metal items in 2400 to 3000 mm lengths. Single pieces less than 2400 mm long may be used to connect to factory-fabricated inside and outside corners, and at ends of runs. Factory fabricate corner pieces with minimum 300 mm legs. Provide accessories and other items essential to complete the sheet metal installation. Provide accessories made of the same or compatible materials as the items to which they are applied. Fabricate sheet metal items of the materials specified below and to the gage, thickness, or weight shown in Table I at the end of this section. Provide sheet metal items with mill finish unless specified otherwise. Where more than one material is listed for a particular item in Table I, each is acceptable and may be used except as follows:

2.1.1 Accessories

Accessories and other items essential to complete the sheet metal installation, though not specifically indicated or specified, shall be

provided.

2.1.2 Stainless Steel

ASTM, DIN, B5, or EN Standards fully annealed, dead-soft temper.

2.1.3 Solder

ASTM, DIN, B5, or EN Standards.

2.1.4 Fasteners

Fasteners shall be compatible with the fastened material and shall be best suited for the application. Space fasteners at 300 mm O.C., typical.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Cleats

Provide cleats for sheet metal 450 mm and over in width. Space cleats evenly not over 300 mm on center unless otherwise specified or indicated. Unless otherwise specified, provide cleats of 50 mm wide by 75 mm long and of the same material and thickness as the sheet metal being installed. Secure one end of the cleat with two nails and the cleat folded back over the nailheads. Lock the other end into the seam. Where the fastening is to be made to concrete or masonry, use screws and drive in expansion shields set in concrete or masonry. Pretin cleats for soldered seams.

3.1.2 Riveting

Provide mechanically formed joints in aluminum sheets 1.0 mm or less in thickness.

3.1.3 Seaming

Straight and uniform in width and height with no solder showing on the face.

3.1.3.1 Flat-lock Seams

Finish not less than 25 mm wide. Unsoldered plain-lap seems shall lap not less than 75 mm unless otherwise specified. Flat seams shall be made in the direction of flow.

3.1.4 Soldering

Where soldering is specified, apply to copper, terne-coated stainless steel, and zinc-coated steel items. Pretin edges of sheet metal before soldering is begun. Seal the joints in aluminum sheets of 0.040 inch or less in thickness with specified sealants. Do not solder aluminum.

3.1.4.1 Edges

Flux brush the seams in before soldering. Treat with soldering acid flux the edges of stainless steel to be pretinned. Seal the joints in aluminum sheets of one mm or less in thickness with specified sealants. Do not solder aluminum.

-- End of Section --

SECTION 07 92 00

JOINT SEALANTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C 920	(2008) Standard Specification for Elastomeric Joint Sealants

1.2 SUBMITTALS

Submit for approval all sealants and backings.

1.3 ENVIRONMENTAL CONDITIONS

Apply sealant when the ambient temperature is between 4 and 32 degrees C.

1.4 DELIVERY AND STORAGE

Deliver materials to the job site in unopened manufacturers' external shipping containers, with brand names, date of manufacture, color, and material designation clearly marked thereon. Label elastomeric sealant containers to identify type, class, grade, and use. Carefully handle and store materials to prevent inclusion of foreign materials or subjection to sustained temperatures exceeding 32 degrees C or less than 4 degrees C.

1.5 QUALITY ASSURANCE

1.5.1 Compatibility with Substrate

Verify that each of the sealants are compatible for use with joint substrates and backing.

1.5.2 Joint Tolerance

Provide joint tolerances in accordance with manufacturer's printed instructions.

PART 2 PRODUCTS

2.1 SEALANTS

2.1.1 Latex

Interior use only; limited joint movement only: latex sealant shall be single-component, latex formulation with fillers, pigments, and chemical additives.

2.1.2 Exterior Sealant

Exterior sealant shall be a one component, gun grade, moisture curing silicone or polyurethane sealant to be used for sealing and caulking applications in active exterior joints. Joint movement capability shall be -25 percent to +25 percent. Sealer shall be weather resistant. Sealer shall bond to most construction material without using a primer. Sealer shall conform to ASTM C 920 or DIN, BS, or EN Equal Standards.

2.2 PRIMERS

Provide a nonstaining, quick-drying type and consistency recommended by the sealant manufacturer for the particular application.

2.3 BOND BREAKERS

Provide the type and consistency recommended by the sealant manufacturer to prevent adhesion of the sealant to backing or to bottom of the joint.

2.4 BACKING

Provide glass fiber roving or neoprene, butyl, polyurethane, or polyethylene foams free from oil or other staining elements as recommended by sealant manufacturer. Provide 25 to 33 percent oversized backing for closed cell and 40 to 50 percent oversized backing for open cell material, unless otherwise indicated. Make backstop material compatible with sealant. Do not use oakum and other types of absorptive materials as backstops.

2.4.1 Rubber

Cellular rubber sponge backing shall be closed cell type suitable for intended locations of use; provide oil and fuel-resistant type at horizontal surfaces; round cross section.

2.4.2 Synthetic Rubber

Synthetic rubber backing shall be performed rods or tubes.

2.4.3 Neoprene

Neoprene backing shall be closed cell expanded neoprene chord.

2.5 CLEANING SOLVENTS

Provide type(s) recommended by the sealant manufacturer.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Clean surfaces from dirt frost, moisture, grease, oil, wax, lacquer, paint, or other foreign matter that would tend to destroy or impair adhesion. Remove oil and grease with solvent. Surfaces must be wiped dry with clean cloths.

3.2 APPLICATION

3.2.1 Sealants

Provide a sealant compatible with the material(s) to which it is applied. Do not use a sealant that has exceeded shelf life be discharged in a continuous flow from the gun. Apply the sealant with a gun having a nozzle that fits the joint width. Force sealant into joints to fill the joints solidly without air pockets. Tool sealant after application to ensure adhesion. Make sealant uniformly smooth and free of wrinkles. Upon completion of sealant application, roughen partially filled or unfilled joints, apply sealant, and tool smooth as specified. Apply sealer over the sealant when and as specified by the sealant manufacturer.

3.3 PROTECTION AND CLEANING

3.3.1 Final Cleaning

Upon completion of sealant application, remove remaining smears and stains and leave the work in a clean and neat condition.

-- End of Section --

SECTION 08 11 13

STEEL DOORS AND FRAMES

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2008; Errata 2008) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A 653/A 653M	(2009a) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

1.2 SUBMITTALS

Submit for approval one sample of each type of steel door and frame to be installed. Sample to be returned for installation after approval.

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver doors, frames, and accessories undamaged and with protective wrappings or packaging. Provide temporary steel spreaders securely fastened to the bottom of each welded frame. Store doors and frames on platforms under cover in clean, dry, ventilated, and accessible locations, with 6 mm airspace between doors. Remove damp or wet packaging immediately and wipe affected surfaces dry. Replace damaged materials with new.

PART 2 PRODUCTS

2.1 MANUFACTURERS

Acceptable Manufacturers: Cozuman or equal.

2.2 STEEL DOORS

Zinc coated steel meeting ASTM A 653/A 653M or DIN, BS, or EN Equal Standards, except as specified otherwise. Prepare doors to receive door hardware as specified in Section 08 71 00. Undercut where indicated. Exterior doors shall have top edge closed flush and sealed to prevent water intrusion. Doors shall be 44.5 mm thick, unless otherwise indicated.

Doors shall be constructed using heavy gage steel with minimum thickness of 0.7 mm.

2.3 STANDARD STEEL FRAMES

ASTM, DIN, BS, or EN Standards, except as otherwise specified. Form frames to sizes and shapes indicated, with welded corners. Provide steel frames for doors unless otherwise indicated.

2.3.1 Steel Thickness

Steel frame shall be as recommended by the manufacturer to support the heavy gage doors.

2.3.2 Welded Frames

Continuously weld frame faces at corner joints. Mechanically interlock or continuously weld stops and rabbets. Grind welds smooth.

Weld frames in accordance with the recommended practice of the Structural Welding Code Sections 1 through 6, AWS D1.1/D1.1M and in accordance with the practice specified by the producer of the metal being welded.

2.3.3 Stops and Beads

Form stops and beads from 0.9 mm thick steel. Provide for openings in standard steel frames. Secure beads to frames with oval-head, countersunk Phillips self-tapping sheet metal screws or concealed clips and fasteners. Space fasteners approximately 300 to 400 mm on center. Miter molded shapes at corners. Butt or miter square or rectangular beads at corners.

2.3.4 Cased Openings

Fabricate frames for cased openings of same material, gage, and assembly as specified for metal door frames, except omit door stops and preparation for hardware.

2.3.5 Anchors

Provide anchors to secure the frame to adjoining construction. Provide steel anchors, zinc-coated.

2.3.5.1 Wall Anchors

Provide at least three anchors for each jamb.

a. Masonry: Provide anchors of corrugated or perforated steel straps or 5 mm diameter steel wire, adjustable or T-shaped;

b. Completed openings: Secure frames to previously placed concrete or masonry with expansion bolts.

2.3.5.2 Floor Anchors

Provide floor anchors drilled for 10 mm anchor bolts at bottom of each jamb member.

2.4 WEATHERSTRIPPING

As specified in Section 08 71 00 DOOR HARDWARE.

2.4.1 Integral Gasket

Black synthetic rubber gasket with tabs for factory fitting into factory slotted frames, or extruded neoprene foam gasket made to fit into a continuous groove formed in the frame, may be provided in lieu of head and jamb seals specified in Section 08 71 00 DOOR HARDWARE. Insert gasket in groove after frame is finish painted.

2.5 HARDWARE PREPARATION

Provide minimum hardware reinforcing gages as specified in DIN, BS, or EN Standards. Drill and tap doors and frames to receive finish hardware. Prepare doors and frames for hardware in accordance with the manufacturer's requirements. Drill and tap for surface-applied hardware at the project site. Build additional reinforcing for surface-applied hardware into the door at the factory. Locate hardware in accordance with the requirements of DIN, BS, or EN Standards, as applicable. Punch door frames, with the exception of frames that will have weatherstripping to receive a minimum of two rubber or vinyl door silencers on lock side of single doors and one silencer for each leaf at heads of double doors. Set lock strikes out to provide clearance for silencers.

2.6 FINISHES

Steel doors shall be factory primed and field painted in accordance with the requirements of Section 09 90 00 PAINTS AND COATINGS. Provide prefinished doors and accessories where indicated.

2.7 FABRICATION AND WORKMANSHIP

Finished doors and frames shall be strong and rigid, neat in appearance, and free from defects, waves, scratches, cuts, dents, ridges, holes, warp, and buckle. Molded members shall be clean cut, straight, and true, with joints coped or mitered, well formed, and in true alignment. Dress exposed welded and soldered joints smooth. Design door frame sections for use with the wall construction indicated. Corner joints shall be well formed and in true alignment. Conceal fastenings where practicable. On wraparound frames for masonry partitions, provide a throat opening 3 mm larger than the actual masonry thickness. Design frames in exposed masonry walls or partitions to allow sufficient space between the inside back of trim and masonry to receive calking compound.

2.7.1 Grouted Frames

Fill the stops with strips of rigid insulation to keep the grout out of the stops and to facilitate installation of stop-applied head and jamb seals.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Frames

Plumb, align, and brace securely until permanent anchors are set. Anchor bottoms of frames with expansion bolts or powder-actuated fasteners. Build in or secure wall anchors to adjoining construction. Backfill frames with mortar. Coat inside of frames with corrosion-inhibiting bituminous material. For frames in exterior walls, ensure that stops are filled with rigid insulation before grout is placed.

3.1.2 Doors

Hang doors in accordance with clearances recommended by door manufacturer. After erection and glazing, clean and adjust hardware.

3.2 PROTECTION

Protect doors and frames from damage. Repair damaged doors and frames prior to completion and acceptance of the project or replace with new, as directed. Wire brush rusted frames until rust is removed. Clean thoroughly. Apply an all-over coat of rust-inhibitive paint of the same type used for shop coat.

3.3 CLEANING

Upon completion, clean exposed surfaces of doors and frames thoroughly. Remove mastic smears and other unsightly marks.

3.4 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of inch-pound measurements, and not on metric measurement commonly agreed to by the manufacturers or other parties. The inch-pound and metric measurements are as follows:

PRODUCTS	INCH POUND	METRIC
Door thickness	1 3/4"	44.5 mm
Steel channels	16 gage	1.5 mm
Steel Sheet	23 gage	0.7 mm
	20 gage	1.5 mm
	13 gage	0.9 mm
	16 gage	1.2 mm
Anchor bolts	3/8 in	10 mm

-- End of Section --

SECTION 08 34 19.10 20

ROLLING SERVICE DOORS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M	(2009) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 653/A 653M	(2009a) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A 780/A 780M	(2009) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

1.2 SUBMITTALS

Submit roll up door and frame for it to be installed for approval. Sample to be returned for installation after approval.

1.3 DELIVERY AND STORAGE

Protect doors and accessories from damage during delivery, storage, and handling. Clearly mark manufacturer's brand name. Store doors in dry locations with adequate ventilation, free from dust and water, and in such a manner as to permit access for inspection and handling. Handle doors carefully to prevent damage. Remove damaged items that cannot be restored to like-new condition and provide new items.

PART 2 PRODUCTS

2.1 ROLLING SERVICE DOORS

Shall be spring counterbalanced, rolling type, and shall be designed for use on exterior openings, as indicated. Doors shall be operated by hand chain with gear or sprocket reduction. Doors shall be complete with guides, hardware, fastenings, operating mechanisms, and accessories. Doors shall be surface-mounted type with guides at jambs set back a sufficient distance to provide a clear opening when door is in open position. Doors, hardware, and anchors shall be designed to withstand a wind pressure of 0.96 kilopascals of door area without damage. Exterior doors shall be mounted as indicated.

2.2 FABRICATION

2.2.1 Curtains

Shall be formed of interlocking galvanized steel slats of shapes standard with the manufacturer, except that slats for exterior doors shall be flat type. Curtain shall roll up on a barrel supported at head of opening on brackets and be balanced by a torsional spring system in the barrel. Slats for doors less than 4500 mm wide shall be not lighter than 0.8 mm thick. Slats shall be of the gage required for the width indicated and the wind pressure specified above. Slats for exterior doors shall be insulated with not less than 13 mm thick polyurethane or polyisocyanurate foam insulation. Interior side of insulation shall be covered with interlocking galvanized steel slats not lighter than 0.6 mm thick.

2.2.2 Endlocks and Windlocks

The ends of each slat or each alternate slat shall have malleable iron or galvanized steel endlocks of manufacturer's stock design.

2.2.3 Bottom Bar

The curtain shall have a steel bottom bar consisting of two angles of equal weight, one on each side, or an equivalent extruded aluminum section, fastened to bottom of curtain. In addition, exterior doors shall have a compressible and replaceable rubber, neoprene, or vinyl weather seal attached to bottom bar.

2.2.4 Guides

Steel structural shapes or formed steel shapes fastened to wall with steel shapes not less than 5 mm thick. Guides shall be of sufficient depth or shall incorporate a steel locking bar to retain the curtain in place under the wind pressure specified. Provide continuous vinyl or neoprene weather seals on guides at exterior doors. Securely attach guides to adjoining construction with not less than 10 mm diameter bolts, spaced near each end and not over 750 mm apart.

2.2.5 Barrel

Steel pipe or commercial welded steel tubing of proper diameter and thickness for the size of curtain. Deflection shall not exceed one mm per 400 mm of span. Close ends of barrel with cast-iron plugs, machined to fit the pipe and either pinned or attached with screws in the spring barrel, except that drive end plug may be steel welded in place. Welding shall not be used on the tension end. Install within the barrel an oil-tempered, stress relieved, helical, counterbalancing steel spring, capable of producing sufficient torque to assure easy operation of the door curtain from any position. At least 80 percent of the door weight shall be counterbalanced at any position. Spring-tension shall be adjustable without removing the hood.

2.2.6 Brackets

Fabricate of steel plate or heavy cast iron to support the barrel, curtain, and operator and to form a supporting ring and end closure for the hood. Provide prelubricated, self-aligning ball bearings, shielded or sealed.

2.2.7 Hoods

Steel, not lighter than 0.6 mm thick formed to fit contour of end brackets and reinforced with steel rods, or rolled beads at top and bottom edges. Provide a weather baffle at the lintel or inside the hood of each exterior door.

2.2.8 Locking Device

For each manually operated exterior rolling door provide manufacturer's standard chain- or bar-type locking device on the inside. The locking device shall be of type to receive a padlock with a 8 mm diameter shackle.

2.3 MANUAL OPERATION

2.3.1 Manual Push-Up Operation

Provide lifting handles on both sides of door and counterbalance in a manner to provide easy operation while raising or lowering the curtain by hand. The force required to operate the door shall not exceed 11 kgs. Provide pull-down straps or pole hooks on bottom rail of doors over 2130 mm high.

2.3.2 Manual Hand-Chain Operation

Provide galvanized, endless chain operating over a sprocket and extending to within 900 mm of floor. Obtain reduction by use of roller chain and sprocket drive or suitable gearing. Gears shall be high-grade gray iron, cast from machine-cut patterns. The pull required to operate the door shall not exceed 15 kgs.

2.4 FINISHES

Slats, steel bottom bars, and hoods shall be hot-dip galvanized and shop primed. Shop prime other parts of coiling doors, except faying surfaces.

2.4.1 Primed Finish

Clean surfaces thoroughly, treat to assure maximum paint adherence, and provide a factory dip or spray coat of rust-inhibitive metallic oxide or synthetic resin primer on exposed surfaces.

2.4.2 Galvanized and Shop-Primed Finish

Surfaces specified shall have a zinc coating, a phosphate treatment, and a shop prime coat of rust-inhibitive paint. The galvanized coating shall conform to ASTM A 653/A 653M, coating designation Z275, for steel sheets. The weight of coatings for products shall be as designated in Table I of ASTM A 123/A 123M for the thickness of base metal to be coated. The prime coat shall be a type especially developed for materials treated by phosphates and adapted to application by dipping or spraying. Repair damaged zinc-coated surfaces by the materials and methods conforming to ASTM A 780/A 780M and spot prime. At the option of the Contractor, a two-part system including bonderizing, baked-on epoxy primer, and baked-on enamel top coat may be applied to slats before forming, in lieu of prime coat specified.

PART 3 EXECUTION

3.1 INSTALLATION

Install doors in accordance with approved detail drawings and manufacturer's directions. Locate anchors and inserts for guides, brackets, hardware, and other accessories accurately. Upon completion, doors shall be weathertight and shall be free from warp, twist, or distortion.

3.2 FINAL ADJUSTMENT

Doors shall be lubricated and properly adjusted to operate freely.

-- End of Section --

SECTION 08 71 00

DOOR HARDWARE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101 (2009; Amd 09-1 & 09-2) Life Safety Code

1.2 SUBMITTALS

Submit for approval one of each type of door hardware item as listed in Section 08 71 00 DOOR HARDWARE, "HARDWARE SCHEDULE".

1.3 HARDWARE SCHEDULE

Hardware shall match that required by the original contract and as directed by USAID Implementing Partner.

1.4 KEY BITTING CHART REQUIREMENTS

Key bitting shall match original contract requirements as directed by the USAID Implementing Partner.

1.5 DELIVERY, STORAGE, AND HANDLING

Deliver hardware in original individual containers, complete with necessary appurtenances including fasteners and instructions. Mark each individual container with item number as shown in hardware schedule.

PART 2 PRODUCTS

2.1 TEMPLATE HARDWARE

Provide hardware to be applied to metal manufactured to template. Promptly furnish template information or templates to door and frame manufacturers. Coordinate hardware items to prevent interference with other hardware.

2.2 HARDWARE ITEMS

Clearly and permanently mark with the manufacturer's name or trademark, hinges, locks, latches, exit devices, bolts and closers where the identifying mark will be visible after the item is installed. For closers with covers, the name or trademark may be beneath the cover.

2.2.1 Hinges

120 by 83 mm by 4 mm thick, unless otherwise indicated. Construct 5-knuckle, 4-hole, satin finish hinges so that pins will be nonremovable

when door is closed. Provide four hinges for each exterior door leaf and three hinges for each exterior door leaf.

Acceptable Manufacturer: Meysa or equal.

2.2.2 Locks and Latches

Provide locks, keys and latches as required, matching original contract, and as required by USAID Implementing Partner.

2.2.3 Weather Stripping Gasketing

Provide the type and function designation as specified. Provide a set to include head and jamb seals. Provide weather stripping with the following:

2.2.3.1 Door Gasketing

Generally provide continuous weather-strip gasketing on exterior doors. Provided non-corrosive fasteners for exterior applications.

a. Perimeter Gasketing: Apply to head and jambs, forming seal between door and frame.

b. Door Bottoms: Apply to bottom of door, forming seal with threshold when door is closed.

2.2.4 Special Tools

Provide special tools, such as spanner and socket wrenches and dogging keys, required to service and adjust hardware items.

2.3 FASTENERS

Provide fasteners of proper type, quality, size, quantity, and finish with hardware. Provide stainless steel or nonferrous metal fasteners that are exposed to weather. Provide fasteners of type necessary to accomplish a permanent installation.

2.4 FINISHES

Provide hardware with finish as required by original Contract and as directed by the USAID Implementing Partner.

PART 3 EXECUTION

3.1 INSTALLATION

Install hardware in accordance with manufacturers' printed installation instructions. Provide machine screws set in expansion shields for fastening hardware to solid concrete and masonry surfaces. Provide through bolts where necessary for satisfactory installation.

3.1.1 Weather Stripping Installation

Handle and install weather stripping to prevent damage. Provide full contact, weather-tight seals. Operate doors without binding.

3.1.1.1 Stop-Applied Weather Stripping

Fasten to frame with color-matched sheet metal screws not more than 225 mm on center after doors and frames have been finish painted.

3.2 EXIT DOORS

Install hardware in accordance with NFPA 101 for exit doors.

3.3 HARDWARE LOCATIONS

As indicated and directed by USAID Implementing Partner.

3.4 FIELD QUALITY CONTROL

After installation, protect hardware from paint, stains, blemishes, and other damage until acceptance of work. Submit notice of testing 15 days before scheduled, so that testing can be witnessed by the USAID Implementing Partner. Adjust hinges, locks, latches, bolts, holders, and other items to operate properly. Demonstrate that permanent keys operate respective locks, and give keys to the USAID Implementing Partner. Correct, repair, and finish, as directed, errors in cutting and fitting and damage to adjoining work.

3.5 HARDWARE SETS

Hardware sets per original contract and as directed by the USAID Implementing Partner.

-- End of Section --

SECTION 08 91 00

METAL WALL LOUVERS

PART 1 GENERAL

1.1 SUBMITTALS

Submit for approval, prior to material delivery to site, a sample louver. Lourer will be returned for installation after approval.

1.2 DELIVERY, STORAGE, AND PROTECTION

Deliver materials to the site in an undamaged condition. Carefully store materials off the ground to provide proper ventilation, drainage, and protection against dampness. Louvers shall be free from nicks, scratches, and blemishes. Replace defective or damaged materials with new.

1.3 DETAIL DRAWINGS

Show all information necessary for fabrication and installation of wall louvers. Indicate materials, sizes, thicknesses, fastenings, and profiles.

1.4 COLOR SAMPLES

Colors of finishes for wall louvers shall closely approximate colors indicated. Where color is not indicated, submit the manufacturer's standard colors to the USAid Implementing Partner for selection.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Extruded Aluminum

ASTM, DIN, BS, or EN Standards.

2.2 METAL WALL LOUVERS

Weather resistant type, with bird screens. Wall louvers shall bear a AMCA certified ratings program seal for air performance and water penetration. Provide integral gravity (backdraft) intake damper at louver. Provide size indicated on drawings.

2.2.1 Extruded Aluminum Louvers

Fabricated of extruded aluminum with a wall thickness of not less than 2 mm.

2.2.2 Mullions and Mullion Covers

Same material and finish as louvers. Provide mullions where indicated. Provide mullions covers on both faces of joints between louvers.

2.2.3 Screens and Frames

For aluminum louvers, provide 6 mm square mesh, 1.5 mm aluminum bird screening. Mount screens in removable, rewirable frames of same material

and finish as the louvers.

2.3 FASTENERS AND ACCESSORIES

Provide stainless steel screws and fasteners for aluminum louvers. Provide other accessories as required for complete and proper installation.

2.4 FINISHES

2.4.1 Aluminum

Exposed aluminum surfaces shall be factory finished with an anodic coating. Color shall beselected by USAid Implementing Partner. All Louvers shall have the same finish.

2.4.1.1 Anodic Coating

Clean exposed aluminum surfaces and provide an anodized finish.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Wall Louvers

Install using stops or moldings, flanges, strap anchors, or jamb fasteners as appropriate for the wall construction and in accordance with manufacturer's recommendations. Adjust backdraft damper to open when exhaust fan runs and close securely when fan is off.

3.1.2 Screens and Frames

Attach frames to louvers with screws or bolts.

3.2 PROTECTION FROM CONTACT OF DISSIMILAR MATERIALS

3.2.1 Aluminum

Where aluminum contacts metal other than zinc, paint the dissimilar metal with a primer and two coats of aluminum paint.

3.2.2 Metal

Paint metal in contact with mortar, concrete, or other masonry materials with alkali-resistant coatings such as heavy-bodied bituminous paint.

-- End of Section --

SECTION 09 22 00

SUPPORTS FOR PLASTER AND GYPSUM BOARD

PART 1 GENERAL

1.1 SUBMITTALS

Submit for approval samples of metal support system components.

1.2 DELIVERY, STORAGE, AND HANDLING

Deliver materials to the job site and store in ventilated dry locations. Storage area shall permit easy access for inspection and handling. If materials are stored outdoors, stack materials off the ground, supported on a level platform, and fully protected from the weather. Handle materials carefully to prevent damage. Remove damaged items and provide new items.

PART 2 PRODUCTS

2.1 MATERIALS

Provide steel materials for metal support systems with galvanized coating aluminum coating; or a 55-percent aluminum-zinc coating.

2.1.1 Materials for Attachment of Lath

2.1.1.1 Suspended and Furred Ceiling Systems and Wall Furring

2.1.2 Materials for Attachment of Gypsum Wallboard

2.1.2.1 Suspended and Furred Ceiling Systems

2.1.2.2 Z-Furring Channels with Wall Insulation

Not lighter than 0.5 mm thick galvanized steel, Z-shaped, with 32 mm and 19 mm flanges and 20 mm furring depth.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Systems for Attachment of Lath

3.1.1.1 Wall Furring

Z-Furring channels..

3.1.2 Systems for Attachment of Gypsum Wallboard

3.1.2.1 Suspended and Furred Ceiling Systems

Provide framing members 400 mm o.c. unless indicated otherwise.

3.2 ERECTION TOLERANCES

Provide framing members which will be covered by finish materials such as wallboard, and plaster, within the following limits:

a. Layout of walls and partitions: 6 mm from intended position;

b. Face of framing members: 5 mm in 1.9 meters from a true plane.

-- End of Section --

SECTION 09 24 23

STUCCO

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C 150/C 150M	(2009) Standard Specification for Portland Cement
ASTM C 926	(2006) Application of Portland Cement-Based Plaster

1.2 SUBMITTALS

Submit for approval samples of Stucco producots and accessories.

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver packaged materials to the site in the original packages and containers with labels intact and seals unbroken. Keep cementitious materials dry and stored off the ground, under cover and away from damp surfaces until ready to be used. Aggregate shall be covered to prevent the absorption or loss of moisture.

1.4 ENVIRONMENTAL REQUIREMENTS

Do not apply stucco when the ambient temperature is 4 degrees C or lower, or when a drop in temperature below 4 degrees C is expected within 48 hours after application.

PART 2 PRODUCTS

2.1 PORTLAND CEMENT

Portland cement shall conform to ASTM C 150/C 150M, BIN, BS, or EN equal standards.

2.2 STUCCO FINISH COAT

Stucco finish coat shall be a mill mixed product using portland cement and requiring only the addition of, and mixing with water for application.

2.3 LIME

Lime shall be a special hydrated finishing lime composed primarily of calcium and magnesium oxides and suitable for use in Stucco base coats.

2.4 SAND

Sand aggregate for job-mixed base coat stucco shall be natural or manufactured sand suitable for use in Stucco base coats.

2.5 ACCESSORIES

Accessories shall be roll formed galvanized steel, except that cornerite and striplath shall be formed from steel sheets with manufacturer's standard galvanized coating. Welded wire corner reinforcements shall be zinc coated, galvanized 1.4 mm steel wire. Furring shall include hangers, bolts, inserts, clips, fastenings, and attachments of number, size, and design to develop the full strength of the members.

2.6 METAL LATH

Lath for vertical application on steel and wood framing supports shall be expanded metal or woven wire and shall have paper backing. Woven wire lath shall be a maximum 38 x 38 mm mesh wire of not less than 1.37 mm nominal diameter. Expanded metal or wire lath shall be fabricated in a manner to provide not less than 6 mm keying between wire and paper backing and keying shall be obtained by a uniform series of slots in a perforated face paper woven between the wires.

2.7 FINISH

Paint for Stucco shall be per Section 09 90 00 PAINTS AND COATINGS.

2.8 WATER

Provide clean, fresh, potable water, free from amounts of oils, acids, alkalis and organic matter that would be injurious to the stucco.

PART 3 EXECUTION

3.1 FRAMING

Framing shall be installed as indicated.

3.2 CONTROL JOINTS

Control joints shall be located as indicated on the drawings. Prefabricated control joint members shall be installed prior to the application of the stucco. Control joints shall be cleared of all stucco within the control area after stucco application and prior to final stucco set.

3.3 LATH

Metal and wire lath shall be applied straight, without buckles and with joints staggered. End laps of metal lath shall be not less than 25 mm. When paper-backed lath is used, the paper shall be split from the lath at all lap areas to provide a paper to paper and lath to lath lap. Horizontal joints shall be shiplapped. Lath shall be interrupted at all control joints. Submit drawings showing details of construction for reinforcement, furring, and grounds; including manufacturer's installation instructions for stucco materials, and locations where each mix and coating thickness will be used.

3.3.1 Steel Supports

Metal lath without integral backing over vertical open or solid steel backing frame construction shall be applied only after a backing of shiplapped waterproofed building paper or other approved material has been applied to the area to receive the stucco. Lath shall be secured to steel frames.

3.3.2 On Concrete and Masonry

Fasten lath every 200 mm vertically and every 400 mm horizontally.

3.3.3 Over Metal Lintels and Flashings

Lath over metal flashings shall lap the flashings not less than 50 mm and shall be extended vertically for a height of not less than 150 mm.

3.3.4 Special Shapes, Profiles, and Contours

Special shapes, profiles, and contours shall be formed with metal or aluminum furring and reinforcing.

3.4 FURRING

Furring shall be installed to true lines and surfaces and shall be rigidly supported and secured in place.

3.5 PREPARATION OF SURFACES

Preparation of surfaces for application of stucco to solid bases such as masonry or concrete shall conform to the applicable requirements of ASTM C 926, DIN, BS, or EN Standards.

3.6 PROPORTIONS AND MIXING

Proportions and mixing for job-mixed base coat and finish coat shall conform to the applicable requirements of ASTM C 926, DIN, BS, or EN Standards. Mixing of mill-mixed finish coat shall be in accordance with the manufacturer's directions. Submit detailed description of the proposed job-mix proportions for base and finish coats; including identification of thickness of coats.

3.7 STUCCO APPLICATION

Stucco shall be applied in three coats to a thickness of not less than 20 mm as measured from the back plane of metal reinforcement, exclusive of ribs or dimples or from the face of solid backing or support, with or without metal reinforcement, to the finished stucco surface, including moderate texture variations. Stucco application shall conform to the applicable requirements of ASTM C 926, DIN, BS, or EN Standards.

3.7.1 Workmanship

Items or features of the work in connection with or adjoining the stucco shall be in place, plumb, straight, and true prior to beginning the stucco work. Metal and wire lath, where required, shall be in place and positioned to provide a good key at back of lath. Where lath is applied over copper, the copper shall be given a heavy coat of bituminous paint. Masonry surfaces to receive stucco shall be evenly dampened immediately

prior to application of stucco. Each stucco coat shall be applied continuously in one general direction, without allowing mortar to dry at edges. Where it is impossible to work the full dimension of a wall surface in a continuous operation, jointing shall be made at a break, opening, or other natural division of the surface. Edges to be joined shall be dampened slightly to produce a smooth confluence. Exterior corners of stucco shall be slightly rounded. Stucco on soffit surfaces shall be pitched forward to form a drip.

3.7.2 Scratch Coat

Scratch coat shall be applied not less than 10 mm thick under sufficient pressure to form good keys and to completely embed the reinforcement. Before the scratch coat has set, it shall be lightly scratched in one direction and vertical surfaces shall be scratched in the horizontal direction only. The scratch coat shall be fog cured for a minimum of 72 hours.

3.7.3 Brown Coat

The scratch coat shall be dampened evenly to obtain uniform suction before the brown coat is applied. There shall be no visible water on the surface when the brown coat is applied. The brown coat shall be applied to the scratch coat with sufficient pressure to force the stucco into the scratches and shall be brought to a plumb, true, even plane with rod or straightedge. When set sufficiently, the brown coat shall be uniformly floated with a dry float to promote densification of the coat and to provide a surface receptive to bonding of the finish coat. Brown coat shall be fog cured for a minimum of 72 hours.

3.7.4 Finish Coat

Surfaces of the brown coat shall be dampened not more than 1 hour before the finish coat is to be applied to a uniform wetness with no free-standing water on the surface. The finish coat shall have a smooth trowel finish and shall conform to the approved sample. The finish coat shall be fog cured for a minimum of 48 hours. Care shall be taken to prevent staining.

3.7.5 Surface Tolerance

When a 3 m straightedge is placed at any location on the finished surface of the stucco, excluding rough-textured finish, the surface shall not vary more than 3 mm from the straightedge.

3.8 CURING AND PROTECTION

Perform fog curing by applying a fine mist of water to the stucco. Care shall be exercised during fog curing to avoid erosion damage of the stucco surfaces. Do not use a solid stream of water. Frequency of fogging shall be not less than three times daily. Protect the stucco from the direct rays of the sun during severe drying conditions using canvas, cloth or other approved sheet material, when directed.

3.9 PATCHING AND POINTING

Loose, cracked, damaged or defective work shall be replaced or patched as directed. Patching shall match existing work in texture and color and shall be finished flush.

-- End of Section --

SECTION 09 29 00

GYPSUM BOARD

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C 1396/C 1396M	(2009; R 2009a) Standard Specification for Gypsum Board
ASTM C 475/C 475M	(2002; R 2007) Joint Compound and Joint Tape for Finishing Gypsum Board
ASTM C 840	(2008) Application and Finishing of Gypsum Board

1.2 SUBMITTALS

Submit for approval sample gypsum board and accessories prior to delivery to site.

1.3 DELIVERY, STORAGE, AND HANDLING

1.3.1 Delivery

Deliver materials in the original packages, containers, or bundles with each bearing the brand name, applicable standard designation, and name of manufacturer, or supplier.

1.3.2 Storage

Keep materials dry by storing inside a sheltered building. Where necessary to store gypsum board and cementitious backer units outside, store off the ground, properly supported on a level platform, and protected from direct exposure to rain, snow, sunlight, and other extreme weather conditions. Provide adequate ventilation to prevent condensation. Store per manufacturer's recommendations for allowable temperature and humidity range. Do not store panels near materials that may offgas or emit harmful fumes, such as kerosene heaters, fresh paint, or adhesives.

1.3.3 Handling

Neatly stack gypsum board and cementitious backer units flat to prevent sagging or damage to the edges, ends, and surfaces.

1.4 ENVIRONMENTAL CONDITIONS

1.4.1 Temperature

Maintain a uniform temperature of not less than 10 degrees C in the structure for at least 48 hours prior to, during, and following the application of gypsum board, cementitious backer units, and joint treatment materials, or the bonding of adhesives.

1.4.2 Exposure to Weather

Protect gypsum board and cementitious backer unit products from direct exposure to rain, snow, sunlight, and other extreme weather conditions.

1.4.3 Temporary Ventilation

Provide temporary ventilation for work of this section.

1.5 QUALIFICATIONS

Furnish type of gypsum board work specialized by the installer with a minimum of 3 years of documented successful experience.

PART 2 PRODUCTS

2.1 MATERIALS

Conform to specifications, standards and requirements specified. Provide gypsum board types and joint treating materials manufactured from asbestos free materials only. Submit Material Safety Data Sheets and for gypsum materials including adhesives.

2.1.1 Gypsum Board

ASTM C 1396/C 1396M, DIN, BS, or EN Standards.

2.1.1.1 Regular

1200 mm wide, 20 mm thick, tapered edges.

2.1.2 Joint Treatment Materials

ASTM C 475/C 475M, DIN, BS, or EN Standards.

2.1.2.1 Embedding Compound

Specifically formulated and manufactured for use in embedding tape at gypsum board joints and compatible with tape, substrate and fasteners.

2.1.2.2 Finishing or Topping Compound

Specifically formulated and manufactured for use as a finishing compound.

2.1.2.3 All-Purpose Compound

Specifically formulated and manufactured to serve as both a taping and a finishing compound and compatible with tape, substrate and fasteners.

2.1.2.4 Joint Tape

Use cross-laminated, tapered edge, reinforced paper, or fiber glass mesh tape recommended by the manufacturer.

2.1.3 Fasteners

2.1.3.1 Nails

Nails shall be appropriate for intended use.

2.1.3.2 Screws

ASTM, DIN, BS, or EN Standards steel drill screws for fastening gypsum board to gypsum board, wood framing members and steel framing members less than 0.84 mm thick. ASTM, DIN, BS, or EN Standards steel drill screws for fastening gypsum board to steel framing members 0.84 to 2.84 mm thick. Provide cementitious backer unit screws with a polymer coating.

2.1.4 Adhesives

Do not use adhesive containing benzene, carbon tetrachloride, or trichloroethylene. Adhesive shall contain a maximum VOC content of 50 grams per liter.

2.1.4.1 Adhesive for Fastening Gypsum Board to Metal Framing

Not permitted.

2.1.5 Accessories

Fabricate from corrosion protected steel or plastic designed for intended use. Accessories manufactured with paper flanges are not acceptable. Flanges shall be free of dirt, grease, and other materials that may adversely affect bond of joint treatment. Provide prefinished or job decorated materials.

2.1.6 Water

Provide clean, fresh, and potable water.

PART 3 EXECUTION

3.1 EXAMINATION

3.1.1 Framing and Furring

Verify that framing and furring are securely attached and of sizes and spacing to provide a suitable substrate to receive gypsum board and cementitious backer units. Verify that all blocking, headers and supports are in place. Do not proceed with work until framing and furring are acceptable for application of gypsum board.

3.2 APPLICATION OF GYPSUM BOARD

Apply gypsum board to framing and furring members in accordance with ASTM C 840, DIN, BS, or EN Standards and the requirements specified. Apply gypsum board with separate panels in moderate contact; do not force in place. Stagger end joints of adjoining panels. Neatly fit abutting end

and edge joints. Use gypsum board of maximum practical length; select panel sizes to minimize waste. Cut out gypsum board to make neat, close, and tight joints around openings. In vertical application of gypsum board, provide panels in lengths required to reach full height of vertical surfaces in one continuous piece. Lay out panels to minimize waste; reuse cutoffs whenever feasible. Surfaces of gypsum board and substrate members may not be bonded together with an adhesive. Treat edges of cutouts for plumbing pipes, screwheads, and joints with water-resistant compound as recommended by the gypsum board manufacturer.

3.2.1 Application of Gypsum Board to Steel Framing and Furring

Apply in accordance with ASTM C 840, DIN, BS, or EN Standards.

3.3 FINISHING OF GYPSUM BOARD

Tape and finish gypsum board in accordance with ASTM C 840, DIN, BS, or EN Standards. Provide joint, fastener depression, and corner treatment. Tool joints as smoothly as possible to minimize sanding and dust. Do not use fiber glass mesh tape with conventional drying type joint compounds; use setting or hardening type compounds only. Protect workers, building occupants, and HVAC systems from gypsum dust.

3.4 SEALING

Seal openings around pipes, fixtures, and other items projecting through gypsum board and cementitious backer units as specified in Section 07 92 00 JOINT SEALANTS Apply material with exposed surface flush with gypsum board or cementitious backer units.

3.5 PATCHING

Patch surface defects in gypsum board to a smooth, uniform appearance, ready to receive finishes.

-- End of Section --

SECTION 09 90 00

PAINTS AND COATINGS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6/NACE No.3 (2007) Commercial Blast Cleaning

1.2 SUBMITTALS

Submit the following for approval: Contractor shall submit the following using procedures as specified in the Contract Documents.

The current MPI, "Approved Product List" which lists paint by brand, label, product name and product code as of the date of contract award, will be used to determine compliance with the submittal requirements of this specification. The Contractor may choose to use a subsequent MPI "Approved Product List", however, only one list may be used for the entire contract and each coating system is to be from a single manufacturer. All coats on a particular substrate must be from a single manufacturer. No variation from the MPI Approved Products List is acceptable.

1.2.1 SD-03 Product Data

Coating
Manufacturer's Technical Data Sheets

1.2.2 SD-04 Samples

If product data or other submittal data is not available, the Contractor's QC Manager may request samples be provided to verify acceptability of the item to be furnished.

Color

Submit manufacturer's samples of paint colors. Cross reference color samples to color scheme as indicated.

1.3 STANDARDS

Contractor may also use ASTM Standards for the work and products under this Section.

1.4 REGULATORY REQUIREMENTS

1.4.1 Lead Content

Do not use coatings having a lead content over 0.06 percent by weight of nonvolatile content.

1.4.2 Chromate Content

Do not use coatings containing zinc-chromate or strontium-chromate.

1.4.3 Asbestos Content

Materials shall not contain asbestos.

1.4.4 Mercury Content

Materials shall not contain mercury or mercury compounds.

1.4.5 Silica

Abrasive blast media shall not contain free crystalline silica.

1.4.6 Human Carcinogens

Materials shall not contain confirmed human carcinogens or suspected human carcinogens.

1.5 PACKAGING, LABELING, AND STORAGE

Paints shall be in sealed containers that legibly show the contract specification number, designation name, formula or specification number, batch number, color, quantity, date of manufacture, manufacturer's formulation number, manufacturer's directions including any warnings and special precautions, and name and address of manufacturer. Pigmented paints shall be furnished in containers not larger than 20 liters. Paints and thinners shall be stored in accordance with the manufacturer's written directions, and as a minimum, stored off the ground, under cover, with sufficient ventilation to prevent the buildup of flammable vapors, and at temperatures between 4 to 35 degrees C.

1.6 SAFETY AND HEALTH

Apply coating materials using safety methods and equipment in accordance with the following:

Work shall comply with applicable local laws and regulations, and with the Contract Requirements.

1.6.1 Safety Methods Used During Coating Application

Comply with the Contract requirements.

1.6.2 Toxic Materials

To protect personnel from overexposure to toxic materials, conform to the most stringent guidance of:

a. The applicable manufacturer's Material Safety Data Sheets (MSDS) or local regulation.

1.7 ENVIRONMENTAL CONDITIONS

Comply, at minimum, with manufacturer recommendations for space ventilation during and after installation.

1.7.1 Coatings

Do not apply coating when air or substrate conditions are:

a. Less than 3 degrees C above dew point;

b. Below 10 degrees C or over 35 degrees C, unless specifically pre-approved by the USAID Implementing Partner and the product manufacturer. Under no circumstances shall application conditions exceed manufacturer recommendations.

1.8 COLOR SELECTION

Color will be selected by the USAID Implementing Partner from the manufacturer's standard colors.

1.9 LOCATION AND SURFACE TYPE TO BE PAINTED

1.9.1 Painting Included

Where a space or surface is indicated to be painted, include the following unless indicated otherwise.

a. Surfaces behind portable objects and surface mounted articles readily detachable by removal of fasteners, such as screws and bolts.

b. New factory finished surfaces that require identification or color coding and factory finished surfaces that are damaged during performance of the work.

c. Existing coated surfaces that are damaged during performance of the work.

1.9.1.1 Exterior Painting

Includes new surfaces of the building and appurtenances. Also included are existing coated surfaces made bare by cleaning operations.

1.9.1.2 Interior Painting

Includes new surfaces of the building and appurtenances as indicated and existing coated surfaces made bare by cleaning operations. Where a space or surface is indicated to be painted, include the following items, unless indicated otherwise.

a. Exposed columns, girders, beams, joists, and metal deck; and

b. Other contiguous surfaces.

1.9.2 Painting Excluded

Do not paint the following unless indicated otherwise.

a. Surfaces concealed and made inaccessible by panelboards, fixed ductwork, machinery, and equipment fixed in place.

b. Surfaces in concealed spaces. Concealed spaces are defined as

enclosed spaces above suspended ceilings, furred spaces, attic spaces, crawl spaces, elevator shafts and chases.

c. Steel to be embedded in concrete.

d. Copper, stainless steel, aluminum, brass, and lead except existing coated surfaces.

e. Hardware, fittings, and other factory finished items.

f. Surfaces in the following areas shall not be painted: floors.

1.9.3 Mechanical and Electrical Painting

Includes field coating of interior and exterior new surfaces.

a. Where a space or surface is indicated to be painted, include the following items unless indicated otherwise.

(1) Exposed piping, conduit, and ductwork;

(2) Supports, hangers, air grilles, and registers;

(3) Miscellaneous metalwork and insulation coverings.

b. Do not paint the following, unless indicated otherwise:

(1) New zinc-coated, aluminum, and copper surfaces under insulation

(2) New aluminum jacket on piping

(3) New interior ferrous piping under insulation.

1.9.4 Definitions and Abbreviations

1.9.4.1 Coating

A film or thin layer applied to a base material called a substrate. A coating may be a metal, alloy, paint, or solid/liquid suspensions on various substrates (metals, plastics, wood, paper, leather, cloth, etc.). They may be applied by electrolysis, vapor deposition, vacuum, or mechanical means such as brushing, spraying, calendaring, and roller coating. A coating may be applied for aesthetic or protective purposes or both. The term "coating" as used herein includes emulsions, enamels, stains, varnishes, sealers, epoxies, and other coatings, whether used as primer, intermediate, or finish coat. The terms paint and coating are used interchangeably.

1.9.4.2 DFT or dft

Dry film thickness, the film thickness of the fully cured, dry paint or coating.

1.9.4.3 DSD

Degree of Surface Degradation as defined by DIN, BS, EN Standards or equivalent.

1.9.4.4 EXT

Short term designation for an exterior coating system.

1.9.4.5 INT

Short term designation for an interior coating system.

1.9.4.6 micron / microns

The metric measurement for 0.001 mm or one/one-thousandth of a millimeter.

1.9.4.7 mm

The metric measurement for millimeter, 0.001 meter or one/one-thousandth of a meter.

1.9.4.8 MPI or DIN, BS, or EN Standards Gloss Levels

Use either the MPI system or DIN system of defining gloss. Traditionally, Flat refers to G1/G2, Eggshell refers to G3, Semigloss refers to G5, and Gloss refers to G6. Use DIN gloss levels as defined in DN 67 530, equivalent to MPI levels below.

Gloss levels are defined by MPI as follows:

Gloss Level	Description	Units @ 60 degrees	Units @ 85 degrees
G1	Matte or Flat	0 to 5	10 max
G2	Velvet	0 to 10	10 to 35
G3	Eggshell	10 to 25	10 to 35
G4	Satin	20 to 35	35 min
G5	Semi-Gloss	35 to 70	
G6	Gloss	70 to 85	
G7	High Gloss		

Historically, the Government has used Flat (G1 / G2), Eggshell (G3), Semi-Gloss (G5), and Gloss (G6).

1.9.4.9 Paint

See Coating definition.

PART 2 PRODUCTS

2.1 MATERIALS

Conform to the coating specifications and standards referenced in PART 3. Submit manufacturer's technical data sheets for specified coatings and solvents.

PART 3 EXECUTION

3.1 PROTECTION OF AREAS AND SPACES NOT TO BE PAINTED

Prior to surface preparation and coating applications, remove, mask, or otherwise protect, hardware, hardware accessories, machined surfaces,

radiator covers, plates, lighting fixtures, public and private property, and other such items not to be coated that are in contact with surfaces to be coated. Following completion of painting, workmen skilled in the trades involved shall reinstall removed items. Restore surfaces contaminated by coating materials, to original condition and repair damaged items.

3.2 SURFACE PREPARATION

Remove dirt, splinters, loose particles, grease, oil, and other foreign matter and substances deleterious to coating performance as specified for each substrate before application of paint or surface treatments. Oil and grease shall be removed prior to mechanical cleaning. Cleaning shall be programmed so that dust and other contaminants will not fall on wet, newly painted surfaces. Exposed ferrous metals such as nail heads on or in contact with surfaces to be painted with water-thinned paints, shall be spot-primed with a suitable corrosion-inhibitive primer capable of preventing flash rusting and compatible with the coating specified for the adjacent areas.

3.3 PREPARATION OF METAL SURFACES

3.3.1 Existing and New Ferrous Surfaces

a. Ferrous Surfaces including Shop-coated Surfaces and Small Areas That Contain Rust, Mill Scale and Other Foreign Substances: Solvent clean or detergent wash to remove oil and grease. Where shop coat is missing or damaged, clean according to DIN, BS, or EN Standards. Shop-coated ferrous surfaces shall be protected from corrosion by treating and touching up corroded areas immediately upon detection.

b. Surfaces With More Than 20 Percent Rust, Mill Scale, and Other Foreign Substances: Clean entire surface in accordance with DIN, BS, or EN standards.

3.3.2 Final Ferrous Surface Condition:

For abrasive blast cleaned surfaces, the requirements are stated in DIN, BS, or EN Standards. As a visual reference, cleaned surfaces shall be similar to photographs in DIN, BS, and EN Standards.

3.3.3 Non-Ferrous Metallic Surfaces

Aluminum and aluminum-alloy, lead, copper, and other nonferrous metal surfaces.

a. Surface Cleaning: Solvent clean in accordance with DIN, BS, and EN Standards and wash with mild non-alkaline detergent to remove dirt and water soluble contaminants.

3.4 PREPARATION OF CONCRETE AND CEMENTITIOUS SURFACE

3.4.1 Concrete and Masonry

a. Curing: Concrete, stucco and masonry surfaces shall be allowed to cure at least 7 days before painting, except concrete slab on grade, which shall be allowed to cure 14 days before painting.

b. Surface Cleaning: Remove the following deleterious substances.

(1) Dirt, Grease, and Oil: Wash new surfaces with a solution composed of 0.2 liter trisodium phosphate, 0.1 liter household detergent, and 6.4 liters of warm water. Then rinse thoroughly with fresh water. For large areas, water blasting may be used.

(2) Fungus and Mold: Wash new surfaces with a solution composed of 0.2 liter trisodium phosphate, 0.1 liter household detergent, 1.6 liters 5 percent sodium hypochlorite solution and 4.8 liters of warm water. Rinse thoroughly with fresh water.

(3) Paint and Loose Particles: Remove by wire brushing.

(4) Efflorescence: Remove by scraping or wire brushing followed by washing with a 5 to 10 percent by weight aqueous solution of hydrochloric (muriatic) acid. Do not allow acid to remain on the surface for more than five minutes before rinsing with fresh water. Do not acid clean more than 0.4 square meter of surface, per workman, at one time.

c. Cosmetic Repair of Minor Defects: Repair or fill mortar joints and minor defects, including but not limited to spalls, in accordance with manufacturer's recommendations and prior to coating application.

d. Allowable Moisture Content: Latex coatings may be applied to damp surfaces, but not to surfaces with droplets of water. Do not apply epoxies to damp vertical surfaces as determined by DIN, BS, or EN Standards or horizontal surfaces that exceed 3 lbs of moisture per 1000 square feet in 24 hours as determined by DIN, BS, or EN Standards. In all cases follow manufacturers recommendations. Allow surfaces to cure a minimum of 30 days before painting.

3.4.2 Gypsum Board, Plaster, and Stucco

a. Surface Cleaning: Plaster and stucco shall be clean and free from loose matter; gypsum board shall be dry. Remove loose dirt and dust by brushing with a soft brush, rubbing with a dry cloth, or vacuum-cleaning prior to application of the first coat material. A damp cloth or sponge may be used if paint will be water-based.

b. Repair of Minor Defects: Prior to painting, repair joints, cracks, holes, surface irregularities, and other minor defects with patching plaster or spackling compound and sand smooth.

c. Allowable Moisture Content: Latex coatings may be applied to damp surfaces, but not surfaces with droplets of water. New plaster to be coated shall have a maximum moisture content of 8 percent, when measured in accordance with DIN, BS, or EN Standards unless otherwise authorized. In addition to moisture content requirements, allow new plaster to age a minimum of 30 days before preparation for painting.

3.5 APPLICATION

3.5.1 Coating Application

Painting practices shall comply with applicable local laws enacted to

ensure compliance with DIN, BS, or EN Standards. Apply coating materials in accordance with DIN, BS, or EN Standards. DIN, BS, or EN Standards methods are applicable to all substrates, except as modified herein.

At the time of application, paint shall show no signs of deterioration. Uniform suspension of pigments shall be maintained during application.

Unless otherwise specified or recommended by the paint manufacturer, paint may be applied by brush, roller, or spray.

Paints, except water-thinned types, shall be applied only to surfaces that are completely free of moisture as determined by sight or touch.

Thoroughly work coating materials into joints, crevices, and open spaces. Special attention shall be given to insure that all edges, corners, crevices, welds, and rivets receive a film thickness equal to that of adjacent painted surfaces.

Each coat of paint shall be applied so dry film shall be of uniform thickness and free from runs, drops, ridges, waves, pinholes or other voids, laps, brush marks, and variations in color, texture, and finish. Hiding shall be complete.

Touch up damaged coatings before applying subsequent coats. Interior areas shall be broom clean and dust free before and during the application of coating material.

3.5.2 Mixing and Thinning of Paints

Reduce paints to proper consistency by adding fresh paint, except when thinning is mandatory to suit surface, temperature, weather conditions, application methods, or for the type of paint being used. Obtain written permission from the USAID Implementing Partner to use thinners. The written permission shall include quantities and types of thinners to use.

When thinning is allowed, paints shall be thinned immediately prior to application with not more than 0.125 L of suitable thinner per liter. The use of thinner shall not relieve the Contractor from obtaining complete hiding, full film thickness, or required gloss. Thinning shall not cause the paint to exceed limits on volatile organic compounds. Paints of different manufacturers shall not be mixed.

3.5.3 Two-Component Systems

Two-component systems shall be mixed in accordance with manufacturer's instructions. Any thinning of the first coat to ensure proper penetration and sealing shall be as recommended by the manufacturer for each type of substrate.

3.5.4 Coating Systems

a. Systems by Substrates: Apply coatings that conform to the respective specifications listed in the following Tables:

Table

Division 3. Exterior Concrete Paint Table

Division 5. Exterior Metal, Ferrous and Non-Ferrous Paint Table

Division 6. Exterior Wood; Dressed Lumber, Paneling, Decking, Shingles Paint Table
Division 9: Exterior Stucco Paint Table

Division 3. Interior Concrete Paint Table

Division 5. Interior Metal, Ferrous and Non-Ferrous Paint Table

Division 9: Interior Plaster, Gypsum Board, Textured Surfaces Paint Table

b. Minimum Dry Film Thickness (DFT): Apply paints, primers, varnishes, enamels, undercoats, and other coatings to a minimum dry film thickness of 0.038 mm each coat unless specified otherwise in the Tables. Coating thickness where specified, refers to the minimum dry film thickness.

c. Coatings for Surfaces Not Specified Otherwise: Coat surfaces which have not been specified, the same as surfaces having similar conditions of exposure.

d. Existing Surfaces Damaged During Performance of the Work, Including New Patches In Existing Surfaces: Coat surfaces with the following:

(1) One coat of primer.

(2) One coat of undercoat or intermediate coat.

(3) One topcoat to match adjacent surfaces.

3.6 COATING SYSTEMS FOR METAL

Apply coatings of Tables in Division 5 for Exterior and Interior.

a. Apply specified ferrous metal primer on the same day that surface is cleaned, to surfaces that meet all specified surface preparation requirements at time of application.

b. Inaccessible Surfaces: Prior to erection, use one coat of specified primer on metal surfaces that will be inaccessible after erection.

c. Shop-primed Surfaces: Touch up exposed substrates and damaged coatings to protect from rusting prior to applying field primer.

d. Pipes and Tubing: The semitransparent film applied to some pipes and tubing at the mill is not to be considered a shop coat, but shall be overcoated with the specified ferrous-metal primer prior to application of finish coats.

e. Exposed Nails, Screws, Fasteners, and Miscellaneous Ferrous Surfaces. On surfaces to be coated with water thinned coatings, spot prime exposed nails and other ferrous metal with latex primer.

3.7 COATING SYSTEMS FOR CONCRETE AND CEMENTITIOUS SUBSTRATES

Apply coatings of Tables in Division 3 and 9 for Exterior and Interior.

3.8 PIPING IDENTIFICATION

Piping Identification, Including Surfaces In Concealed Spaces: Provide in accordance with DIN, BS, or EN Standards. Place stenciling in clearly visible locations. On piping not covered by DIN, BS, or EN Standards, stencil approved names or code letters, in letters a minimum of 13 mm high for piping and a minimum of 50 mm high elsewhere. Stencil arrow-shaped markings on piping to indicate direction of flow using black stencil paint.

3.9 INSPECTION AND ACCEPTANCE

In addition to meeting previously specified requirements, demonstrate mobility of moving components, including swinging and sliding doors, cabinets, and windows with operable sash, for inspection by the Contracting Officer. Perform this demonstration after appropriate curing and drying times of coatings have elapsed and prior to invoicing for final payment.

3.10 PAINT TABLES

All DFT's are minimum values.

3.10.1 EXTERIOR PAINT TABLES

DIVISION 3: EXTERIOR CONCRETE PAINT TABLE

A. New and uncoated existing concrete; vertical surfaces, including undersides of soffits but excluding tops of slabs:

1. Latex
   New; (Flat)
   Primer, Intermediate, Topcoat: Exterior Latex; flat
   System DFT: 88 microns

Primer as recommended by manufacturer. Topcoat: Coating to match adjacent surfaces.

DIVISION 5: EXTERIOR METAL, FERROUS AND NON-FERROUS PAINT TABLE

STEEL / FERROUS SURFACES

A. New Steel that has been blast-cleaned to SSPC SP 6/NACE No.3:

2. Alkyd
   New; (Semigloss)
   Primer, Intermediate, Topcoat: Alkyd, Semigloss

   System DFT: 131 microns

EXTERIOR SURFACES, OTHER METALS (NON-FERROUS)

I. Aluminum, aluminum alloy and other miscellaneous non-ferrous metal items not otherwise specified except hot metal surfaces, roof surfaces, and new prefinished equipment. Match surrounding finish:

1. Alkyd
   New: (Flat)
   Primer, Intermediate, Topcoat: Alkyd, Flat

EXTERIOR SURFACES, OTHER METALS (NON-FERROUS)
System DFT: 125 microns

J. Surfaces adjacent to painted surfaces; Mechanical, Electrical, and miscellaneous metal items not otherwise specified except floors, hot metal surfaces, and new prefinished equipment. Match surrounding finish:

1. Alkyd
New; (Flat)
Primer, Intermediate, Topcoat: Alkyd; Flat

System DFT: 131 microns

DIVISION 6: EXTERIOR WOOD; DRESSED LUMBER, PANELING, DECKING, SHINGLES PAINT TABLE

A. New Dressed lumber and plywood not otherwise specified:
1. Alkyd
New; (Semigloss)
Primer, Intermediate, Topcoat: Alkyd; Semigloss

System DFT: 125 microns

New; (Gloss)
Primer, Intermediate, Topcoat: Primer; Gloss

System DFT: 125 microns

2. Latex
New; (Flat)
Primer, Intermediate, Topcoat: Latex; Flat

System DFT: 125 microns

New; (Semigloss)
Primer, Intermediate, Topcoat: Latex; Semigloss

System DFT: 125 microns

New; (Gloss)
Primer, Intermediate, Topcoat: Latex; Gloss

System DFT: 125 microns

DIVISION 9: EXTERIOR STUCCO PAINT TABLE

A. New stucco:

1. Latex
New; (Flat)
Primer, Intermediate, Topcoat: Latex; Flat
System DFT: 112 microns

3.10.2 INTERIOR PAINT TABLES

DIVISION 3: INTERIOR CONCRETE PAINT TABLE

A. New and uncoated existing Concrete, vertical surfaces, not specified otherwise:

DIVISION 3: INTERIOR CONCRETE PAINT TABLE

1. Latex
   New; (Flat)
   Primer, Intermediate, Topcoat: Latex; Flat
   System DFT: 100 microns

DIVISION 5: INTERIOR METAL, FERROUS AND NON-FERROUS PAINT TABLE

INTERIOR STEEL / FERROUS SURFACES

A. Metal, Mechanical, Electrical, and miscellaneous metal items not otherwise specified except floors, hot metal surfaces, and new prefinished equipment:

1. High Performance Architectural Latex
   New; (Flat)
   Primer, Intermediate, Topcoat: Latex; Flat
   System DFT: 100 microns

DIVISION 9: INTERIOR PLASTER, GYPSUM BOARD, TEXTURED SURFACES PAINT TABLE

A. New Plaster and Wallboard not otherwise specified:

1. Latex
   New; (Flat)
   Primer, Intermediate, Topcoat: Latex; Flat
   System DFT: 100 microns

-- End of Section --

SECTION 13 48 00.00 10

SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325	(2005) Steel Construction Manual

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2007; Change 1) Seismic Design for Buildings

1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

Apply the requirements for seismic protection measures described in this section to the mechanical equipment and systems listed below. Structural requirements shall be in accordance with Section 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT.

1.2.2 Mechanical Equipment

Mechanical equipment to be seismically protected shall include the following items to the extent required on the drawings or in other sections of these specifications:

Storage Tanks for Oil and Water
Valves and Fittings for Piping
Pumps with Motors
Unit Heaters

1.2.3 Mechanical Systems

Install the following mechanical systems as required on the drawings and other sections of these specifications and seismically protect them in accordance with this specification:

a. All Piping Inside the Building Except as Specifically Stated Below Under "Items Not Covered By This Section".

b. Fuel Piping Outside of Buildings.

c. All Water Supply Systems.

d. Storm and Sanitary Sewer Systems.

e. Fuel Storage Tanks.

1.2.4 Contractor Designed Bracing

Design the bracing in accordance with UFC 3-310-04 and additional data furnished by the Contracting Officer. Resistance to lateral forces induced by earthquakes shall be accomplished without consideration of friction resulting from gravity loads. UFC 3-310-04 uses parameters for the building, not for the equipment in the building; therefore, corresponding adjustments to the formulas shall be required. Loadings determined using UFC 3-310-04 are based on strength design; therefore, AISC 325 Specifications shall be used for the design. The bracing for the following mechanical equipment and systems shall be developed by the Contractor:

a. Unit Heaters

1.2.5 Items Not Covered By This Section

1.2.5.1 Items Requiring No Seismic Restraints

Seismic restraints are not required for the following items:

a. Gas piping less than 25 mm inside diameter.

b. All other piping less than 64 mm inside diameter.

c. Piping suspended by individual hangers 300 mm or less in length from the top of pipe to the bottom of the supporting structural member where the hanger is attached, except as noted below.

In exemptions c. all hangers shall meet the length requirements. If the length requirement is exceeded by one hanger in the run, the entire run shall be braced. Interior piping and ducts not listed above shall be seismically protected in accordance with the provisions of this specification.

1.3 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.

SD-02 Shop Drawings

Coupling and Bracing.
Flexible Couplings or Joints.
Equipment Requirements.
Contractor Designed Bracing

Detail drawings along with catalog cuts, templates, and erection and installation details, as appropriate, for the items listed. Submittals shall be complete in detail; shall indicate thickness, type, grade, class of metal, and dimensions; and shall show construction details, reinforcement, anchorage, and installation with relation to the building construction.

SD-03 Product Data

Coupling and Bracing
Equipment Requirements

Copies of the design calculations with the detail drawings. Calculations shall be stamped by a registered engineer and shall verify the capability of structural members to which bracing is attached for carrying the load from the brace.

Contractor Designed Bracing

Copies of the design calculations with the drawings. Calculations shall be approved, certified, stamped and signed by a registered Professional Engineer. Calculations shall verify the capability of structural members to which bracing is attached for carrying the load from the brace.

SD-07 Certificates

Flexible Ball Joints.

Flexible ball joints shall be certified to be suitable for the service intended by the manufacturer. Information verifying experience at not less than 3 locations of 2 years' satisfactory operation in a similar application shall be submitted.

PART 2 PRODUCTS

2.1 FLEXIBLE COUPLINGS

Flexible couplings shall have same pressure and temperature ratings as adjoining pipe.

2.2 FLEXIBLE BALL JOINTS

Flexible ball joints shall have cast or wrought steel casing and ball parts capable of 360-degree rotation with not less than 15-degree angular movement.

2.3 FLEXIBLE MECHANICAL JOINTS

a. Mechanical couplings for steel or cast iron pipe shall be of the sleeve type and shall provide a tight flexible joint under all reasonable conditions, such as pipe movement caused by expansion, contraction, slight settling or shifting of the ground, minor variations in trench gradients, and traffic vibrations. Where permitted in other sections of these specifications, joints utilizing split-half couplings with grooved or shouldered pipe ends may be used.

b. Sleeve-type couplings shall be used for joining plain-end pipe sections. The coupling shall consist of one steel middle ring, two steel followers, two gaskets, and necessary steel bolts and nuts to compress the gaskets.

2.4 MANUFACTURED BALL JOINTS

Manufactured ball joints shall be as recommended by the manufacturer for the intended use, and shall be approved by the Contracting Officer before installation.

2.5 SWAY BRACING MATERIALS

Sway bracing materials (e.g. rods, plates, rope, angles, etc.) shall be as specified in Section 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT.

PART 3 EXECUTION

3.1 COUPLING AND BRACING

Coupling installation shall conform to the details shown on the drawings. Provisions of this paragraph apply to all piping within a 1.5 m line around outside of building unless buried in the ground. Piping grouped for support on trapeze-type hangers shall be braced at the most frequent interval as determined by applying the requirements of this specification to each piping run on the common support. Bracing components shall be sized as required for the total load carried by the common supports. Bracing rigidly attached to pipe flanges, or similar, shall not be used where it would interfere with thermal expansion of piping.

3.2 FLEXIBLE COUPLINGS OR JOINTS

3.2.1 Building Piping

Flexible couplings or joints in building piping shall be provided at bottom of all pipe risers for pipe larger than 90 mm in diameter. Flexible couplings or joints shall be braced laterally without interfering with the action of the flexible coupling or joint. Cast iron waste and vent piping need only comply with these provisions when caulked joints are used. Flexible bell and spigot pipe joints using rubber gaskets may be used at each branch adjacent to tees and elbows for underground waste piping inside of building to satisfy these requirements.

3.3 SWAY BRACES FOR PIPING

Sway braces shall be provided to prevent movement of the pipes under seismic loading. Braces shall be provided in both the longitudinal and transverse directions, relative to the axis of the pipe. The bracing shall not interfere with thermal expansion requirements for the pipes as described in other sections of these specifications.

3.3.1 Transverse Sway Bracing

Transverse sway bracing for steel and copper pipe shall be provided as specified in Section 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT. All runs (length of pipe between end joints) shall have a minimum of two transverse braces.

3.3.2 Vertical Runs

Run is defined as length of pipe between end joints. Vertical runs of piping shall be braced at not more than 3 m vertical intervals. Braces for vertical runs shall be above the center of gravity of the segment being braced. All sway braces shall be constructed in accordance with the drawings. Sway braces shall attach to the structural system and shall not be connected to branch lines, walls, or floors.

-- End of Section --

SECTION 13 48 00

SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASME INTERNATIONAL (ASME)

ASME B18.2.1	(1996; R 2005) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(1987; R 2005) Standard for Square and Hex Nuts

ASTM INTERNATIONAL (ASTM)

ASTM A 153/A 153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 307	(2007b) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A 325M	(2009a) Standard Specification for Structural Bolts, Steel, Heat Treated, 830 MPa Minimum Tensile Strength (Metric)
ASTM A 36/A 36M	(2008) Standard Specification for Carbon Structural Steel
ASTM A 500/A 500M	(2009) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A 53/A 53M	(2007) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 572/A 572M	(2007) Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
ASTM A 603	(1998; R 2009e1) Standard Specification for Zinc-Coated Steel Structural Wire Rope
ASTM A 653/A 653M	(2009a) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by

the Hot-Dip Process

ASTM E 488 (1996; R 2003) Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04 (2007; Change 1) Seismic Design for Buildings

1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

Apply the requirements for seismic protection measures, described in this section, to the mechanical equipment and systems outlined in Section 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT, the electrical equipment and systems outlined in Section 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT, and the miscellaneous equipment and systems listed below, in accordance with UFC 3-310-04 and additional data furnished by the Contracting Officer. Provide seismic protection measures in addition to any other requirements called for in other sections of these specifications. The design for seismic protection shall be based on a Seismic Use Group II building occupancy and on site response coefficients for S_{MS} = 1.34 g and S_{M1} = 0.77 g. Accomplish resistance to lateral forces induced by earthquakes without consideration of friction resulting from gravity loads. The basic force formulas, for Ground Motions A and B in UFC 3-310-04, use the design spectral response acceleration parameters for the performance objective of the building, not for equipment in the building; therefore, corresponding adjustments to the formulas are required.

1.2.2 Miscellaneous Equipment and Systems

The bracing for the following miscellaneous equipment and systems shall be developed by the Contractor in accordance with the requirements of this specification:

Booster Pumps

1.3 EQUIPMENT REQUIREMENTS

1.3.1 Rigidly Mounted Equipment

The following specific items of equipment: booster pumps to be furnished under this contract shall be constructed and assembled to withstand the seismic forces specified in UFC 3-310-04.

1.4 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.

SD-02 Shop Drawings

Bracing
Resilient Vibration Isolation Devices
Equipment Requirements

Detail drawings along with catalog cuts, templates, and erection and installation details, as appropriate, for the items listed. Submittals shall: be complete in detail; indicate thickness, type, grade, class of metal, and dimensions; and show construction details, reinforcement, anchorage, and installation with relation to the building construction.

SD-03 Product Data

Bracing
Equipment Requirements

Copies of the design calculations with the detail drawings. Calculations shall be stamped, by a registered engineer, and verify the capability of structural members to which bracing is attached for carrying the load from the brace.

SD-06 Test Reports

Anchor Bolts

Copies of test results to verify the adequacy of the specific anchor and application, as specified.

PART 2 PRODUCTS

2.1 BOLTS AND NUTS

Squarehead and hexhead bolts, and heavy hexagon nuts, ASME B18.2.1, ASME B18.2.2, or ASTM A 325M for bolts and nuts. Provide bolts and nuts galvanized in accordance with ASTM A 153/A 153M when used underground and/or exposed to weather.

2.2 SWAY BRACING

Material used for members listed in this section and on the drawings, shall be structural steel conforming with the following:

a. Plates, rods, and rolled shapes, ASTM A 36/A 36M. If the Contractor does the design, both ASTM A 36/A 36Mand ASTM A 572/A 572M, grade 503 will be allowed.

b. Wire rope, ASTM A 603.

c. Tubes, ASTM A 500/A 500M, Grade B.

d. Pipes, ASTM A 53/A 53M, Type E or S, Grade B.

e. Light gauge angles, less than 6 mm thickness, ASTM A 653/A 653M.

PART 3 EXECUTION

3.1 BRACING

Provide bracing conforming to the arrangements shown. Secure trapeze-type hanger with not less than two 13 mm bolts.

3.2 BUILDING DRIFT

Sway braces for a piping run shall not be attached to two dissimilar structural elements of a building that may respond differentially during an earthquake unless a flexible joint is provided.

3.3 ANCHOR BOLTS

3.3.1 Cast-In-Place

Use cast-in-place anchor bolts, conforming to ASTM A 307, for floor or pad mounted equipment, except as specified below. Provide two nuts on each bolt. Anchor bolts shall have an embedded straight length equal to at least 12 times nominal diameter of the bolt. Anchor bolts that exceed the normal depth of equipment foundation piers or pads shall either extend into concrete floor or the foundation or be increased in depth to accommodate bolt lengths.

3.3.2 Expansion or Chemically Bonded Anchors

Do not use expansion or chemically bonded anchors: 1)Unless test data in accordance with ASTM E 488 has been provided to verify the adequacy of the specific anchor and application. 2)To resist pull-out in overhead and wall installations if the adhesive is manufactured with temperature sensitive epoxies and the location is accessible to a building fire. Install expansion and chemically bonded anchors in accordance with the manufacturer's recommendations. Adjust the allowable forces for the spacing between anchor bolts and the distance between the anchor bolt and the nearest edge, as specified by the manufacturer.

3.3.2.1 General Testing

Test in place expansion and chemically bonded anchors not more than 24 hours after installation of the anchor, conducted by an independent testing agency; testing shall be performed on random anchor bolts as described below.

3.3.2.2 Torque Wrench Testing

Perform torque wrench testing on not less than 50 percent of the total installed expansion anchors and at least one anchor for every piece of equipment containing more than two anchors. The test torque shall equal the minimum required installation torque as required by the bolt manufacturer. Calibrate torque wrenches at the beginning of each day the torque tests are performed. Recalibrate torque wrenches for each bolt diameter whenever tests are run on bolts of various diameters. Apply torque between 20 and 100 percent of wrench capacity. Reach the test torque within one half turn of the nut, except for 9 mm sleeve anchors which shall reach their torque by one quarter turn of the nut. If any anchor fails the test, test similar anchors not previously tested until 20 consecutive anchors pass. Failed anchors shall be retightened and retested to the specified torque; if the anchor still fails the test it shall be replaced.

3.3.2.3 Pullout Testing

Test expansion and chemically bonded anchors by applying a pullout load using a hydraulic ram attached to the anchor bolt. At least 5 percent of the anchors, but not less than 3 per day shall be tested. Apply the load

to the anchor without removing the nut; when that is not possible, the nut shall be removed and a threaded coupler shall be installed of the same tightness as the original nut. Check the test setup to verify that the anchor is not restrained from withdrawing by the baseplate, the test fixture, or any other fixtures. The support for the testing apparatus shall be at least 1.5 times the embedment length away from the bolt being tested. Load each tested anchor to 1 times the design tension value for the anchor. The anchor shall have no observable movement at the test load. If any anchor fails the test, similar anchors not previously tested shall be tested until 20 consecutive anchors pass. Failed anchors shall be retightened and retested to the specified load; if the anchor still fails the test it shall be replaced.

3.4 RESILIENT VIBRATION ISOLATION DEVICES

Where the need for these devices is determined, based on the magnitude of the design seismic forces, selection of anchor bolts for vibration isolation devices and/or snubbers for equipment base and foundations shall follow the same procedure as in paragraph ANCHOR BOLTS, except that an equipment weight equal to five times the actual equipment weight shall be used.

3.4.1 Resilient and Spring-Type Vibration Devices

Select vibration isolation devices so that the maximum movement of equipment from the static deflection point is 13 mm.

3.4.2 Multidirectional Seismic Snubbers

Install multidirectional seismic snubbers employing elastomeric pads on floor- or slab-mounted equipment. These snubbers shall provide 6 mm free vertical and horizontal movement from the static deflection point. Snubber medium shall consist of multiple pads of cotton duct and neoprene or other suitable materials arranged around a flanged steel trunnion so both horizontal and vertical forces are resisted by the snubber medium.

3.5 SWAY BRACES FOR PIPING

Provide transverse sway bracing for steel and copper pipe at intervals not to exceed those shown on the drawings. Provide bracing consisting of at least one vertical angle 50 by 50 mm by 16 gauge and one diagonal angle of the same size.

3.5.1 Longitudinal Sway Bracing

Provide longitudinal sway bracing in accordance with Section 13 48 00.00 10 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT.

3.5.2 Anchor Rods, Angles, and Bars

Anchor rods, angles, and bars shall be bolted to either pipe clamps or pipe flanges at one end and cast-in-place concrete or masonry insert or clip angles bolted to the steel structure on the other end. Rods shall be solid metal or pipe as specified below. Anchor rods, angles, and bars shall not exceed lengths given in the tabulation below.

3.5.3 Maximum Length for Anchor Braces

Type	Size (millimeters)	Maximum Length* (meters)
Angles	38 x 38 x 6	1.5
	50 x 50 x 6	2.0
	64 x 38 x 6	2.5
	75 x 64 x 6	2.5
	75 x 75 x 6	3.0
Rods	91	1.0
	22	1.0
Flat Bars	38 x 6	0.4
	50 x 6	0.4
	50 x 10	0.5
Pipes (40s)	25	2.0
	32	2.8
	40	3.2
	50	4.0

3.5.4 Bolts

Bolts used for attachment of anchors to pipe and structure shall be not less than 13 mm diameter.

3.6 EQUIPMENT SWAY BRACING

3.6.1 Suspended Equipment and Light Fixtures

Provide equipment sway bracing for items supported from overhead floor or roof structural systems, including light fixtures. Braces shall consist of angles, rods, wire rope, bars, or pipes arranged as shown and secured at both ends with not less than 13 mm bolts. Provide sufficient braces for equipment to resist a horizontal force as specified in UFC 3-310-04 without exceeding safe working stress of bracing components. Provide, for approval, specific force calcualtions in accordance with UFC 3-310-04 for the equipment in the project. Submit details of equipment bracing for acceptance. In lieu of bracing with vertical supports, these items may be supported with hangers inclined at 45 degrees directed up and radially away from equipment and oriented symmetrically in 90-degree intervals on the horizontal plane, bisecting the angles of each corner of the equipment, provided that supporting members are properly sized to support operating weight of equipment when hangers are inclined at a 45-degree angle.

3.6.2 Floor or Pad Mounted Equipment

3.6.2.1 Shear Resistance

Bolt to the floor, floor mounted equipment. Requirements for the number and installation of bolts to resist shear forces shall be in accordance with paragraph ANCHOR BOLTS.

3.6.2.2 Overturning Resistance

Use the ratio of the overturning moment from seismic forces to the

resisting moment due to gravity loads to determine if overturning forces need to be considered in the sizing of anchor bolts. Provide calculations to verify the adequacy of the anchor bolts for combined shear and overturning.

-- End of Section --

SECTION 23 00 00

AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

AMCA 201	(2002) Fans and Systems
AMCA 210	(2007) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
AMCA 300	(2005) Reverberant Room Method for Sound Testing of Fans
AMCA 301	(2006; INT 2007; Errata 2008) Methods for Calculating Fan Sound Ratings from Laboratory Test Data

ASTM INTERNATIONAL (ASTM)

ASTM A 53/A 53M	(2007) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM C 553	(2008) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications

UNDERWRITERS LABORATORIES (UL)

UL 6	(2007) Electrical Rigid Metal Conduit-Steel
UL 705	(2004; R 2004 thru 2009) Standard for Power Ventilators
UL Bld Mat Dir	(2009) Building Materials Directory

1.2 SUBMITTALS

Contractor shall submit the following using submittal procedures as specified in the Contract Documents.

SD-02 Shop Drawings

Detail Drawings

SD-03 Product Data

Louvers
Panel Type Power Wall Ventilators
Electric Unit Heaters

SD-06 Test Reports

Performance Tests

SD-07 Certificates

Bolts

SD-08 Manufacturer's Instructions

Manufacturer's Installation Instructions
Operation and Maintenance Training

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals
Panel Type Power Wall Ventilators

1.3 QUALITY ASSURANCE

Except as otherwise specified, approval of materials and equipment is based on manufacturer's published data.

a. Where materials and equipment are specified to conform to the standards of the Underwriters Laboratories, the label of or listing with reexamination in UL Bld Mat Dir, and UL 6 is acceptable as sufficient evidence that the items conform to Underwriters Laboratories requirements. In lieu of such label or listing, submit a written certificate from any nationally recognized testing agency, adequately equipped and competent to perform such services, stating that the items have been tested and that the units conform to the specified requirements. Outline methods of testing used by the specified agencies.

b. Where materials or equipment are specified to be constructed or tested, or both, in accordance with the standards of the ASTM International (ASTM), the ASME International (ASME), or other standards, a manufacturer's certificate of compliance of each item is acceptable as proof of compliance.

c. Conformance to such agency requirements does not relieve the item from compliance with other requirements of these specifications.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect stored equipment at the jobsite from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, cap or plug all pipes until installed.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide components and equipment that are "standard products" of a manufacturer regularly engaged in the manufacturing of products that are of

a similar material, design and workmanship. "Standard products" is defined as being in satisfactory commercial or industrial use for 2 years before bid opening, including applications of components and equipment under similar circumstances and of similar size, satisfactorily completed by a product that is sold on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a 2-year field service record are acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. Provide equipment items that are supported by a service organization.

2.2 ANCHOR BOLTS

Provide anchor bolts for equipment placed on concrete equipment pads or on concrete slabs. Bolts to be of the size and number recommended by the equipment manufacturer and located by means of suitable templates. Installation of anchor bolts shall not degrade the surrounding concrete.

2.3 DUCT SYSTEMS

2.3.1 Louvers

Provide louvers for installation in exterior walls that are associated with the air supply and distribution system as specified in Section 08 91 00 METAL WALL LOUVERS.

2.4 AIR SYSTEMS EQUIPMENT

2.4.1 Fans

Test and rate fans according to AMCA 210. Calculate system effect on air moving devices in accordance with AMCA 201 where installed ductwork differs from that indicated on drawings. The sound power level of the fans shall not exceed 85 dBA when tested according to AMCA 300 and rated in accordance with AMCA 301. Provide all fans with an AMCA seal. Connect fans to the motors either directly. Provide fan and motor assemblies with vibration-isolation supports or mountings as indicated. Use vibration-isolation units that are standard products with published loading ratings. Select each fan to produce the capacity required at the fan static pressure indicated. Provide sound power level as indicated. Obtain the sound power level values according to AMCA 300. Provide standard AMCA arrangement, rotation, and discharge as indicated. Provide power ventilators that conform to UL 705 and have a UL label.

2.4.1.1 Panel Type Power Wall Ventilators (Ventilation Fan)

Provide propeller type fans, assembled on a reinforced metal panel with venturi opening spun into panel. Provide direct or V-belt driven fans with wheels less than 600 mm in diameter and provide V-belt driven fans with wheels 600 mm in diameter and larger. Provide fans with wall mounting collar. Provide lubricated bearings. Equip fans with wheel and motor side metal or wire guards which have a corrosion-resistant finish. Install gravity backdraft dampers where indicated.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions

in the field, and advise the USAID Implementing Partner of any discrepancy before performing the work.

3.2 INSTALLATION

a. Install materials and equipment in accordance with the requirements of the contract drawings and approved manufacturer's installation instructions. Accomplish installation by workers skilled in this type of work. Perform installation so that there is no degradation of the designed fire ratings of walls, partitions, ceilings, and floors.

b. No installation is permitted to block or otherwise impede access to any existing machine or system. Install all hinged doors to swing open a minimum of 120 degrees. Provide an area in front of all access doors that clears a minimum of 900 mm. In front of all access doors to electrical circuits, clear the area the minimum distance to energized circuits as specified in OSHA Standards, part 1910.333 Electrical-Safety Related work practices.

3.3 CUTTING AND PATCHING

Install work in such a manner and at such time that a minimum of cutting and patching of the building structure is required. Make holes in exposed locations, in or through existing floors, by drilling and smooth by sanding. Use of a jackhammer is permitted only where specifically approved. Make holes through masonry walls to accommodate sleeves with an iron pipe masonry core saw.

3.4 CLEANING

Thoroughly clean surfaces of piping and equipment that have become covered with dirt, plaster, or other material during handling and construction before such surfaces are prepared for final finish painting or are enclosed within the building structure. Before final acceptance, clean mechanical equipment, including piping, ducting, and fixtures, and free from dirt, grease, and finger marks.

3.5 PENETRATIONS

Provide sleeves and prepared openings for duct mains, branches, and other penetrating items, and install during the construction of the surface to be penetrated. Cut sleeves flush with each surface. Sleeves and ventilation framed openings are also required where fans are installed at the openings. Provide 25 mm clearance between penetrating and penetrated surfaces. Pack spaces between sleeve or opening and duct or duct insulation with mineral fiber conforming with ASTM C 553, Type 1, Class B-2.

a. Sleeves: Fabricate sleeves, except as otherwise specified or indicated, from 1 mm thick mill galvanized sheet metal. Where sleeves are installed in bearing walls or partitions, provide black steel pipe conforming with ASTM A 53/A 53M, Schedule 20.

b. Framed Prepared Openings: Fabricate framed prepared openings from 1 mm galvanized steel, unless otherwise indicated.

c. Closure Collars: Provide closure collars of a minimum 100 mm wide, unless otherwise indicated, for exposed ducts and items on each side of penetrated surface, except where equipment is installed. Install collar tight against the surface and fit snugly around the duct or

insulation. Grind sharp edges smooth to prevent damage to penetrating surface. Install collars with fasteners a maximum of 150 mm on center. Attach to collars a minimum of 4 fasteners where the opening is 300 mm in diameter or less, and a minimum of 8 fasteners where the opening is 500 mm in diameter or less.

-- End of Section --

SECTION 23 82 46

ELECTRIC UNIT HEATERS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

UNDERWRITERS LABORATORIES (UL)

UL 1996	(2009; R 2009) Standard for Electric Duct Heaters

1.2 GENERAL REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS applies to work specified in this section.

Include within the Fabrication Drawings for electric heaters the of fabrication and assembly details to be performed in the factory.

Include with the Equipment and Performance Data for electric heaters life, test, system functional flows, safety features, and mechanical automated details.

Include with the Manufacturer's Instructions for electric heaters the special provisions required to install equipment components and system packages. Detail impedances, hazards and safety precautions within the special notices.

1.3 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.

SD-02 Shop Drawings

Submit Fabrication Drawings in accordance with paragraph entitled, "General Requirements," of this section.

SD-03 Product Data

Submit Equipment and Performance Data in accordance with paragraph entitled, "General Requirements," of this section.

Submit manufacturer's catalog data for the following items:

Electric Unit Heaters
Heating Element
Controls
Casings
Propellers and Motors

SD-08 Manufacturer's Instructions

Submit Manufacturer's Instructions in accordance with paragraph entitled, "General Requirements," of this section.

PART 2 PRODUCTS

2.1 PRODUCT STANDARDS

Conform to the requirements of UL 1996 for electric unit heaters.

2.2 DESCRIPTION

Use Suspended electric unit heaters and arrange for discharge of air as indicated.

Provide Electric unit heaters with not less than the indicated capacity and conform to requirements specified herein.

Factory prewire Electric unit heaters, ready for field terminal connections.

2.3 CASINGS

Construct casings with smoothly contoured propeller orifice rings of not less than 1.0 millimeter cold-rolled carbon steel. Provide casing surface finish with phosphate pretreatment, prime coating, and baked-enamel finish.

2.4 AIR DISTRIBUTION

Provide horizontal units with adjustable single- or double-deflection louvers.

2.5 HEATING ELEMENT

Construct heating element of a resistance wire insulated by highly compacted refractory insulation protected by a sealed metallic-finned sheath. Component materials are as follows:

Provide resistance wire not less than 20-helix wound alloy approximately 80-percent nickel and 20-percent chromium.

Provide refractory insulation of magnesium oxide with a resistance of not less than 50,000-ohms after exposure to an ambient temperature and humidity of 32 degrees C and 85 plus or minus 5-percent relative humidity, respectively, for not less than 24 hours.

Provide sheathing consisting of aluminum fins cast around an internal steel sheath containing refractory insulation and resistance wire or carbon-steel fins permanently attached to a tubular carbon-steel sheath containing refractory insulation and resistance wire and with external surfaces porcelainized.

Maximum surface temperature of porcelain-protected steel sheathing shall be 700 degrees C.

Maximum surface temperature of cast-aluminum sheathing shall be 500 degrees C.

2.6 CONTROLS

Fit units up to and including 5 kilowatts with integral controls including thermal overload cutout switches, necessary transformers, liquid-vapor system, and low-mass bimetal thermostat as required. Provide automatically resettable cutout switch.

Provide unit with a remote unfused disconnect switch that opens ungrounded conductors in the OFF position and a thermostat with integral controls including thermal overload cutout switches, magnetic contactors, necessary transformers, and thermostat protection as required. Provide automatically resettable cutout switches.

Provide wall-mounted thermostats complete with thermometer, mechanical high-limit stop, calibrated operator, and an adjustable heater to effect anticipation and to prevent override of space temperature with a range between 12 and 41 degrees C and a differential not exceeding 1 degrees C. Rate thermostat for operation at 24 volts, 60 hertz. Provide transformers, wiring, and devices necessary to meet this requirement. Finish cases in brushed or satin chrome.

2.7 PROPELLERS AND MOTORS

Provide propellers with galvanized-steel or all-aluminum blades and be statically and dynamically balanced to within 0.5 percent. Provide units with fan-inlet safety guards.

AMCA certify propellers and motors for air performance and noise level.

Protect motors against damage by the heating element and resilient mount.

Motors shall be totally enclosed and fan-cooled.

Subfractional and fractional custom-designed or applied motors may deviate from the preceding motor requirements as follows:

Shaded-pole motors rated less than 125 watt may be used for direct-drive service.

Permanent split-capacitor, split-phase, and capacitor-start motors rated 185 watt and less may be used for direct-drive service.

Split-phase and capacitor-start motors, rated 185 watt and less, may be used for belt-drive service.

Motor bearings may be manufacturer's standard prelubricated sleeve type except provide motor with antifriction thrust bearings, when specified. Lubricant provisions shall be extended service requiring replenishment not more than twice per year of continuous operation.

Provide motor identification plate per manufacturer's standard.

Provide motor speed and control per unit-heater manufacturer's standard.

PART 3 EXECUTION

3.1 INSTALLATION

Install unit heaters in accordance with the manufacturer's instructions at

the mounting heights indicated.

3.2 FIELD TESTING

Demonstrate in the presence of the USAID Implementing Partner that the unit heaters operate satisfactorily.

Cycle unit heaters five times, from start to operating thermal conditions to off, to verify adequacy of construction, system controls, and component performance.

Conduct an operational test for a minimum of 6 hours.

-- End of Section --

SECTION 26 00 00.00 20

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D 709	(2001; R 2007) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2007; Errata 2006 & 2007; INT 44-56 2007; INT 47, 49, 50, 52-56 2008; INT 57, 58, 51, 48, 59 2009) National Electrical Safety Code
IEEE C57.12.28	(2005) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.29	(2005) Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments
IEEE Std 100	(2000) The Authoritative Dictionary of IEEE Standards Terms

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2008) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2008; AMD 1 2008) National Electrical Code - 2008 Edition

1.2 RELATED REQUIREMENTS

This section applies to all sections of Division 26 and 33, ELECTRICAL and UTILITIES, of this project specification unless specified otherwise in the individual sections. This section has been incorporated into, and thus, does not apply to, and is not referenced in the following sections.

Section 26 11 16 SECONDARY UNIT SUBSTATIONS
Section 26 23 00 SWITCHBOARDS
Section 33 71 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and

electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE Std 100.

b. The technical sections referred to herein are those specification sections that describe products, installation procedures, and equipment operations and that refer to this section for detailed description of submittal types.

c. The technical paragraphs referred to herein are those paragraphs in PART 2 - PRODUCTS and PART 3 - EXECUTION of the technical sections that describe products, systems, installation procedures, equipment, and test methods.

1.4 ELECTRICAL CHARACTERISTICS

Electrical characteristics for this project shall be 15/20 kV primary, three phase, three wire, 50 Hz, and 400 volts secondary, three phase, four wire. Final connections to the power distribution system at the existing manhole shall be made by the Contractor as directed by the USAID Implementing Partner.

1.5 ADDITIONAL SUBMITTALS INFORMATION

Submittals required in other sections that refer to this section must conform to the following additional requirements as applicable.

1.5.1 Shop Drawings (SD-02)

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.

1.5.2 Product Data (SD-03)

Submittal shall include performance and characteristic curves.

1.6 QUALITY ASSURANCE

1.6.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the USAID Implementing Partner. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory

commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in the technical section.

1.6.2.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.6.2.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.7 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.8 POSTED OPERATING INSTRUCTIONS

Provide for each system and principal item of equipment as specified in the technical sections for use by operation and maintenance personnel. The operating instructions shall include the following:

a. Wiring diagrams, control diagrams, and control sequence for each principal system and item of equipment.

b. Start up, proper adjustment, operating, lubrication, and shutdown procedures.

c. Safety precautions.

d. The procedure in the event of equipment failure.

e. Other items of instruction as recommended by the manufacturer of each system or item of equipment.

Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. For operating instructions exposed to the weather, provide weather-resistant materials or weatherproof enclosures. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal or peeling.

1.9 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be

acceptable.

1.10 FIELD FABRICATED NAMEPLATES

ASTM D 709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified in the technical sections or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 3 mm (0.125 inch) thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be 25 by 65 mm (one by 2.5 inches). Lettering shall be a minimum of 6.35 mm (0.25 inch) high normal block style.

1.11 WARNING SIGNS

Provide warning signs for the enclosures of electrical equipment including substations, pad-mounted transformers, pad-mounted switches, generators, and switchgear having a nominal rating exceeding 600 volts.

a. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.28 or IEEE C57.12.29, such as for pad-mounted transformers, provide self-adhesive warning signs on the outside of the high voltage compartment door(s). Sign shall be a decal and shall have nominal dimensions of 178 by 255 mm (7 by 10 inches) with the legend "DANGER HIGH VOLTAGE" printed in two lines of nominal 50 mm (2 inch) high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background. Decal shall be Panduit No. PPSO710D72 or approved equal.

1.12 ELECTRICAL REQUIREMENTS

Electrical installations shall conform to IEEE C2, NFPA 70, and requirements specified herein.

1.13 INSTRUCTION TO OWNER'S PERSONNEL

Where specified in the technical sections, furnish the services of competent instructors to give full instruction to personnel designated by the USAID Implementing Partner in the adjustment, operation, and maintenance of the specified systems and equipment, including pertinent safety requirements as required. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work. Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the facility owner for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be as specified in the individual section.

PART 2 PRODUCTS

2.1 FACTORY APPLIED FINISH

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test.

PART 3 EXECUTION

3.1 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in the section specifying the associated electrical equipment.

3.2 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.3 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side, but space the signs a maximum of 9 meters (30 feet) apart.

-- End of Section --

SECTION 26 05 00.00 40

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D 709	(2001; R 2007) Laminated Thermosetting Materials

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA 480	(1981) Toggle Switches

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms

INTERNATIONAL CODE COUNCIL (ICC)

ICC/ANSI A117.1	(2003; Errata 2007) Accessible and Usable Buildings and Facilities

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2008) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA FB 1	(2007) Standard for Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
NEMA PB 1	(2006; Errata 2008) Standard for Panelboards
NEMA RN 1	(2005) Standard for Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	(2003) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2004) Standard for Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2008; AMD 1 2008) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005; R 2003 thru 2007) Standard for Flexible Metal Conduit
UL 1242	(2006; R 2001 thru 2007) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 489	(2009) Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 6	(2007) Electrical Rigid Metal Conduit-Steel
UL 797	(2007) Electrical Metallic Tubing -- Steel

1.2 SUBMITTALS

Contractor shall submit the following using submittal procedures as specified in the Contract Documents.

SD-03 Product Data

Submit manufacturer's catalog data for the following items:

Conduits, Raceways and Fittings
Wire and Cable
Splices and Connectors
Switches
Receptacles
Outlets, Outlet Boxes, and Pull Boxes
Circuit Breakers
Panelboards
Lamps and Lighting Fixtures

SD-06 Test Reports

Continuity Test
Phase-Rotation Tests
Insulation Resistance Test

SD-08 Manufacturer's Instructions

Submit Manufacturer's Instructions.

1.3 PREVENTION OF CORROSION

Protect metallic materials against corrosion. Provide equipment enclosures with the standard finish by the manufacturer when used for most indoor installations. Do not use aluminum when in contact with earth or concrete and, where connected to dissimilar metal, protect by approved fittings and treatment. Ferrous metals such as, but not limited to, anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washers, and miscellaneous spare parts not of corrosion-resistant

steel shall be hot-dip galvanized except where other equivalent protective treatment is specifically approved in writing.

1.4 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100.

b. The technical sections referred to herein are those specification sections that describe products, installation procedures, and equipment operations and that refer to this section for detailed description of submittal types.

1.5 GENERAL REQUIREMENTS

Submit Material, Equipment, and Fixture Lists for the following items showing manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site.

Submit Manufacturer's Instructions including special provisions required to install equipment components and system packages. Special notices shall detail impedances, hazards and safety precautions.

Submit Certification required to install equipment components and system packages.

1.6 POSTED OPERATING INSTRUCTIONS

Provide for each system and principal item of equipment as specified in the technical sections for use by operation and maintenance personnel. The operating instructions shall include the following:

a. Wiring diagrams, control diagrams, and control sequence for each principal system and item of equipment.

b. Start up, proper adjustment, operating, lubrication, and shutdown procedures.

c. Safety precautions.

d. The procedure in the event of equipment failure.

e. Other items of instruction as recommended by the manufacturer of each system or item of equipment.

Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. For operating instructions exposed to the weather, provide weather-resistant materials or weatherproof enclosures. Operating instructions shall not fade when exposed to sunlight and be secured to prevent easy removal or peeling.

1.7 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

1.8 FIELD FABRICATED NAMEPLATES

ASTM D 709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified in the technical sections or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 3 mm thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be 25 by 65 mm. Lettering shall be a minimum of 6.35 mm high normal block style.

PART 2 PRODUCTS

2.1 MATERIALS

Materials and equipment to be provided shall be the standard cataloged products of manufacturers regularly engaged in the manufacture of the products.

2.1.1 Rigid Steel Conduit

Rigid steel conduit shall comply with UL 6 and be galvanized by the hot-dip process. Rigid steel conduit shall be polyvinylchloride (PVC) coated in accordance with NEMA RN 1, where underground and in corrosive areas, or must be painted with bitumastic.

Fittings for rigid steel conduit shall be threaded.

Gaskets shall be solid. Conduit fittings with blank covers shall have gaskets, except in clean, dry areas or at the lowest point of a conduit run where drainage is required.

Covers shall have captive screws and be accessible after the work has been completed.

2.1.2 Electrical Metallic Tubing (EMT)

EMT shall be in accordance with UL 797 and be zinc coated steel. Couplings and connectors shall be zinc-coated, raintight, gland compression with insulation throat. Crimp, spring, or setscrew type fittings are not acceptable.

2.1.3 Flexible Metallic Conduit

Flexible metallic conduit shall comply with UL 1 and be galvanized steel.

Fittings for flexible metallic conduit shall be specifically designed for such conduit.

Provide liquidtight flexible metallic conduit with a protective jacket of PVC extruded over a flexible interlocked galvanized steel core to protect wiring against moisture, oil, chemicals, and corrosive fumes.

Specifically design fittings for liquidtight flexible metallic conduit for such conduit.

2.1.4 Intermediate Metal Conduit

Intermediate metal conduit shall comply with UL 1242 and be galvanized.

2.1.5 Rigid Nonmetallic Conduit

Rigid nonmetallic conduit shall comply with NEMA TC 2 and NEMA TC 3 with wall thickness not less than Schedule 40.

2.2 WIRE AND CABLE

Conductors installed in conduit shall be copper 600-volt type THHN. All conductors 3.15 millimeter diameter and larger, shall be stranded. All conductors smaller than 3.15 millimeter diameter shall be stranded.

2.3 SPLICES AND CONNECTORS

Make all splices in 3.15 millimeter diameter and smaller with approved insulated electrical type.

Make all splices in 4.1 millimeter diameter and larger with bolted clamp-type connectors. Joints shall be wrapped with an insulating tape that has an insulation and temperature rating equivalent to that of the conductor.

2.4 SWITCHES

2.4.1 Toggle Switches

Toggle switches shall comply with EIA 480, control incandescent, mercury, and fluorescent lighting fixtures and be of the heavy duty, general purpose, noninterchangeable flush-type.

Toggle switches shall be commercial grade toggle type, single-pole, two-position devices rated 20 amperes at 230 volts, 50 hertz alternating current (ac) only.

All toggle switches shall be products of the same manufacturer.

2.5 RECEPTACLES

Receptacles shall be commercial grade, 16A, 250 VAC, 2-pole, 3-wire duplex, schuko type.

2.6 OUTLETS, OUTLET BOXES, AND PULL BOXES

Outlet boxes for use with conduit systems shall be in accordance with NEMA FB 1 and be not less than 40 millimeter deep. Furnish all pull and junction boxes with screw-fastened covers.

2.7 PANELBOARDS

Lighting and appliance branch circuit panelboards shall be the circuit-breaker type in accordance with NEMA PB 1. Bolt circuit breakers to the bus. Plug-in circuit breakers are not acceptable. Buses shall be copper of the rating indicated, with main lugs or main circuit breaker as indicated. Provide all panelboards for use on grounded ac systems with a full-capacity isolated neutral bus and a separate grounding bus bonded to the panelboard enclosure. Panelboard enclosures shall be NEMA 250, Type 1,

in accordance with NEMA PB 1. Provide enclosure fronts with latchable hinged doors.

2.8 CIRCUIT BREAKERS

Circuit-breaker interrupting rating shall be not less than those indicated. Multipole circuit breakers shall be the common-trip type with a single handle. Molded case circuit breakers shall be bolt-on type conforming to UL 489.

2.9 LAMPS AND LIGHTING FIXTURES

Manufacturers and catalog numbers shown are indicative of the general type desired and are not intended to restrict the selection to fixtures of any particular manufacturer. Fixtures with the same salient features and equivalent light distribution and brightness characteristics, of equal finish and quality, are acceptable. Provide lamps of the proper type and wattage for each fixture.

Ballasts shall be high power factor and be energy efficient. Ballasts shall have a Class P terminal protective device for 230-volt operation as indicated and be rapid-start fluorescent. Ballasts shall be "A" sound rated. Fluorescent lamps shall be standard reduced wattage type.

PART 3 EXECUTION

3.1 CONDUITS, RACEWAYS AND FITTINGS

Conduit runs between outlet and outlet, between fitting and fitting, or between outlet and fitting shall not contain more than the equivalent of three 90-degree bends, including those bends located immediately at the outlet or fitting.

Do not install crushed or deformed conduit. Avoid trapped conduit runs where possible. Take care to prevent the lodgment of foreign material in the conduit, boxes, fittings, and equipment during the course of construction. Clear any clogged conduit of obstructions or be replaced.

Conduit and raceway runs concealed in or behind walls, above ceilings, or exposed on walls and ceilings 1470 millimeter or more above finished floors and not subject to mechanical damage may be electrical metallic tubing (EMT).

3.1.1 Rigid Steel Conduit

Make field-made bends and offsets with approved hickey or conduit bending machine. Conduit elbows larger than 65 millimeter shall be long radius.

Provide all conduit stubbed-up through concrete floors for connections to free-standing equipment with the exception of motor-control centers, cubicles, and other such items of equipment, with a flush coupling when the floor slab is of sufficient thickness. Otherwise,provide a floor box set flush with the finished floor. Conduits installed for future use shall be terminated with a coupling and plug set flush with the floor.

3.1.2 Electrical Metallic Tubing (EMT)

EMT shall be grounded in accordance with NFPA 70, using pressure grounding connectors especially designed for EMT.

3.1.3 Flexible Metallic Conduit

Use flexible metallic conduit to connect recessed fixtures from outlet boxes in ceilings, transformers, and other approved assemblies.

Bonding wires shall be used in flexible conduit as specified in NFPA 70, for all circuits. Flexible conduit shall not be considered a ground conductor.

Electrical connections to vibration-isolated equipment shall be made with flexible metallic conduit.

Liquidtight flexible metallic conduit shall be used in wet and oily locations and to complete the connection to motor-driven equipment.

3.1.4 Intermediate Conduit

Make all field-made bends and offsets with approved hickey or conduit bending machine. Use intermediate metal conduit only for indoor installations.

3.1.5 Rigid Nonmetallic Conduit

Rigid PVC conduit shall be direct buried.

A green insulated copper grounding conductor shall be in conduit with conductors and be solidly connected to ground at each end. Grounding wires shall be sized in accordance with NFPA 70.

3.2 WIRING

Conductors up to and including 6.5 millimeter diameter shall be manufactured with colored insulating materials. Conductors larger than 6.5 millimeter diameter shall have ends identified with color plastic tape in outlet, pull, or junction boxes.

Splice in accordance with the NFPA 70. Provide conductor identification within each enclosure where a tap, splice, or termination is made and at the equipment terminal of each conductor. Terminal and conductor identification shall match as indicated.

Where several feeders pass through a common pullbox, the feeders shall be tagged to clearly indicate the electrical characteristics, circuit number, and panel designation.

3.3 WIRING DEVICES

3.3.1 Wall Switches and Receptacles

Install wall switches and receptacles so that when device plates are applied, the plates will be aligned vertically to within 2 millimeter.

Ground terminal of each flush-mounted receptacle shall be bonded to the outlet box with an approved green bonding jumper.

3.3.2 Device Plates

Device plates for switches that are not within sight of the loads

controlled shall be suitably engraved with a description of the loads.

Device plates and receptacle cover plates for receptacles other than 230 -volt, single-phase, duplex, convenience outlets shall be suitably marked, showing the circuit number, voltage, frequency, phasing, and amperage available at the receptacle. Required marking shall consist of a self-adhesive label having 6 millimeter embossed letters.

Device plates for convenience outlets shall be similarly marked indicating the supply panel and circuit number.

3.4 BOXES AND FITTINGS

Furnish and install pullboxes where necessary in the conduit system to facilitate conductor installation. Conduit runs longer than 30 meter or with more than three right-angle bends shall have a pullbox installed at a convenient intermediate location.

Securely mount boxes and enclosures to the building structure with supporting facilities independent of the conduit entering or leaving the boxes.

Mounting height of wall-mounted outlet and switch boxes, measured between the bottom of the box and the finished floor, shall be in accordance with ICC/ANSI A117.1 and as follows:

LOCATION	MOUNTING HEIGHT
Receptacles	1200 millimeter
Switches for light control	1200 millimeter

3.5 LAMPS AND LIGHTING FIXTURES

Install new lamps of the proper type and wattage in each fixture. Securely fasten fixtures and supports to structural members and install parallel and perpendicular to major axes of structures.

3.6 PANELBOARDS

Securely mount panelboards so that the top operating handle does not exceed 1800 millimeter above the finished floor. Do not mount equipment within 914 millimeter of the front of the panel. Directory card information shall be complete and legible.

3.7 IDENTIFICATION PLATES AND WARNINGS

Furnish and install identification plates for lighting and power panelboards, all line voltage heating and ventilating control panels, and magnetic starters. Process control devices and pilot lights shall have identification plates.

Furnish identification plates for all line voltage enclosed circuit breakers, identifying the equipment served, voltage, phase(s) and power source. Circuits 400 volts and above shall have conspicuously located warning signs in accordance with OSHA requirements.

3.8 PAINTING

Exposed conduit, supports, fittings, cabinets, pull boxes, and racks shall

be thoroughly cleaned and painted.

3.9 FIELD TESTING

Submit Test Reports in accordance with referenced standards in this section.

After completion of the installation and splicing, and prior to energizing the conductors, perform wire and cable continuity and insulation tests as herein specified before the conductors are energized.

Contractor shall provide all necessary test equipment, labor, and personnel to perform the tests, as herein specified.

Isolate completely all wire and cable from all extraneous electrical connections at cable terminations and joints. Substation and switchboard feeder breakers, disconnects in combination motor starters, circuit breakers in panel boards, and other disconnecting devices shall be used to isolate the circuits under test.

Perform Insulation-Resistance Test on each field-installed conductor with respect to ground and adjacent conductors. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Take readings after 1 minute and until the reading is constant for 15 seconds. Minimum insulation-resistance values shall not be less than 25 Megohms for 300 volt rated cable and 100 Megohms for 600 volt rated cable. For circuits with conductor sizes 8AWG and smaller insulation resistance testing is not required.

Perform Continuity Test to insure correct cable connection (i.e correct phase conductor, grounded conductor, and grounding conductor wiring) end-to end. Any damages to existing or new electrical equipment resulting from contractor mis-wiring will be repaired and re-verified at contractor's expense. All repairs shall be approved by the USAid Implementing Partner prior to acceptance of the repair.

Conduct Phase-Rotation Tests on all three-phase circuits using a phase-rotation indicating instrument. Perform phase rotation of electrical connections to connected equipment clockwise, facing the source.

Final acceptance will depend upon the successful performance of wire and cable under test. Do not energize any conductor until the final test reports are reviewed and approved by the USAid Implementing Partner.

-- End of Section --

SECTION 26 05 19.00 10

INSULATED WIRE AND CABLE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC C8	(2000) Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV
AEIC CS8	(2000) Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE Std 383	(2003) Standard for Qualifying Class 1E Electric Cables and, Field Splices for Nuclear Power Generating Stations 2004

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA WC 70	(2009) Standard for Non-Shielded Power Cable 2000 V or Less for the Distribution of Electrical Energy

1.2 SUBMITTALS

Contractor shall submit the follwoing using procedures as specified in the Contract Documents.

SD-03 Product Data

Installation Instructions

Cable manufacturing data as requested.

SD-06 Test Reports

Tests, Inspections, and Verifications

6 certified copies of test reports.

1.3 DELIVERY, STORAGE, AND HANDLING

Furnish cables on reels or coils. Each cable and the outside of each reel or coil, shall be plainly marked or tagged to indicate the cable length, voltage rating, conductor size, and manufacturer's lot number and reel number. Each coil or reel of cable shall contain only one continuous cable without splices. Cables for exclusively dc applications, as specified in

paragraph HIGH VOLTAGE TEST SOURCE, shall be identified as such. Shielded cables rated 2,001 volts and above shall be reeled and marked in accordance with Section I of AEIC C8 or AEIC CS8, as applicable. Reels shall remain the property of the Contractor.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Wire Table

Furnish wire and cable in accordance with the requirements of the wire called for in the drawings, conforming to the detailed requirements specified herein.

2.1.2 Rated Circuit Voltages

All wire and cable shall have minimum rated circuit voltages in accordance with NEMA WC 70.

2.1.3 Conductors

2.1.3.1 Material for Conductors

Conductors shall conform to all the applicable requirements of NEMA WC 70, as applicable, and shall be annealed copper. Copper conductors may be bare, or tin- or lead-alloy-coated, if required by the type of insulation used.

2.1.3.2 Size

Minimum wire size shall be 2.5 mm2 for power and lighting circuits; 4 mm2 for current transformer secondary circuits; 1.5 mm2 for potential transformer, relaying, and control circuits; 1.5 mm2 for annunciator circuits; and 1.5 mm2 for alarm circuits. Minimum wire sizes for rated circuit voltages of 2,001 volts and above shall not be less than those listed for the applicable voltage in NEMA WC 70, as applicable.

2.1.3.3 Stranding

Conductor stranding classes cited herein shall be as defined in NEMA WC 70, as applicable. Lighting conductors 2.5 mm2 and smaller shall be solid or have Class B stranding. Any conductors used between stationary and moving devices, such as hinged doors or panels, shall have Class H or K stranding. All other conductors shall have Class B or C stranding, except that conductors shown on the drawings, or in the schedule, as 2.5 mm2 may be 19 strands and conductors shown as 4 mm2 may be 19 strands.

2.1.3.4 Conductor Shielding

Use conductor shielding conforming to NEMA WC 70, as applicable, on power cables having a rated circuit voltage above 2,000 volts. In addition, conductor shielding for shielded cables shall also comply with Section C of AEIC C8 or AEIC CS8. Strict precautions shall be taken after application of the conductor shielding to prevent the inclusion of voids or contamination between the conductor shielding and the subsequently applied insulation.

2.1.3.5 Separator Tape

Where conductor shielding, strand filling, or other special conductor treatment is not required, a separator tape between conductor and insulation is permitted.

2.1.4 Insulation

2.1.4.1 Insulation Material

Provide insulation which is a cross-linked thermosetting polyethylene (XLPE) type, meeting the requirements of NEMA WC 70, as applicable, or an ethylene-propylene rubber (EPR) type meeting the requirements of NEMA WC 70. For shielded cables of rated circuit voltages above 2,000 volts, the following provisions shall also apply:

a. XLPE, if used, shall be tree-retardant.

b. Insulation shall be chemically bonded to conductor shielding.

c. The insulation material and its manufacturing, handling, extrusion and vulcanizing processes, shall all be subject to strict procedures to prevent the inclusion of voids, contamination, or other irregularities on or in the insulation. Insulation material shall be inspected for voids and contaminants. Inspection methods, and maximum allowable void and contaminant content shall be in accordance with Section B of AEIC C8 or AEIC CS8, as applicable.

d. Cables with repaired insulation defects discovered during factory testing, or with splices or insulation joints, are not acceptable.

2.1.4.2 Insulation Thickness

The insulation thickness for each conductor shall be based on its rated circuit voltage.

a. Power Cables/Single-Conductor Control Cables, 2,000 Volts and Below - The insulation thickness for single-conductor cables rated 2,000 volts and below shall be as required by NEMA WC 70, as applicable. Some thicknesses of NEMA WC 70 will be permitted only for single-conductor cross-linked thermosetting polyethylene insulated cables without a jacket. NEMA WC 70 ethylene-propylene rubber-insulated conductors shall have a jacket.

b. Power Cables, Rated 2,001 Volts and Above - Thickness of insulation for power cables rated 2,001 volts and above shall be in accordance with the following:

(1) Non-shielded cables, 2,001 to 5,000 volts, shall comply with NEMA WC 70, as applicable.

(2) Shielded cables rated 2,001 volts and above shall comply with Column B of Table B1, of AEIC C8 or AEIC CS8, as applicable.

c. Multiple-Conductor Control Cables - The insulation thickness of multiple-conductor cables used for control and related purposes shall be as required by NEMA WC 70, as applicable.

2.1.4.3 Insulation Shielding

Unless otherwise specified, provide insulation shielding for conductors having rated circuit voltages of 2,001 volts and above. The voltage limits above which insulation shielding is required, and the material requirements, are given in NEMA WC 70, as applicable. The material, if thermosetting, shall meet the wafer boil test requirements as described in Section D of AEIC C8 or AEIC CS8, as applicable. The method of shielding shall be in accordance with the current practice of the industry; however, the application process shall include strict precautions to prevent voids or contamination between the insulation and the nonmetallic component. Voids, protrusions, and indentations of the shield shall not exceed the maximum allowances specified in Section C of AEIC C8 or AEIC CS8, as applicable. The cable shall be capable of operating without damage or excessive temperature when the shield is grounded at both ends of each conductor. All components of the shielding system shall remain tightly applied to the components they enclose after handling and installation in accordance with the manufacturer's recommendations. Shielding systems which require heat to remove will not be permitted unless specifically approved.

2.1.5 Jackets

All cables shall have jackets meeting the requirements of NEMA WC 70, as applicable, and as specified herein. Individual conductors of multiple-conductor cables shall be required to have jackets only if they are necessary for the conductor to meet other specifications herein. Jackets of single-conductor cables and of individual conductors of multiple-conductor cables, except for shielded cables, shall be in direct contact and adhere or be vulcanized to the conductor insulation. Multiple-conductor cables and shielded single-conductor cables shall be provided with a common overall jacket, which shall be tightly and concentrically formed around the core. Repaired jacket defects found and corrected during manufacturing are permitted if the cable, including jacket, afterward fully meets these specifications and the requirements of the applicable standards.

2.1.5.1 Jacket Material

The jacket shall be one of the materials listed below. Variations from the materials required below will be permitted only if approved for each specific use, upon submittal of sufficient data to prove that they exceed all specified requirements for the particular application.

a. General Use

(1) Heavy-duty black neoprene (NEMA WC 70).

(2) Heavy-duty chlorosulfonated polyethylene (NEMA WC 70).

(3) Heavy-duty cross-linked (thermoset) chlorinated polyethylene (NEMA WC 70).

b. Accessible Use Only, 2,000 Volts or Less - Cables installed where they are entirely accessible, such as cable trays and raceways with removable covers, or where they pass through less than 3 meters of exposed conduit only, shall have jackets of one of the materials specified in above paragraph GENERAL USE, or the jackets may be of one of the following:

(1) General-purpose neoprene (NEMA WC 70).

(2) Black polyethylene (NEMA WC 70).

(3) Thermoplastic chlorinated polyethylene (NEMA WC 70).

2.1.5.2 Jacket Thickness

The minimum thickness of the jackets at any point shall be not less than 80 percent of the respective nominal thicknesses specified below.

a. Multiple-Conductor Cables - Thickness of the jackets of the individual conductors of multiple-conductor cables shall be as required by NEMA WC 70, and shall be in addition to the conductor insulation thickness required by Column B of Table 3-1 of the applicable NEMA publication for the insulation used. Thickness of the outer jackets or sheaths of the assembled multiple-conductor cables shall be as required by NEMA WC 70.

b. Single-Conductor Cables - Single-conductor cables, if nonshielded, shall have a jacket thickness as specified in NEMA WC 70. If shielded, the jacket thickness shall be in accordance with the requirements of NEMA WC 70.

2.1.6 Metal-Clad Cable

2.1.6.1 General

The metallic covering shall be interlocked steel tape or corrugated metal, conforming to the applicable requirements of NEMA WC 70. If the covering is of ferrous metal, it shall be galvanized. Copper grounding conductor(s) conforming to NEMA WC 70 shall be furnished for each multiple-conductor metal-clad cable. Assembly and cabling shall be as specified in paragraph CABLING. The metallic covering shall be applied over an inner jacket or filler tape. The cable shall be assembled so that the metallic covering will be tightly bound over a firm core.

2.1.6.2 Jackets

Metal-clad cables may have a jacket under the armor, and shall have a jacket over the armor. Jackets shall comply with the requirements of NEMA WC 70. The outer jacket for the metal-clad cable may be of polyvinyl chloride only if specifically approved.

2.2 CABLE IDENTIFICATION

2.2.1 Color-Coding

Insulation of individual conductors of multiple-conductor cables shall be color-coded in accordance with NEMA WC 70, except that colored braids will not be permitted. Only one color-code method shall be used for each cable construction type. Control cable color-coding shall be in accordance with NEMA WC 70. Power cable color-coding shall be black for Phase A, red for Phase B, blue for Phase C, white for grounded neutral, and green for an insulated grounding conductor, if included. Other individual conductors shall be color-coded as indicated on the contract drawings but such color-coding may be accomplished by applying colored plastic tapes or sleeving at terminations.

2.2.2 Shielded Cables Rated 2,001 Volts and Above

Marking shall be in accordance with Section H of AEIC C8 or AEIC CS8, as applicable.

2.2.3 Cabling

Individual conductors of multiple-conductor cables shall be assembled with flame-and moisture-resistant fillers, binders, and a lay conforming to NEMA WC 70, except that flat twin cables will not be permitted. Fillers shall be used in the interstices of multiple-conductor round cables with a common covering where necessary to give the completed cable a substantially circular cross section. Fillers shall be non-hygroscopic material, compatible with the cable insulation, jacket, and other components of the cable. The rubber-filled or other approved type of binding tape shall consist of a material that is compatible with the other components of the cable and shall be lapped at least 10 percent of its width.

2.2.4 Dimensional Tolerance

The outside diameters of single-conductor cables and of multiple-conductor cables shall not vary more than 5 percent and 10 percent, respectively, from the manufacturer's published catalog data.

PART 3 EXECUTION

3.1 INSTALLATION INSTRUCTIONS

The following information shall be provided by the cable manufacturer for each size, conductor quantity, and type of cable furnished:

a. Minimum bending radius, in inches - For multiple-conductor cables, this information shall be provided for both the individual conductors and the multiple-conductor cable.

b. Pulling tension and sidewall pressure limits, in newtons.

c. Instructions for stripping semiconducting insulation shields, if furnished, with minimum effort without damaging the insulation.

d. Upon request, compatibility of cable materials and construction with specific materials and hardware manufactured by others shall be stated. Also, if requested, recommendations shall be provided for various cable operations, including installing, splicing, terminating, etc.

3.2 TESTS, INSPECTIONS, AND VERIFICATIONS

3.2.1 Cable Data

Manufacture of the wire and cable shall not be started until all materials to be used in the fabrication of the finished wire or cable have been approved by the Contracting Officer. Cable data shall be submitted for approval including dimensioned sketches showing cable construction, and sufficient additional data to show that these specifications will be satisfied.

3.2.2 Inspection and Tests

Inspection and tests of wire and cable furnished under these specifications shall be made by and at the plant of the manufacturer, and shall be witnessed by the USAid Implementing Partner, unless waived in writing. The USAid Implementing Partner may perform further tests before or after installation. Testing in general shall comply with NEMA WC 70. Specific tests required for particular materials, components, and completed cables shall be as specified in the sections of the above standards applicable to those materials, components, and cable types. Tests shall also be performed in accordance with the additional requirements specified below.

3.2.2.1 High-Voltage Test Source

Where the applicable standards allow a choice, high-voltage tests for cables to be used exclusively on dc circuits shall be made with dc test voltages. Cables to be used exclusively on ac circuits shall be tested with ac test voltages. If both ac and dc will be present, on either the same or separate conductors of the cable, ac test voltages shall be used.

3.2.2.2 Shielded Cables Rated 2,001 Volts or Greater

The following tests shall be performed in addition to those specified above. Section or paragraph references are to AEIC C8 or AEIC CS8 as applicable, unless otherwise stated.

a. High potential test voltages shall be as required by Table B1 of AEIC C8 or AEIC CS8 as applicable, rather than by NEMA WC 70.

b. If high potential testing is done with an ac test voltage as specified in paragraph HIGH-VOLTAGE TEST SOURCE, an additional test shall be made using a dc test voltage rated at 75 percent of the specified full dc test voltage, for 5 consecutive minutes.

c. Production sampling tests shall be performed in accordance with Section D. Sampling frequency and failure contingencies shall be in accordance with paragraph G.3. Unless otherwise approved, samples shall not be taken from the middle of extruder runs of insulation or shielding made only for one continuous shipping length of cable, if such sampling will result in the need to repair the sampled area.

d. Partial discharge tests shall be performed in accordance with Section E, paragraph E.2, and Section F.

3.2.2.3 Flame Tests

All cable assemblies shall pass IEEE Std 383 flame tests, paragraph 2.5, using the ribbon gas burner. Single-conductor cables and individual conductors of multiple-conductor cables shall pass the flame test of NEMA WC 70. If such tests, however, have previously been made on identical cables, these tests need not be repeated. Instead, certified reports of the original qualifying tests shall be submitted. In this case the reports furnished under paragraph REPORTS, shall verify that all of each cable's materials, construction, and dimensions are the same as those in the qualifying tests.

3.2.2.4 Independent Tests

The USAid Implementing Partner may at any time make visual inspections,

continuity or resistance checks, insulation resistance readings, power factor tests, or dc high-potential tests at field test values. A cable's failure to pass these tests and inspections, or failure to produce readings consistent with acceptable values for the application, will be grounds for rejection of the cable.

3.2.2.5 Reports

Furnish results of tests made. No wire or cable shall be shipped until authorized. Lot number and reel or coil number of wire and cable tested shall be indicated on the test reports.

| -- End of Section --

SECTION 26 05 48.00 10

SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04 (2007) Seismic Design for Buildings

UNDERWRITERS LABORATORIES (UL)

UL 1598 (2008; Rev thru Jan 2010) Luminaires

1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

The requirements for seismic protection measures described in this section shall be applied to the electrical equipment and systems listed below. Structural requirements shall be in accordance with Section 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT.

1.2.2 Electrical Equipment

Electrical equipment shall include the following items to the extent required on the drawings or in other sections of these specifications:

Control Panels	
Pumps with Motors	Switchgear
Unit Substations	
Transformers	
Switchboards (Floor Mounted)	Storage Racks

1.2.3 Electrical Systems

The following electrical systems shall be installed as required on the drawings and other sections of these specifications and shall be seismically protected in accordance with this specification: Generators, Fuel Tank, Unit Substation.

1.2.4 Conduits Requiring No Special Seismic Restraints

Seismic restraints may be omitted from electrical conduit less than 64 mm trade size . All other interior conduit, shall be seismically protected as specified.

1.3 EQUIPMENT REQUIREMENTS

1.3.1 Rigidly Mounted Equipment

The following specific items of equipment to be furnished under this contract shall be constructed and assembled to withstand the seismic forces specified in UFC 3-310-04. Each item of rigid electrical equipment shall be entirely located and rigidly attached on one side only of a building expansion joint. Piping, electrical conduit, etc., which cross the expansion joint shall be provided with flexible joints that are capable of accommodating displacements equal to the full width of the joint in both orthogonal directions.

Engine-Generators
Substations
Transformers
Switch Boards and Switch Gears
Free Standing Electric Motors

1.4 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.

SD-03 Product Data

Contractor Designed Bracing

Copies of the Design Calculations with the Drawings. Calculations shall be approved, certified, stamped and signed by a Registered Professional Engineer. Calculations shall verify the capability of structural members to which bracing is attached for carrying the load from the brace.

PART 2 PRODUCTS

2.1 LIGHTING FIXTURE SUPPORTS

Lighting fixtures and supports shall conform to UL 1598.

2.2 SWAY BRACING MATERIALS

Sway bracing materials (e.g. rods, plates, rope, angles, etc.) shall be as specified in Section 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT.

PART 3 EXECUTION

3.1 SWAY BRACES FOR CONDUIT

Conduit shall be braced as for an equivalent weight pipe in accordance with Section 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT.

3.2 LIGHTING FIXTURES IN BUILDINGS

3.2.1 Assembly Mounted on Outlet Box

A supporting assembly, that is intended to be mounted on an outlet box, shall be designed to accommodate mounting features on 100 mm boxes, plaster

rings, and fixture studs.

3.2.2 Lateral Force

Structural requirements for light fixture bracing shall be in accordance with Section 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT.

-- End of Section --

SECTION 26 05 71.00 40

LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C39.1	(1981; R 1992) Requirements for Electrical Analog Indicating Instruments

ASTM INTERNATIONAL (ASTM)

ASTM D 877	(2002; R 2007) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA 443	(1979) Standard for Solid-State Relay Service, EIA/NARM

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C37.17	(1997) Standard for Trip Devices for AC and General-Purpose DC Low-Voltage Power Circuit Breakers
IEEE C37.90	(2005) Standard for Relays and Relay Systems Associated With Electric Power Apparatus
IEEE C57.13	(2008) Standard Requirements for Instrument Transformers
IEEE C63.2	(2009) Standard for Electromagnetic Noise and Field Strength Instrumentation, 10 Hz to 40 GHz - Specifications
IEEE C63.4	(2009) American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

IPC - ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES (IPC)

IPC D330	(1992) Switches

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 107	(1998; R 1993) Methods of Measurement of Radio Influence Voltage (RIV) of High-Voltage Apparatus
NEMA 250	(2008) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA AB 1	(2002) Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures
NEMA AB 3	(2001) Molded Case Circuit Breakers and Their Application
NEMA C12.1	(2008) Electric Meters; Code for Electricity Metering
NEMA C78.23	(1995; R 2003) Standard for Incandescent Lamps - Miscellaneous Types
NEMA FU 1	(2002; R 2007) Low Voltage Cartridge Fuses
NEMA ICS 1	(2000; R 2005; R 2008) Standard for Industrial Control and Systems General Requirements
NEMA ICS 2	(2000; R 2005; Errata 2008) Standard for Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated Not More than 2000 Volts AC or 750 Volts DC: Part 8 - Disconnect Devices for Use in Industrial Control Equipment
NEMA ICS 6	(1993; R 2006) Standard for Industrial Controls and Systems Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2008; AMD 1 2008) National Electrical Code - 2008 Edition

UNDERWRITERS LABORATORIES (UL)

UL 20	(2000 ; Rev thru Dec 2008) Standard for General-Use Snap Switches
UL 489	(2009) Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 508	(1999; Rev thru Sep 2008) Standard for Industrial Control Equipment

1.2 SUBMITTALS

Contractor shall submit the following using procedures as specified in the

Contract Documents.

SD-01 Preconstruction Submittals

Prior to the beginning of construction, submit manufactures equipment and performance data for the following items including use life, system functional flows, safety features, and mechanical automated details.

Fuses

SD-02 Shop Drawings

Submit Connection Diagrams and Fabrication Drawings for the following items in accordance with paragraph entitled, "General Requirements," of this section.

Submit Installation drawings for the following items in accordance with the paragraph entitled, "Installation," of this section.

Control Devices
Protective Devices

SD-03 Product Data

Submit manufacturer's equipment and performance data for the following items including use life, system functional flows, safety features, and mechanical automated details.

Motor Control
Instrument Transformers
Enclosures
Circuit Breakers
Control Devices
Time Switches
Protective Relays
Indicating Instruments
Indicating Lights

SD-07 Certificates

Submit certificates for Circuit Tests on similar motor-control or submit motor-circuit protector (MCP) units under actual conditions in lieu of factory tests on the actual units provided. Also include dielectric tests.

SD-08 Manufacturer's Instructions

Submit manufacturer's instructions for the following items, including special provisions required to install equipment components and system packages. Provide detail on resistance impedances, hazards and safety precautions within the special notices.

Control Devices
Protective Devices

SD-10 Operation and Maintenance Data

Submit Operation and Maintenance Manuals for the following equipment:

Manual Motor Controllers
Magnetic Motor Controllers
Combination Motor Controllers
Circuit Breakers
Time Switches
Protective Relays
Indicating Instruments

1.3 GENERAL REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS applies to work specified in this section.

Submit Connection Diagrams showing the relations and connections of control devices and protective devices by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

Submit Fabrication Drawings for control devices and protective devices consisting of fabrication and assembly details to be performed in the factory.

PART 2 PRODUCTS

2.1 MOTOR CONTROL

Conform to NEMA ICS 1, NEMA ICS 2, and UL 508 for motor controllers. Provide controllers that have thermal overload protection in each phase.

2.1.1 Manual Motor Controllers

Provide full-voltage, manually operated manual motor controllers for the control and protection of single-phase 60-hertz ac small wattage rating squirrel-cage induction motors.

Provide single-throw, single- or double-pole, three-position controllers rated at not more than 750 watt rated at 230-volts single phase. Include a supporting base or body of electrical insulating material with enclosed switching mechanism, yoke, thermal overload relay, and terminal connectors. Provide controllers that clearly indicate operating condition: on, off, or tripped.

Provide toggle- or key-operated type manual motor controllers as indicated and arrange so that they are lockable with a padlock in the "OFF" position.

Provide recessed manual motor controllers for single-speed, small wattage rating squirrel-cage induction motors, that include a single controller and indicating light in a 100 millimeter square wall outlet box, for flush-wiring devices with matching corrosion-resistant steel flush cover plate. Provide surface-mounted manual motor controllers for single-speed, small wattage rating squirrel cage induction motors that include a single controller and indicating light in a NEMA 250, Type 1 general-purpose enclosure.

Provide recessed and surface-mounted manual motor controllers for two-speed, small wattage rating squirrel-cage induction motors, that include two controllers, two indicating lights, and a selector switch in a multiple-gang wall outlet box for flush-wiring devices, with matching corrosion-resistant steel flush-cover plate. Provide surface-mounted manual motor controllers for two-speed small wattage rating squirrel-cage induction motors, that include two controllers, two indicating lights, and a selector switch in a NEMA 250, Type 1 general-purpose enclosure.

2.1.2 Magnetic Motor Controllers

2.1.2.1 Full-Voltage Controllers

Provide full-voltage, full magnetic devices in accordance with NEMA ICS 1, NEMA ICS 2, and UL 508for magnetic motor controllers for the control and protection of single- and three-phase, 50-hertz, squirrel-cage induction motors.

Provide operating coil assembly that operates satisfactorily between 85 and 110 percent of rated coil voltage. Provide 230 volts, 50 hertz motor control circuits.

Provide controller with two normally open and two normally closed auxiliary contacts rated per NEMA ICS 1 and NEMA ICS 2 in addition to the sealing-in contact for control circuits.

Provide solderless pressure wire terminal connectors for line-and load-connections to controllers.

Include three manual reset thermal overload devices for overcurrent protection, one in each pole of the controller. Provide thermal overload relays of melting-alloyor bimetallic nonadjustable type with continuous current ratings and service-limit current ratings, and with a plus or minus 15 percent adjustment to compensate for ambient operating conditions.

Provide an externally operable manual-reset button to re-establish control power to the holding coil of the electromagnet. After the controller has tripped from overload, ensure that resetting the motor-overload device does not restart the motor.

Provide enclosure in accordance with NEMA 250, Type 1.

2.1.2.2 Reduced-Voltage Starters

Conform to the requirements for full-voltage controllers for reduced-voltage starters, except for voltage, and to the following additional requirements.

Fully protect the motor during all phases of motor starting with an overload device in each motor leg. Rate starter contacts to withstand the switching surges during selector to full voltage. Provide starter that contains the necessary sensing and timing devices to monitor motor operation and select the correct time for selector to full voltage.

Adequately ventilate resistors and autotransformers used for starting. Ventilate solid-state starters for starting cycles as well as any follow-on restart-run cycles. Operate external control circuits or solid-state starters at a maximum of 230 volts ac.

For solid-state starters, provide adjustable starting torque from 0 to 50 percent of applied voltage, minimum. Provide autotransformer starters with a minimum of three taps above 50 percent reduced voltage.

2.1.3 Combination Motor Controllers

Following requirements are in addition to the requirements specified for magnetic motor controller:

Provide combination motor controllers for the control and protection of single-and three-phase 50-hertz alternating-current squirrel-cage induction motors with branch-circuit disconnecting and protective devices in accordance with NEMA ICS 1, NEMA ICS 2, and NEMA ICS 6.

For combination motor controllers include magnetic motor controllers and molded-case circuit breakers or MCP in metal enclosures in accordance with NEMA 250 or motor-control center draw-out assemblies with control-power transformers, selector switches, pushbuttons, and indicating lights as follows:

Provide full-voltage, full-magnetic devices as specified in this section under paragraph entitled, "Remote-Control Station Enclosures." for magnetic motor controllers and enclosures.

Provide thermal-magnetic breakers as specified in paragraph entitled, "Manual Motor Controllers."for molded-case circuit breakers. Manufacturer's standard MCP may be used in lieu of molded-case circuit breakers.

Provide control-power transformers 230-volt ac maximum, selector switches, pushbuttons, and pilot lights as required.

Identify combination motor controllers with identification plates affixed to front cover of the controller.

2.1.3.1 Nonreversing Combination Motor Controllers

Following requirements are in addition to the requirements for magnetic motor controllers:

For nonreversing combination motor controllers for the control and protection of single-speed squirrel-cage induction motors, include a magnetic controller with molded-case circuit breaker or MCP with selector switch or start/stop pushbutton and indicating light in the cover of the enclosure.

Provide rating of single and three-phase single-speed full-voltage magnetic controllers for nonplugging and nonjogging duty in accordance with NEMA ICS 1 and NEMA ICS 2.

Provide wiring and connections for full-voltage single-speed magnetic controllers in accordance with NEMA ICS 1 and NEMA ICS 2.

2.1.3.2 Reversing Combination Motor Controllers

Following requirements are in addition to the requirements for magnetic motor controllers:

For reversing combination motor controllers for the control and protection

of single-speed squirrel-cage induction motors, include two interlocked magnetic controllers with molded-case circuit breaker or MCP, with selector switch or forward/reverse/stop pushbutton and two indicating lights in the cover of the enclosure. Indicate with indicating lights the forward and reverse running connection of the motor controller.

Provide rating of single and three-phase single-speed full-voltage magnetic controllers for plug-stop, plug-reverse, or jogging duty in accordance with NEMA ICS 1 and NEMA ICS 2.

Provide wiring and connections for full-voltage single-speed magnetic controllers in accordance with NEMA ICS 1 and NEMA ICS 2.

2.1.3.3 Two-Speed Combination Motor Controllers

Following requirements are in addition to the requirements for magnetic motor controllers:

For two-speed combination motor controllers for the control and protection of single- and two-winding, two-speed, three-phase, squirrel-cage induction motors, include two magnetic controllers with molded-case circuit breaker or MCP, with selector switch or fast/slow/stop pushbutton and two indicating lights in the cover of the enclosure. Indicate with indicating lights the high- and low-speed running connection of the motor controller.

Provide rating of three-phase, two-speed, full-voltage, magnetic controllers for nonplugging and nonjogging duty for constant- and variable-torque motors in accordance with NEMA ICS 1 and NEMA ICS 2.

Provide rating of three-phase, two-speed, full-voltage, magnetic controllers for nonplugging and nonjogging duty for constant-motors motors in accordance with NEMA ICS 1 and NEMA ICS 2.

Provide rating of three-phase, two-speed, full-voltage, magnetic controllers for plug-stop, plug-reverse, or jogging duty for constant-torque, variable-torque, and constant wattage motors in accordance with NEMA ICS 1 and NEMA ICS 2.

2.2 INSTRUMENT TRANSFORMERS

Comply with the interference requirements listed below, measured in accordance with IEEE C63.2, IEEE C63.4, and NEMA 107 for Instrument transformers.

Insulation Class, kV	Basic Insulation Level, kV	Preferred Nominal System Voltage, kV	Test Voltage for Potential Transformers, kV	Test Voltage for Current Transformers, kV	Radio Influence Voltage Level, Microvolts Dry Type	Radio Influence Voltage Level, Microvolts Oil Filled
0.6	10	.....	.....	0.76	250	250
1.2	30	0.208 0.416 0.832 1.04	0.132 0.264 0.528 0.66	0.76	250	250
2.5	45	2.40	1.52	1.67	250	250

Insulation Class, kV	Basic Insulation Level, kV	Preferred Nominal System Voltage, kV	Test Voltage for Potential Transformers, kV	Test Voltage for Current Transformers, kV	Radio Influence Voltage Level, Microvolts Dry Type	Radio Influence Voltage Level, Microvolts Oil Filled
5.0	60	4.16 4.80	2.64 3.04	3.34	250	250
8.7	75	7.20 8.32	4.57 5.28	5.77	250	250
15L or 15H	95-110	12.00 12.47 14.40	7.62 7.92 9.14	9.41	1000	250
25	150	23.00	14.60	15.70	2500	650
34.5	200	34.50	21.90	23.0	....	650
46	250	46.00	29.20	29.30	....	1250
69	350	69.00	43.80	44.00	....	1250
92	450	92.00	58.40	58.40	....	2500
115	550	115.00	73.40	73.40	....	2500
138	650	138.00	88.00	88.00	....	2500

2.2.1 Current Transformers

Provide current transformers that conform to IEEE C57.13 for installation in metal-clad switchgear. Use standard 3-A secondary transformer.

Provide bushing or window type transformers.

Provide transformers that have single secondary winding.

Provide transformers that are complete with secondary short-circuiting device.

For window-type current transformers, provide indoor dry type construction with secondary current ratings as indicated with specified burden, frequency, and accuracy.

2.2.2 Potential Transformers

For potential transformers, conform to IEEE C57.13 for installation in metal-clad switchgear. Use standard 230-volt secondary transformers.

Provide transformers that have single secondary.

Provide burden, frequency, and accuracy as required.

For disconnecting potential transformers with integral fuse mountings and current-limiting fuses, provide indoor dry type two-winding construction with primary and secondary voltage ratings as required.

2.3 ENCLOSURES

2.3.1 Equipment Enclosures

Provide enclosures for equipment in accordance with NEMA 250.

Contain equipment installed in industrial locations in a NEMA Type 12 industrial use, sheet-steel enclosure, constructed to prevent the entrance of dust, lint, fibers, flyings, oil, and coolant seepage.

2.3.2 Remote-Control Station Enclosures

Provide remote-control station enclosures for pushbuttons, selector switches, and indicating lights in accordance with the appropriate articles of NEMA ICS 6 and NEMA 250.

Contain remote-control stations installed in wet locations in NEMA Type 4 watertight, cast-iron enclosures, constructed to prevent entrance of water when tested in accordance with NEMA ICS 6 and NEMA 250 for Type 4 enclosures.

Install remote-control stations with the centerline 1700 millimeter above the finished floor.

2.4 CIRCUIT BREAKERS

Provide circuit breakers that conform to UL 489, NEMA AB 1, and NEMA AB 3.

2.4.1 Molded-Case Circuit Breakers

Provide molded case, manually operated, trip-free, circuit breakers, with inverse-time thermal-overload protection and instantaneous magnetic short-circuit protection as required. Completely enclose circuit breakers in a molded case, with the calibrated sensing element factory-sealed to prevent tampering.

Locate thermal-magnetic tripping elements in each pole of the circuit breaker, and provide inverse-time-delay thermal overload protection and instantaneous magnetic short-circuit protection. Provide instantaneous magnetic tripping element, that is adjustable and accessible from the front of the breaker on frame sizes larger than 100 amperes.

Size breaker as required for the continuous current rating of the circuit. Provide breaker class as required.

Provide sufficient interrupting capacity of the panel and lighting branch circuit breakers, to successfully interrupt the maximum short-circuit current imposed on the circuit at the breaker terminals. Provide circuit breaker interrupting capacities with a minimum of 10,000 amperes and that conform to NEMA AB 3.

Provide the common-trip type multipole circuit breakers having a single operating handle and a two-position on/off indication. Provide circuit breakers with temperature compensation for operation in an ambient temperature of 40 degrees C. Provide circuit breakers that have root mean

square (rms) symmetrical interrupting ratings sufficient to protect the circuit being supplied. Interrupting ratings may have selective type tripping (time delay, magnetic, thermal, or ground fault).

Provide phenolic composition breaker body capable of having such accessories as handle-extension, handle-locking, and padlocking devices attached where required.

Provide circuit breakers used for meter circuit disconnects that meet the applicable requirements of NFPA 70 and that are of the motor-circuit protector type.

For circuit breakers used for service disconnection, provide an enclosed circuit-breaker type with external handle for manual operation. Provide sheet metal enclosures with a hinged cover suitable for surface mounting.

2.4.2 Enclosed Molded-Case Circuit Breakers

For enclosed circuit breakers, provide thermal-magnetic molded-case circuit breakers in surface-mounted, nonventilated enclosures conforming to the appropriate articles of NEMA 250 and NEMA AB 1.

Provide enclosed circuit breakers in nonhazardous locations as follows:

Contain circuit breakers installed in wet locations in NEMA Type 4, watertight cast-iron enclosures, constructed to prevent entrance of water when tested in accordance with NEMA ICS 1 for Type 4 enclosures.

2.5 FUSES

Provide a complete set of fuses for all switches and switchgear. Rate fuses that have a voltage rating of not less than the circuit voltage.

Make no change in continuous-current rating, interrupting rating, and clearing or melting time of fuses unless written permission has first been secured.

Provide nonrenewable cartridge type fuses for ratings 30 amperes, 125 volts or less. Provide renewable cartridge type fuses for ratings above 30 amperes 600 volts or less with time-delay dual elements, except where otherwise indicated. Conform to NEMA FU 1 for fuses.

Install special fuses such as extra-high interrupting-capacity fuses, fuses for welding machines, and capacitor fuses where required. Plug fuses are not permitted.

Label fuses showing UL class, interrupting rating, and time-delay characteristics, when applicable. Additionally, clearly list fuse information on equipment drawings.

Provide porcelain fuse holders when field-mounted in a cabinet or box. Do not use fuse holders made of such materials as ebony asbestos, Bakelite, or pressed fiber for field installation.

2.6 CONTROL DEVICES

2.6.1 Magnetic Contactors

Provide magnetic contactors in accordance with NEMA ICS 1 and NEMA ICS 2 as

required for the control of low-voltage, 60-hertz, tungsten-lamp loads, fluorescent-lamp loads, resistance-heating loads, and the primary windings of low-voltage transformers.

Provide core-and-coil assembly that operates satisfactorily with coil voltage between 85 and 110 percent of its voltage rating.

Provide contactor that is designed with a normally open holding circuit auxiliary contact for control circuits, with a rating in accordance with NEMA ICS 1 and NEMA ICS 2.

Furnish solderless pressure wire terminal connectors, or make available for line-and-load connections to contactors in accordance with NEMA ICS 1 and NEMA ICS 2.

Provide magnetic contactors with a rating in accordance with NEMA ICS 1and NEMA ICS 2.

2.6.2 Control-Circuit Transformers

Provide control-circuit transformers within the enclosure of magnetic contactors and motor controllers when the line voltage is in excess of 120 volts. Provide encapsulated dry type, single-phase, 50-hertz transformer, with a 230-volt (or 24-volt) isolated secondary winding.

Do not provide a transformer with a rated primary voltage less than the rated voltage of the controller, or a rated secondary current less than the continuous-duty current of the control circuit.

Provide voltage regulation of the transformer such that, with rated primary voltage and frequency, the secondary voltage is not less than 95 percent nor more than 105 percent of rated secondary voltage.

Provide source of supply for control-circuit transformers at the load side of the main disconnecting device. Protect secondary winding of the transformer and control-circuit wiring against overloads and short circuits, with fuses selected in accordance with NEMA ICS 6. Ground secondary winding of the control-circuit transformer in accordance with NEMA ICS 6.

2.6.3 Magnetic Control Relays

Provide magnetic control relays for energizing and de-energizing the coils of magnetic contactors or other magnetically operated devices, in response to variations in the conditions of electric control devices in accordance with NEMA ICS 1, and NEMA ICS 2.

Provide core-and-coil assembly that operates satisfactorily with coil voltages between 85 and 110 percent of their voltage rating.

Provide relays that are designed to accommodate normally open and normally closed contacts.

Provide 230 -volt, 50-hertz, Class AIB magnetic control relays with a continuous contact rating of 10 amperes, and with current-making and -breaking ability in accordance with NEMA ICS 1 and NEMA ICS 2, two normally open and two normally closed.

2.6.4 Pushbuttons and Switches

2.6.4.1 Pushbuttons

For pushbuttons for low-voltage ac full-voltage magnetic controllers, provide heavy-duty oiltight NEMA 250, Type 12, momentary-contact devices rated 600 volts, with pilot light, and with the number of buttons and the marking of identification plates as shown. Furnish pushbutton color code in accordance with NEMA ICS 6.

Provide pushbuttons that are designed with normally open, circuit-closing contacts; normally closed circuit-opening contacts; and two-circuit normally open and normally closed circuit-closing and -opening contacts. Provide pushbutton-contact ratings in accordance with NEMA ICS 1 and NEMA ICS 2 with contact designation A600.

Identify pushbuttons in remote control stations with identification plates affixed to front cover in a prominent location. Carry the identification of the system being controlled on the identification plate.

2.6.4.2 Selector Switches

Provide heavy-duty oiltight maintained-contact selector switches for low-voltage control circuits, with the number of positions and the marking of identification plates in accordance with NEMA ICS 1 and NEMA ICS 2.

Identify selector switches in remote control stations with engraved identification plates affixed to front cover in a prominent location. Carry the identification of the system being controlled on the identification plate.

2.6.4.3 Ammeter Selector Switches

Provide rotary multistage snap-action type ammeter selector switches for switchgear in accordance with UL 20 with silver-plated contacts rated for 600 volts ac or dc. Provide a manually operated, four-position selector switch rated for 600 volts, 20 amperes, minimum, and designed to permit current readings on each bus of the main bus from a single indicating instrument. Mount ammeter switch on the hinged front panel of the switchgear compartment and completely isolate it from high-voltage circuits, with engraved escutcheon plate.

Provide a pistol-grip type selector switch handle.

2.6.4.4 Voltmeter Selector Switches

Provide rotary snap-action type voltmeter selector switches for switchgear in accordance with UL 20 with silver-plated contacts rated for 600 volts ac or dc. Provide manually operated, four-position switch designed to permit voltage readings on each phase of the main bus from a single indicating instrument. Mount voltmeter switch on the hinged front panel of the switchgear compartment and completely isolate from high-voltage circuits, and with engraved escutcheon plate.

Provide a pistol-grip type selector switch handle.

2.6.4.5 Miscellaneous Switches

Provide float, limit, door, pressure, proximity, and other types of

switches in accordance with IPC D330 and of the types and classes indicated.

2.7 TIME SWITCHES

Provide time switches for the control of tungsten-lamp loads, fluorescent-lamp loads, resistive-heating loads, motors, and magnetically operated devices, consisting of a motor-driven time dial and switch assembly in a NEMA 250, Type 1 general-purpose enclosure.

Provide motor drives consisting of 230-volt, single-phase, 50-hertz, heavy-duty, self-starting synchronous motors, directly connected to the time dial through a geartrain operating mechanism. Provide a spring-wound stored-energy source of reserve power that will automatically operate the mechanism for a period of not less than 12 hours in case of electric power failure. Provide spring that automatically rewinds electrically in not more than 3 hours of time after electric power is restored.

Include a heavy-duty general-purpose precision snap-action switch in accordance with UL 20 for switch mechanism, with provision for a manual "OFF" and "ON" operation of the switch.

Provide time switches for the control of 230-volt, 2- and 3-wire, single-phase, 60-hertz circuits and 400/230-volt, three-phase, 4-wire, 60-hertz circuits, with a continuous-current tungsten-lamp load rating of 35 amperes.

Provide astronomic type time dials which automatically change settings each day, in accordance with the seasonal time changes in sunrise and sunset. Provide astronomic type dials that have adjustable on and off trippers, for repetitive switching operations at solar time each day and each day in the year and that make one revolution in a 24-hour period of time. Provide time dials that are designed to operate in the "ON" position at sunset and be fully adjustable upward in 15-minute intervals of time throughout each day, and that indicate the day and month of the year. Calibrate dial in 15-minute intervals over a 24-hour period of time around its circumference. Make provision to defeat the switching operation over weekends or up to 6 preselected calendar days each week.

2.8 PROTECTIVE RELAYS

2.8.1 Overcurrent Relays

Conform to IEEE C37.90 for overcurrent relays.

For protection against phase and ground faults, provide single-phase nondirectional removable induction type overcurrent relays with built-in testing facilities designed for operation on the dc or ac control circuit indicated.

Provide ground-fault overcurrent relays with short-time inverse time characteristics with adjustable current tap range as required.

Provide phase-fault overcurrent relays with varied inverse-time characteristics with adjustable current tap range as required, and indicating instantaneous-trip attachments with adjustable current range as required.

Semiflush-mount case with matching cover to the hinged instrument panel.

Provide solid-state static-type trips for low-voltage power circuit breakers in accordance with EIA 443 and IEEE C37.17.

Provide a trip unit that employs a combination of discreet components and integrated circuits to provide the time-current protection functions required in a modern selectively coordinated distribution system.

Provide complete system selective coordination by utilizing a combination of the following time-current curve-shaping adjustments: ampere setting; long-time delay; short-time pickup; short-time delay; instantaneous pickup; and ground fault.

Provide switchable or easily defeatable instantaneous and ground fault trips.

Make all adjustments using non-removable, discrete step, highly reliable switching plugs for precise settings. Provide a sealable, transparent cover over the adjustments to prevent tampering.

Furnish trip devices with three visual indicators to denote the automatic tripping mode of the breaker including: overload; short circuit; and ground fault.

Wire trip unit to appropriate terminals whereby an optional remote automatic trip accessory can be utilized to provide the same indication.

Make available for use a series of optional automatic trip relays for use with the trip unit to provide remote alarm and lockout circuits.

Provide all trip units with test jacks for in-service functional testing of the long-time instantaneous and ground fault circuits using a small hand-held test kit.

2.8.2 Directional Overcurrent Relays

Provide directional overcurrent relays in accordance with IEEE C37.90.

For directional overcurrent relays for protection against reverse-power faults, provide single-phase induction type with adjustable time-delay and instantaneous trip attachments. Provide removable type relays with inverse-time directional and overcurrent units with built-in testing facilities.

Semi-flush mount case with matching cover to the hinged instrument panel.

2.8.3 Reclosing Relays

For reclosing relays, conform to IEEE C37.90.

Design reclosing relays to reclose circuit breakers that have tripped from overcurrent. Provide device that automatically recloses the breaker at adjustable time intervals between reclosures and then locks out the breaker in the open position if the fault persists. If the fault disappears after any reclosure, the circuit breaker remains closed and the reclosing relay resets automatically and is ready to start a new sequence of operation.

Provide removable reclosing relays with built-in testing facilities and consisting of a timing unit rated at 120/240 volts, single-phase, ac and solenoid and contactor units with dc rating as indicated. Arrange contacts

for one instantaneous reclosure and two subsequent reclosures at 15 and 45 seconds, respectively. Set time dial for 60-second drum speed.

Semi-flush mount case with matching cover to the hinged instrument panel.

2.8.4 Undervoltage Relays

For undervoltage relays conform to IEEE C37.90.

Provide three-phase induction type undervoltage relays, including inverse timing with adjustable high- and low-voltage contacts and calibrated scale for protection against loss of voltage, undervoltage, and overvoltage. Equip relays with indicating contactor and voltage switches to provide electrically separate contact circuits. Provide relays that are removable with built-in testing facilities and that are suitable for operation on 120-volt ac circuits, with contacts that are suitable for operation on dc or ac control circuits.

Semi-flush mount case with matching cover to the hinged instrument panel.

2.9 INDICATING INSTRUMENTS

2.9.1 Ammeters

For ammeters, conform to ANSI C39.1.

Provide switchboard indicating ammeters of approximately 115 millimeter square with 250-degree scale and recessed cases suitable for flush mounting. Furnish white dials with black figures and black pointers. Mount instruments on the hinged front panel of the switchgear compartment completely isolated from high-voltage circuits. Provide standard 5-ampere type meter for a zero to full-scale normal movement, 60 hertz.

2.9.2 Voltmeters

For voltmeters, conform to ANSI C39.1.

Provide a switchboard indicating voltmeters that is approximately 115 millimeter square with 250-degree scale and recessed cases suitable for flush mounting. Furnish white dials with black figures and black pointers. Mount instruments on the hinged front panel of the switchgear compartment completely isolated from high-voltage circuits. Provide standard 230-volt type voltmeter for a zero to full-scale normal movement, 50 hertz.

2.9.3 Watt-Hour Meters/Wattmeters

For watt-hour meters, wattmeters, and pulse initiation meters, conform to NEMA C12.1.

Provide three-phase induction type switchboard wattmeters for use with instrument transformers with two stators, each equipped with a current and potential coil. Provide meter that is rated for 5 amperes at 230 volts and is suitable for connection to three-phase, 3- and 4-wire circuits. Provide instrument complete with potential indicating lamps, light-load and full-load adjustments, phase balance, power-factor adjustments, four-dial clock register, ratchets to prevent reverse rotation, and built-in testing facilities.

Provide pulse initiating meters for use with demand meters or pulse recorders, that are suitable for use with mechanical or electrical pulse initiators. Provide mechanical load imposed on the meter by the pulse initiator that is within the limits of the pulse meter. Provide load as constant as practical throughout the entire cycle of operation to ensure accurate meter readings. Provide pulse initiating meter that is capable of measuring the maximum number of pulses at which the pulse device is nominally rated. Consider pulse initiating meter to be operating properly when a kilowatt hour check indicates that the demand meter kilowatthours are within limits of the watthour meter kilowatthours.

Locate pulse initiating meters such that components sensitive to moisture and temperature conditions are minimized. Take precautions to protect sensitive electronic metering circuitry from electromagnetic and electrostatic induction.

Furnish removable meters with draw out test plug and furnish contact devices to operate remote impulse-totalizing graphic demand meters.

Semi-flush mount case with matching cover to the hinged instrument panel.

2.9.4 Graphic Demand Meters

For impulse-totalizing graphic demand meters, conform to NEMA C12.1.

Provide impulse-totalizing graphic demand meters that are suitable for use with switchboard watt-hour meters and that include a two-circuit totalizing relay, cyclometer for cumulative record of impulses, four-dial totalizing kilowatt-hour register, synchronous motor for timing mechanism, torque motor, and chart drive. Provide a positive chart-drive mechanism consisting of chart spindles and drive sprockets that maintains the correct chart speed for roll strip charts. Provide instrument that records as well as indicates on clearly legible graph paper, the 15-minute integrated kilowatt demand of the totalized system.

Furnish the motive power for advancing the register and pen-movement mechanism with a torque motor. Provide capillary pen containing a 1-month ink supply. Provide a 31-day continuous record of operation roll charts.

Semi-flush mount case with matching cover to the hinged instrument panel.

2.9.5 Specialty-Type Meters

For specialty meters, conform to ANSI C39.1. Specialty-type meters are panel meters applicable to specific situations, such as pyrometers and dc parameter meters that conform to the panel layout specified. Provide meter scales that are not less than 180 degrees. Do not use edgewise meters for circuit current and voltage measurements.

2.10 FACTORY TESTING

Perform factory tests on control and low voltage protective devices in accordance with the manufacturer's recommendations.

Conduct short-circuit tests in accordance with Section 2 of NEMA ICS 1.

2.11 INDICATING LIGHTS

2.11.1 General-Purpose Type

For indicating lights, provide oiltight instrument devices with threaded base and collar for flush-mounting, translucent convex lens, candelabra screw-base lampholder, and 230-volt, 6-watt, Type S-6 incandescent lamp in accordance with NEMA C78.23. Provide indicating lights color coded in accordance with NEMA ICS 6.

Provide indicating lights in remote-control stations when pushbuttons and selector switches are out of sight of the controller.

2.11.2 Switchboard Indicating Lights

For switchboard indicating lights, provide the manufacturer's standard transformer type units 230-volt input utilizing low-voltage lamps and convex lenses of the colors indicated. Provide indicating lights that are capable of being relamped from the switchboard front. Indicating lights utilizing resistors in series with the lamps are not permitted except in direct-current control circuits. Provide lights that have a press-to-test feature.

2.12 FINISH

Protect metallic materials against corrosion. Provide equipment with the standard finish by the manufacturer when used for most indoor installations. For harsh indoor environments (any area subjected to chemical and/or abrasive action), and all outdoor installations.

PART 3 EXECUTION

3.1 INSTALLATION

Install Control devices and protective devices that are not factory installed in equipment, in accordance with the manufacturer's recommendations and field adjusted and operation tested. Conform to NFPA 70, NEMA ICS 1 and NEMA ICS 2 requirements for installation of control and protective devices.

3.2 FIELD TESTING

Demonstrate to operate as indicated control and protective devices not factory installed in equipment.

Ratio and verify tap settings of instrumentation, potential, and current transformers.

Perform dielectric tests on insulating oil in oil circuit breakers before the breakers are energized. Test oil in accordance with ASTM D 877, and provide breakdown voltage that is not less than 25,000 volts. Provide manufacturer certification that the oil contains no PCB's, and affix a label to that effect on each breaker tank and on each oil drum containing the insulating oil.

Field adjust reduced-voltage starting devices to obtain optimum operating conditions. Provide test meters and instrument transformers that conform to NEMA C12.1 and IEEE C57.13.

Do not energize control and protective devices until recorded test data has been approved. Provide final test reports with a cover letter/sheet clearly marked with the System name, Date, and the words "Final Test Reports - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

-- End of Section --

SECTION 26 11 16

SECONDARY UNIT SUBSTATIONS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C39.1	(1981; R 1992) Requirements for Electrical Analog Indicating Instruments
ANSI C57.12.13	(1982) Conformance Requirements for Liquid-Filled Transformers

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M	(2009) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153/A 153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 167	(1999; R 2009) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A 653/A 653M	(2009a) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A 780/A 780M	(2001; R 2006) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM D 117	(2002) Standard Guide for Sampling, Test Methods, Specifications and Guide for Electrical Insulating Oils of Petroleum Origin
ASTM D 1535	(2008) Specifying Color by the Munsell System
ASTM D 3487	(2009) Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus
ASTM D 709	(2001; R 2007) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2007; Errata 2006 & 2007; INT 44-56 2007; INT 47, 49, 50, 52-56 2008; INT 57, 58, 51, 48, 59 2009) National Electrical Safety Code
IEEE C37.121	(1989; R 2006) American National Standard for Switchgear Unit Substations Requirements
IEEE C37.20.3	(2001; R 2006) Metal-Enclosed Interrupter Switchgear
IEEE C37.90.1	(2002; Errata 2003; Errata 2004) Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C57.12.00	(2006) Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.29	(2005) Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments
IEEE C57.12.80	(2002) Standard Terminology for Power and Distribution Transformers
IEEE C57.12.90	(2006; INT 2009) Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.13	(2008) Standard Requirements for Instrument Transformers
IEEE C57.98	(1993; R 1999) Guide for Transformer Impulse Tests
IEEE C62.11	(2005; Amendment A 2008) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)
IEEE Std 100	(2000) The Authoritative Dictionary of IEEE Standards Terms
IEEE Std 386	(2006) Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2009) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C12.1	(2008) Electric Meters; Code for Electricity Metering
NEMA C12.10	(2004) Physical Aspects of Watthour Meters
NEMA ICS 6	(1993; R 2006) Standard for Industrial Controls and Systems Enclosures
NEMA LI 1	(1998) Industrial Laminated Thermosetting Products
NEMA ST 20	(1992; R 1997) Standard for Dry-Type Transformers for General Applications

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2008; AMD 1 2008) National Electrical Code - 2008 Edition

UNDERWRITERS LABORATORIES (UL)

UL 467	(2007) Standard for Grounding and Bonding Equipment

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE Std 100.

1.3 SUBMITTALS

Contractor shall submit the following using submittal procedures as specified in the Contract Documents.

As an exception to the transformer submittal requirements specified herein, liquid-filled transformers manufactured by ABB in South Boston, VA; by Cooper Power Systems in Waukesha, WI; or by Howard Industries in Laurel, MS need not meet the submittal requirements of this contract. Instead, the following shall be submitted:

a. A certification, from the manufacturer, that the technical requirements of this specification shall be met.

b. An outline drawing of the transformer with devices identified (paragraph entitled "Transformer Drawings," item a).

c. ANSI nameplate data of the transformer (paragraph entitled "Transformer Drawings", item b).

d. Routine and other tests (paragraph entitled "Routine and Other Tests"), shall be conducted by the manufacturer and may be witnessed by the USAid Implementing Partner (paragraph entitled "Source Quality Control"). Provide transformer test schedule required by submittal item "SD-11 Closeout Submittals". Provide certified copies of the

tests.

e. Provide acceptance test reports required by submittal item "SD-06 Test Reports".

f. Provide operation and maintenance manuals required by submittal item "SD-10 Operation and Maintenance Data".

1.3.1 Coordinated Submittal Reviews

SD-02 Shop Drawings

Unit Substation Drawings

Transformer drawings (to Code CI44

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

SD-03 Product Data

Fuse curves

Secondary unit substation

Unit substation transformer (liquid-filled) (to Code CI44

Submittal shall include manufacturer's information for each component, device, and accessory provided with the transformer.

SD-06 Test Reports

Acceptance checks and tests

SD-07 Certificates

Paint coating system

Transformer Losses

SD-09 Manufacturer's Field Reports

Load Interrupter Switch production tests

Unit substation transformer design tests (liquid-filled) (to code CI44)

Unit substation transformer routine and other tests (liquid-filled) (to code CI44)

SD-10 Operation and Maintenance Data

Unit substations

Submit operation and maintenance data in accordance with the contract documents.

SD-11 Closeout Submittals

Assembled Operation and Maintenance Manuals

Equipment test schedule (to Code CI44 for liquid-filled units)

1.4 QUALITY ASSURANCE

1.4.1 Drawing Requirements

1.4.1.1 Unit Substation Drawings

Drawings shall include, but are not limited to the following:

a. An outline drawing, with front, top, and side views showing incoming, transformer, and outgoing sections. Include switchboard information from Section 26 23 00 SWITCHBOARDS as part of the total unit substation.

b. One-line diagram showing fused load interrupter switch, current transformers, meters, and ampere rating of bus bars.

c. Elementary diagrams and wiring diagrams with terminals identified, and indicating prewired interconnections between items of equipment and the interconnection between the items.

e. Time-current characteristic fuse curves (on full size logarithmic paper) for the load interrupter switch fuse.

1.4.1.2 Transformer Drawings

Drawings shall include, but are not limited to the following:

a. An outline drawing, with front, top, and side views.

b. ANSI nameplate data.

1.4.2 Paint Coating System

Submit IEEE C57.12.29 coating system performance requirement tests. When interrupter switchgear and transformer are provided by two different manufacturers, each one shall provide certification.

1.4.3 Transformer Losses

Submit certification from the manufacturer indicating conformance with the paragraph entitled "Specified Transformer Losses". If tests on transformers of "basically the same design" are not available, provide

written certification by manufacturer that transformers will meet the specified losses, and state what the losses will be. Submit report with transformer shop drawings and product data.

1.4.4 Substation Product Data

Submittal shall include manufacturer's information for each component, device, and accessory provided with the equipment.

1.4.5 Test Reports

Submit report of acceptance test results as specified by paragraph entitled "Field Quality Control."

1.4.6 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.4.7 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.7.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.7.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.5 MAINTENANCE

1.5.1 Assembled Operation and Maintenance Manuals

Manuals shall be assembled in durable, hard covered, water resistant binders. The manual shall be assembled and indexed in the order noted in a table of contents. The contents of the assembled operation and maintenance manuals shall be as follows:

a. Manufacturer's O&M information required by the paragraph entitled, "SD-10 Operation and Maintenance Data."

b. Catalog data required by the paragraph entitled, "SD-03 Product Data."

c. Drawing required by the paragraph entitled, "SD-02 Shop Drawings."

d. Price for spare parts and supply list

e. Routine and field acceptance test reports

1.5.2 Operation and Maintenance Data

Submit operation and maintenance data as specified herein.

1.6 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be secondary unit substations and related accessories are specified in Section 33 71 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION .

2.2 SECONDARY UNIT SUBSTATION

Secondary Unit substations shall comply with IEEE C37.121 regardless of the kVA rating specified. Substation shall consist of one incoming section, one transformer section, and one outgoing section. Substation shall be designed for outdoor service with ventilation openings and gasketing provided to ensure a weatherproof assembly under rain, snow, sleet, and hurricane conditions. Substations shall be subassembled and coordinated by one manufacturer and shall be shipped in complete sections ready for connection at the site. Where practicable, substation shall be shipped as one unit. External doors shall have provisions for padlocking.

2.2.1 Incoming Section

The incoming section shall consist of a metal-enclosed interrupter switchgear section for connecting the incoming circuit through a fused load interrupter switch to the transformer. If required for proper connection and alignment, include a transition section with the incoming section.

2.2.1.1 Incoming Section Enclosure

The incoming section enclosure shall be NEMA ICS 6 Type 3R Bases, frames and channels of enclosure shall be corrosion resistant and shall be fabricated of galvanized steel. Base shall include any part of enclosure that is within 75 mm of concrete pad. Galvanized steel shall be ASTM A 123/A 123M, ASTM A 653/A 653M G90 coating, and ASTM A 153/A 153M, as applicable. Paint enclosure, including bases, ASTM D 1535 light gray No. 61 or No. 49. Paint coating system shall comply with IEEE C57.12.29.

2.2.1.2 Cable Terminations

Provide medium voltage cable terminations as specified in Section 33 71 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION

IEEE Std 386. Insulated High-Voltage Connectors. Connectors shall have steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material.

a. 200 ampere loadbreak connector ratings: Voltage: 25 kV, 125 kV BIL. Short time rating: 10,000 rms symmetrical Amperes.

b. Provide one set of three grounding elbows and one set of three feed-thru inserts for each secondary unit substation. Grounding elbows and feed-thru inserts shall be delivered to the contracting officer.

2.2.1.3 Surge Arresters

IEEE C62.11, rated 20kV, fully shielded, dead-front, metal-oxide-varistor, elbow type with resistance-graded gap, suitable for plugging into inserts. Arresters shall be distribution class. Arresters for use at elevations in excess of 6000 feet above mean sea level shall be specifically rated for that purpose. Arresters shall be equipped with mounting brackets suitable for the indicated installations.

2.2.1.4 Load Interrupter Switch

IEEE C37.20.3, UL listed and labeled load interrupter switchgear. Provide a three-pole, single-throw, deadfront, metal-enclosed, load interrupter switch with manual stored energy operator. Switch shall be fused, with fuses mounted on a single frame and designed for easy inspection and fuse replacement. The switch shall be operated by a manually charged spring stored energy mechanism which shall simultaneously disconnect or connect ungrounded conductors. The moveable blade of the switch shall be deenergized when in the open position. The mechanism shall enable the switch to close against a fault equal to the momentary rating of the switch without affecting its continuous current carrying or load interrupting ability. A ground bus shall extend the width of the switch enclosure and shall be bolted directly thereto. Connect frame of unit to ground bus. The door shall have an inspection window to allow full view of the position of the three switch blades through the closed door. Switch shall have provision for padlocking in the open and closed positions. Switch/fuse integrated ratings shall be as follow:

Rated Maximum Voltage, kV	Rated Withstand Impulse Voltage, kV BIL	Continuous and Load Interrupting Current, A	Short-Circuit Current kA rms Sym	Short-Time/ Fault-Close Current kA
15	95	600	25	40
25.8	125	600	25	40

Fuses shall be current limiting type rated 200amperes continuous, and 10,000 amperes interrupting capacity approximately 150 percent of the transformer

full-load rating and in accordance with the fuse manufacturer's recommendation.

2.2.1.5 Primary Protective Device Connection

Connections between the primary protective device and transformer shall be cable mounted on porcelain insulators, and sized and braced to withstand the specified short-circuit and short-time currents.

2.2.2 Transformer (Liquid-Filled) Sections

ANSI C57.12.13. Mineral oil liquid-filled. Transformer base,including the tank, radiators, flanges, base, lifting provisions, and hardware, shall be fabricated of ASTM A 167 type 304, 304L, or 316 stainless steel. Paint coating system shall comply with IEEE C57.12.29.

2.2.2.1 Transformer Ratings

a. Cooling Class: ONAN-Liquid-filled, self-cooled.

b. Frequency: 50 Hz.

c. Phases: Three phase.

d. Rated Kilovolt Amperes: see drwaings kVA

e. Voltage Rating: See drawings

f. Impedance: Minimum tested impedance shall not be less than 4% percent at 85 degrees C.

g. Insulation Level: 150 kV BIL

h. Temperature Rise: 65 degree C average winding temperature rise above a 30 degree ambient.

i. Audible Sound Levels: Audible sound levels shall comply with the following:

kVA Range	DECIBELS (MAX)
225-300	55
301-500	56
501-700	57
701-1000	58
1001-1500	60
1501-2000	61
2001-2500	62
2501-3000	63
3001-4000	64

2.2.2.2 Transformer Accessories

The transformer shall have the following accessories:

a. Four 2.5 percent full capacity taps, two above and two below rated primary voltage.

b. Tap changer, with external, pad-lockable, manual type operating handle,

for changing tap setting when transformer is de-energized.

c. Dead-front high-voltage bushings; IEEE Std 386. 25kV, 125 kV BIL. Provide 200 ampere bushing wells with bushing well inserts

d. Parking stands: Provide a parking stand near each dead-front bushing. Provide insulated standoff bushings for parking of energized load-break connectors on each parking stands.

e. Insulated low-voltage neutral bushing with lugs for ground cable and removable ground strap.

f. Ground pads.

g. Liquid-level indicator.

h. Pressure-vacuum gage.

i. Liquid temperature indicator.

j. Drain and filter valves.

k. Pressure relief device, top mounted, Qualitrol series 208.

l. Diagrammatic stainless steel or laser-etched anodized aluminum nameplate in accordance with IEEE C57.12.00 and as modified or supplemented by this section.

m. Transformer base with provisions for jacking and for rolling in either direction.

n. Lifting provisions.

o. Bolted transformer top or welded top with bolted handhole access.

2.2.2.3 Specified Transformer Losses

No-load losses (NLL) shall be 1,000 watts at 20 degrees C and load losses (LL) shall be 1,500 watts at 85 degrees C.

The values for the specified losses shall be used for comparison with the losses determined during the routine tests. If the routine test values for no-load losses exceed the specified no-load losses by more than 10 percent, or the total losses exceed the specified total losses (sum of no-load and load losses) by more than 6 percent, the transformer is unacceptable.

2.2.2.4 Insulating Liquid

a. Mineral oil: ASTM D 3487, Type II, tested in accordance with ASTM D 117. Provide identification of transformer as "non-PCB" and "Type II mineral oil" on the nameplate.

2.2.3 Outgoing Section

The outgoing section shall consist of a full height air terminal compartment for physical protection of and connection point for the secondary conductors between the transformer and the switchboard

The outgoing section shall consist of a secondary transition section for connecting to a low-voltage switchboard. The switchboard shall be as specified in Section 26 23 00 SWITCHBOARDS. Connections between the transformer secondary bushings and the outgoing section transition bus shall be flexible braid bus. The secondary transition section shall have a hinged front panel.

2.2.3.1 Outgoing Section Enclosure

Provide outgoing section enclosure in accordance with the requirements in paragraph entitled, "Incoming Section Enclosure".

2.2.4 Watthour and Digital Meters

2.2.4.1 Electronic Watthour Meter

NEMA C12.10. Provide a switchboard style electronic programmable watthour meter, semi-drawout, semi-flush mounted, as indicated. Meter shall either be programmed at the factory or shall be programmed in the field. When field programming is performed, turn field programming device over to the Contracting Officer at completion of project. Meter shall be coordinated to system requirements.

a. Design: Provide meter designed for use on a 3-phase, 4-wire, 400Y/230 volt system with 3 current transformers. Include necessary KYZ pulse initiation hardware for Energy Monitoring and Control System (EMCS).

b. Coordination; Provide meter coordinated with ratios of current transformers and transformer secondary voltage.

c. Class 20. Form: 9S. Accuracy: +/- 1.0 percent.
Finish: Class II.

d. Kilowatt-hour Register: 5 digit electronic programmable type.

e. Demand Register:

1. Provide solid state.

2. Meter reading multiplier: Indicate multiplier on the meter face.

3. Demand interval length: shall be programmed for 15 minutes with rolling demand up to six subintervals per interval.

2.2.4.2 Digital Meters

IEEE C37.90.1 for surge withstand. Provide true rms, plus/minus one percent accuracy, programmable, microprocessor-based meters enclosed in sealed cases with a simultaneous three line display. Meters shall have 16 mm, minimum, LED's. Watthour meter shall have a single line display with 16 mm, minimum, LED's. The meters shall accept input from standard 5A secondary instrument transformers and direct voltage monitoring range to 600 volts, phase to phase to phase. Programming shall be via a front panel display and a communication interface with a computer. Password secured programming shall be stored in non-volatile EEPROM memory. Digital communications shall be Modbus ASCII protocol via an RS232C serial port and an independently addressable RS232C serial port. The meter shall calculate and store average max/min demand values for all readings based on a user

selectable sliding window averaging period. The meter shall have programmable hi/low set limits with two Form C dry contact relays when exceeding alarm conditions.

a. Multi-Function Meter: Meter shall simultaneously display a selected phase to neutral voltage, phase to phase voltage, percent phase to neutral voltage THD, percent phase to phase voltage THD; a selected phase current, neutral current, percent phase current THD, percent neutral current; selected total PF, kW, kVA, kVAR, FREQ, kVAh, kWh. Detected alarm conditions include over/under current, over/under voltage, over/under kVA, over/under frequency, over/under selected PF/kVAR, voltage phase reversal, voltage imbalance, reverse power, over percent THD. The meter shall have a Form C KYZ pulse output relay.

b. Power Meter: Meter shall simultaneously display Watts, VARs, and selected kVA/PF. Detected alarm conditions include over/under kVA, over/under PF, over/under VARs, over/under reverse power.

c. Volt Meter: Meter shall be selectable between simultaneous display of the three phases of phase to neutral voltages and simultaneous display of the three phases of the phase to phase voltages. Detected alarm conditions include over/under voltage, over/under voltage imbalance, and over percent THD.

d. Ammeter: Meter shall simultaneously display phase A, B, and C current. Detected alarm conditions include over/under current, and over percent THD.

e. Digital Watthour Meter: Meter shall have a single selectable display for watts, total kilowatt hours (kWh) and watt demand (Wd). The meter shall have a Form C KYZ pulse output relay.

2.2.5 Instruments

ANSI C39.1 for electrical indicating switchboard style instruments, with 2 percent accuracy. The ac ammeters and voltmeters shall be minimum of 50.8 mm square, with 4.36 rad scale. Provide single phase indicating instruments with flush-mounted transfer switches for reading three phases.

2.2.5.1 Ac Ammeters

Transformers rated, 5-ampere input, for use with a 1,000 to 5-ampere current transformer ratio, 0 to 1,000-ampere scale range, 50 hertz.

2.2.5.2 Ac Voltmeters

Self-contained.

2.2.5.3 Instrument Control Switches

Provide rotary cam-operated type with positive means of indicating contact positions. Switches shall have silver-to-silver contacts enclosed in a protective cover which can be removed to inspect the contacts.

2.2.6 Current Transformers

IEEE C57.13. Transformers shall be single ratio, 50 hertz, 1,000 to 5-ampere ratio, with a metering accuracy class of 0.3 through.

2.2.7 Control Power Transformers

Transformer shall conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.2.8 Meter Fusing

Provide a fuse block mounted in the metering compartment containing one fuse per phase to protect the voltage input to voltage sensing meters. Size fuses as recommended by the meter manufacturer.

2.2.9 Heaters

Provide 230-volt heaters in incoming section and outgoing section. Heaters shall be of sufficient capacity to control moisture condensation in the compartments, shall be 250 watts minimum, and shall be controlled by a thermostat and humidistat located in each section. Thermostat shall be industrial type, high limit, to maintain compartments within the range of 15.5 to 32.2 degrees C. Humidistat shall have a range of 30 to 60 percent relative humidity. If heater voltage is different than substation equipment voltage, provide transformer rated to carry 125 percent of heater full load rating. Transformer shall have 220 degrees C insulation system with a temperature rise not exceeding 115 degrees C and shall conform to NEMA ST 20. Energize electric heaters while the equipment is in storage or in place prior to being placed in service. Provide method for easy connection of heater to external power source.

2.2.10 Insulated Barriers

Where insulated barriers are required by reference standards, provide barriers in accordance with NEMA LI 1, Type GPO-3, 6.35 mm minimum thickness.

2.2.11 Terminal Boards

Provide with engraved plastic terminal strips and screw type terminals for external wiring between components and for internal wiring between removable assemblies. Terminal boards associated with current transformers shall be short-circuiting type. Terminate conductors for current transformers with ring-tongue lugs. Terminal board identification shall be identical in similar units. External wiring shall be color coded consistently for similar terminal boards.

2.2.12 Wire Marking

Mark control and metering conductors at each end. Provide factory-installed, white, plastic tubing, heat stamped with black block type letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Each sleeve shall contain a single letter or number, shall be elliptically shaped to securely grip the wire, and shall be keyed in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Each wire marker shall indicate the device or equipment, including specific terminal number to which the remote end of the wire is attached.

2.2.13 Grounding and Bonding

Provide as specified in Section 33 71 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.2.14 Padlocks

Padlocks shall be provided for secondary unit substation equipment. Padlocks shall be keyed alike. Padlocks shall comply with Section 08 71 00 DOOR HARDWARE.

2.2.15 Cast-in-Place Concrete

Concrete associated with electrical work for other than encasement of underground ducts shall be 30 MPa minimum 28-day compressive strength unless specified otherwise. All concrete shall conform to the requirements of Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE.

2.3 MANUFACTURER'S NAMEPLATES

Each item of equipment shall have a nameplate bearing, as a minimum, the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable. Include additional information as applicable to fully identify the equipment. Nameplates shall be made of noncorrosive metal. Equipment containing liquid dielectric shall include the type of dielectric on the nameplate. Sectionalizer switch nameplates shall have a schematic with all switch positions shown and labeled. As a minimum, provide nameplates for transformers, circuit breakers, meters, switches, and switchgear.

2.4 FIELD FABRICATED NAMEPLATES

ASTM D 709. Provide laminated plastic nameplates for each secondary unit substation, equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 3 mm thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be 25 by 65 mm. Lettering shall be a minimum of 6.35 mm high normal block style.

2.5 WARNING SIGNS

Provide warning signs for the enclosures of secondary unit substations having a nominal rating exceeding 600 volts.

a. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.29, such as for secondary unit substations, provide self-adhesive warning signs on the outside of the high voltage compartment door(s). Sign shall be a decal and shall have nominal dimensions of 178 by 255 mm with the legend "DANGER HIGH VOLTAGE" printed in two lines of nominal 50 mm high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background. Decal shall be Panduit No. PPSO710D72 or approved equal.

2.6 SOURCE QUALITY CONTROL

2.6.1 Equipment Test Schedule

The Government reserves the right to witness tests. Provide equipment test schedules for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

Test Instrument Calibration

1. The manufacturer shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

2. The accuracy shall be directly traceable to the National Institute of Standards and Technology.

3. Instrument calibration frequency schedule shall not exceed 12 months for both test floor instruments and leased specialty equipment.

4. Dated calibration labels shall be visible on all test equipment.

5. Calibrating standard shall be of higher accuracy than that of the instrument tested.

6. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

   (a) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

   (b) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.6.2 Load Interrupter Switch Production Tests

IEEE C37.20.3. Furnish reports of production tests performed on the actual equipment for this project. Required tests shall be as follows:

Production Tests

1. Dielectric

2. Mechanical operation

2.6.3 Transformer Design Tests (Liquid-Filled)

In accordance with IEEE C57.12.00 and IEEE C57.12.90. Additionally, IEEE C57.12.80 section 5.1.2 states that "design tests are made only on representative apparatus of basically the same design." Submit design test reports (complete with test data, explanations, formulas, and results), in the same submittal package as the product data and shop drawings for each of the specified transformers. Design tests shall have been performed prior to the award of this contract.

a. Tests shall be certified and signed by a registered professional engineer.

b. Temperature rise: "Basically the same design" for the temperature rise test means a unit-substation transformer with the same coil construction (such as wire wound primary and sheet wound secondary), the same kVA, the same cooling type (ONAN), the same temperature rise rating, and the same insulating liquid as the transformer specified.

c. Lightning impulse: "Basically the same design" for the lightning impulse dielectric test means a unit-substation transformer with the same BIL, the same coil construction (such as wire wound primary and sheet wound secondary), and a tap changer, if specified. Design lightning impulse tests shall include both the primary and secondary windings of that transformer.

    1. IEEE C57.12.90 paragraph 10.3 entitled "Lightning Impulse Test Procedures," and IEEE C57.98.

    2. State test voltage levels.

    3. Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test report.

d. Lifting and moving devices: "Basically the same design" for the lifting and moving devices test means a transformer in the same weight range as the transformer specified.

e. Pressure: "Basically the same design" for the pressure test means a unit-substation transformer with a tank volume within 30 percent of the tank volume of the transformer specified.

2.6.4 Transformer Routine and Other Tests (Liquid-Filled)

In accordance with IEEE C57.12.00 and IEEE C57.12.90. Routine and other tests shall be performed by the manufacturer on each of the actual transformers prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests and testing sequence shall be as follows:

a. Cold resistance measurements (provide reference temperature)

b. Phase relation

c. Ratio

d. Insulation power-factor by manufacturer's recommended test method.

e. No-load losses (NLL) and excitation current

f. Load losses (LL) and impedance voltage

g. Dielectric

    1. Impulse: Per IEEE C57.12.90 paragraph 10.3 entitled "Lightning Impulse Test Procedures," and IEEE C57.98. Test the primary winding only.

(a) State test voltage levels

(b) Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test reports.

2. Applied voltage

3. Induced voltage

h. Leak

i. Sample insulating liquid. Sample shall be tested for:

1. Dielectric breakdown voltage

2. Acid neutralization number

3. Specific gravity

4. Interfacial tension

5. Color

6. Visual condition

7. Water in insulating liquid

8. Measure dissipation factor or power factor

j. Perform dissolved gas analysis (DGA)

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations shall conform to IEEE C2, NFPA 70, and to the requirements specified herein.

3.2 GROUNDING

NFPA 70 and IEEE C2, except that grounds and grounding systems shall have a resistance to solid earth ground not exceeding 5 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of the ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Substation Grounding

Provide bare copper cable not smaller than No. 4/0 AWG not less than 610 mm below grade interconnecting the indicated ground rods. Surge arrester and neutrals shall be bonded directly to the transformer enclosure and then to the grounding electrode system with bare copper conductors, sized as shown. Lead lengths shall be kept as short as practicable with no kinks or sharp bends. Substation transformer neutral connections shall not be

smaller than No. 1/0 AWG. When work in addition to that indicated or specified is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" shall apply. Fence and equipment connections shall not be smaller than No. 4 AWG. Ground fence at each gate post and cornerpost and at intervals not exceeding 3050 mm. Bond each gate section to the fence post through a 3 by 25 mm (1/8 by one inch) flexible braided copper strap and clamps.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Exothermic welds and compression connectors shall be installed as specified in Section 33 71 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION, paragraph entitled "Grounding".

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect unit substations furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.3.1 Interrupter Switchgear

IEEE C37.20.3.

3.3.2 Meters and Instrument Transformers

NEMA C12.1.

3.3.3 Field Applied Painting

Where field applied painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.3.4 Field Fabricated Nameplate Mounting

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.3.5 Warning Sign Mounting

Provide the number of signs required to be readable from each accessible side, but space the signs a maximum of 9 meters apart.

3.3.6 Galvanizing Repair

Repair damage to galvanized coatings using ASTM A 780/A 780M, zinc rich paint, for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that repair paint has been applied to.

3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

3.4.1 Exterior Location

Mount unit substation on concrete slab. Unless otherwise indicated, the slab shall be at least 200 mm thick, reinforced with a 152 by 152 - MW19 by MW19 mesh placed uniformly 100 mm from the top of the slab. Slab shall be placed on a 150 mm thick, well-compacted gravel base. Top of concrete slab shall be approximately 100 mm above the finished grade. Edges above grade shall have 15 mm chamfer. The slab shall be of adequate size to project at least 200 mm beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Seals shall be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter. Cut off and bush conduits 75 mm above slab surface.

3.4.2 Cast-in-Place Concrete

Cast-in-place concrete work shall conform to the requirements of Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE.

3.5 Padlocks

Provide padlocks for secondary unit substation equipment.

3.6 FIELD QUALITY CONTROL

3.6.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.6.1.1 Interrupter Switchgear (Air Switches)

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Confirm correct application of manufacturer's recommended lubricants.

4. Verify appropriate anchorage and required area clearances.

5. Verify appropriate equipment grounding.

6. Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.

7. Verify that fuse sizes and types correspond to approved shop drawings.

8. Verify that each fuse holder has adequate mechanical support.

9. Inspect all bolted electrical connections for high resistance

using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

10. Test interlocking systems for correct operation and sequencing.

11. Verify correct phase barrier materials and installation.

12. Compare switch blade clearances with industry standards.

13. Inspect all indicating devices for correct operation

b. Electrical Tests

1. Perform insulation-resistance tests.

2. Perform over-potential tests.

3. Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

4. Measure closed contact-resistance across each switch blade and fuse holder.

5. Measure fuse resistance.

6. Verify heater operation.

3.6.1.2 Transformers (Liquid-Filled)

a. Visual and mechanical inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition. Check for damaged or cracked insulators and leaks.

4. Verify operation of all alarm, control, and trip circuits from temperature and level indicators, pressure relief device, and fault pressure relay.

5. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

6. Verify correct liquid level in transformer tank.

7. Perform specific inspections and mechanical tests as recommended by manufacturer.

8. Verify correct equipment grounding.

9. Verify the presence of transformer surge arresters.

b. Electrical Tests

1. Perform resistance measurements through all bolted connections

with low-resistance ohmmeter, if applicable.

2. Perform dissolved gas analysis (DGA).

3. Verify that the tap-changer is set at specified ratio.

4. Verify proper secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

3.6.1.3 Current Transformers

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Verify correct connection.

4. Verify that adequate clearances exist between primary and secondary circuit.

5. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

6. Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

1. Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

2. Perform insulation-resistance tests.

3. Perform polarity tests.

4. Perform ratio-verification tests.

3.6.1.4 Metering and Instrumentation

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Verify tightness of electrical connections.

b. Electrical Tests

1. Verify accuracy of meters at 25, 50, 75, and 100 percent of full scale.

2. Calibrate watthour meters according to manufacturer's published

data.

3. Verify all instrument multipliers.

4. Verify that current transformer and voltage transformer secondary circuits are intact.

3.6.1.5 Grounding System

a. Visual and Mechanical Inspection

1. Inspect ground system for compliance with contract plans and specifications.

b. Electrical Tests

1. Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground testing megger in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument shall be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

2. Submit the measured ground resistance of each ground rod or grounding system, indicating the location of the rod or grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.6.2 Protective Relays

Protective relays shall be visually and mechanically inspected, adjusted, tested, and calibrated in accordance with the manufacturer's published instructions. Tests shall include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Relay settings shall be implemented as directed by the Contracting Officer. Relay contacts shall be manually or electrically operated to verify that the proper breakers and alarms initiate. Relaying current transformers shall be field tested in accordance with IEEE C57.13.

3.6.3 Pre-Energization Services

Calibration, testing, adjustment, and placing into service of the installation shall be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of 2 years of current product experience. The following services shall be performed subsequent to testing but prior to the initial energization. The equipment shall be inspected to ensure that installation is in compliance with the recommendations of the manufacturer and as shown on the detail drawings. Terminations of conductors at major equipment shall be inspected to ensure the adequacy of connections. Bare and insulated conductors between such terminations shall be inspected to detect possible damage during installation. If factory tests were not performed on completed assemblies, tests shall be performed after the installation of completed assemblies.

Components shall be inspected for damage caused during installation or shipment to ensure packaging materials have been removed. Components capable of being both manually and electrically operated shall be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested shall be calibrated, adjusted, and tested in accordance with the instructions of the equipment manufacturer.

3.6.4 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Test shall require each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, the Contracting Officer shall be given 5 working days' advance notice of the dates and times for checks, settings, and tests.

-- End of Section --

SECTION 26 20 00

INTERIOR DISTRIBUTION SYSTEM

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B 1	(2001; R 2007) Standard Specification for Hard-Drawn Copper Wire
ASTM B 8	(2004) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D 709	(2001; R 2007) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE 81	(1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2007; TIA 2007-1; TIA 2007-2; TIA 2007-3; TIA 2007-4; TIA 2007-5) National Electrical Safety Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2009) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.1	(2008) Electric Meters Code for Electricity Metering
ANSI C80.1	(2005) American National Standard for Electrical Rigid Steel Conduit (ERSC)
ANSI C80.3	(2005) American National Standard for Electrical Metallic Tubing (EMT)
ANSI C80.5	(2005) American National Standard for Electrical Rigid Aluminum Conduit

ANSI Z535.4	(2007) American National Standard for Product Safety Signs and Labels
NEMA 250	(2008) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA FU 1	(2002; R 2007) Low Voltage Cartridge Fuses
NEMA ICS 1	(2000; R 2005; R 2008) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; Errata 2006; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 4	(2005) Terminal Blocks
NEMA ICS 6	(1993; R 2001; R 2006) Standard for Enclosures
NEMA KS 1	(2001; R 2006) Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
NEMA MG 1	(2007; Errata 2008) Standard for Motors and Generators
NEMA MG 10	(2001; R 2007) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 2007) Energy Management Guide for Selection and Use of Single Phase Motors
NEMA RN 1	(2005) Standard for Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA ST 20	(1992; R 1997) Standard for Dry-Type Transformers for General Applications
NEMA TC 2	(2003) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2004) Standard for Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA WD 1	(1999; R 2005) Standard for General Color Requirements for Wiring Devices
NEMA WD 6	(2002; R 2008) Dimensions for Wiring Devices

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2008; AMD 1 2008) National Electrical Code
NFPA 70E	(2009; Errata 09-1) Standard for Electrical Safety in the Workplace
NFPA 780	(2008) Standard for the Installation of Lightning Protection Systems

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA J-STD-607-A	(2002) Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.147	Control of Hazardous Energy (Lock Out/Tag Out)

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005; R 2003 thru 2007) Standard for Flexible Metal Conduit
UL 1063	(2006) Standard for Machine-Tool Wires and Cables
UL 1242	(2006; R 2001 thru 2007) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 1449	(2006; R 1998 thru 2009) Standard for Surge Protective Devices
UL 1569	(1999; R 2000 thru 2009) Standard for Metal-Clad Cables
UL 1660	(2004; R 2002 thru 2008) Liquid-Tight Flexible Nonmetallic Conduit
UL 198M	(2003; R 2007) Standard for Mine-Duty Fuses
UL 20	(2000; R 2002 thru 2008) General-Use Snap Switches
UL 360	(2009; R 2009) Standard for Liquid-Tight Flexible Steel Conduit
UL 4	(2004; R 2008) Standard for Armored Cable
UL 44	(2005; R 2005) Thermoset-Insulated Wires and Cables
UL 467	(2007) Grounding and Bonding Equipment
UL 486A-486B	(2003; R 2004 thru 2009) Standard for Wire Connectors

UL 486C	(2004; R 2009) Splicing Wire Connectors
UL 489	(2009) Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2001; R 2002 thru 2009) Standard for Attachment Plugs and Receptacles
UL 5	(2004; R 2007 thru 2009) Standard for Surface Metal Raceways and Fittings
UL 50	(2007) Enclosures for Electrical Equipment, Non-environmental Considerations
UL 506	(2008; R 2009) Standard for Specialty Transformers
UL 508	(1999; R 1999 thru 2008) Standard for Industrial Control Equipment
UL 510	(2005; R 2008) Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape
UL 512	(1993; R 1993 thru 2008) Standard for Fuseholders
UL 514A	(2004; R 2005 thru 2009) Metallic Outlet Boxes
UL 514B	(2004; R 2006 thru 2009) Conduit, Tubing and Cable Fittings
UL 514C	(1996; R 1998 thru 2009) Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 6	(2007) Electrical Rigid Metal Conduit-Steel
UL 651	(2005; R 2006 thru 2008) Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings
UL 67	(2009) Standard for Panelboards
UL 6A	(2008) Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel
UL 719	(2006; R 2006 thru 2007) Standard for Nonmetallic-Sheathed Cables
UL 797	(2007) Electrical Metallic Tubing -- Steel
UL 817	(2001; R 2003 thru 2009) Standard for Cord Sets and Power-Supply Cords
UL 83	(2008) Thermoplastic-Insulated Wires and

	Cables
UL 854	(2004; R 2007 thru 2008) Standard for Service-Entrance Cables
UL 869A	(2006) Reference Standard for Service Equipment
UL 943	(2006; R 2008) Ground-Fault Circuit-Interrupters
UL 984	(1996; R 2005) Hermetic Refrigerant Motor-Compressors

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100.

1.3 SUBMITTALS

Contractor shall submit the following using submittal procedures as specified in the Contract Documents.

SD-02 Shop Drawings

Panelboards

Transformers

Busway

Cable trays

Motor control centers

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.

Wireways

Marking strips drawings

SD-03 Product Data

Receptacles

Circuit breakers

Switches

Transformers

Enclosed circuit breakers

Motor controllers

Combination motor controllers

Manual motor starters

Metering

Surge protective devices

Submittals shall include performance and characteristic curves.

SD-06 Test Reports

600-volt wiring test

Grounding system test

Transformer tests

Ground-fault receptacle test

SD-07 Certificates

Fuses

SD-09 Manufacturer's Field Reports

Transformer factory tests

SD-10 Operation and Maintenance Data

1.4 QUALITY ASSURANCE

1.4.1 Fuses

Submit coordination data as specified in paragraph, FUSES of this section.

1.4.2 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the USAid Implementing Partner. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.4.3 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year

period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.3.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.3.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.5 MAINTENANCE

1.5.1 Electrical Systems

Submit operation and maintenance manuals for electrical systems that provide basic data relating to the design, operation, and maintenance of the electrical distribution system for the building. This shall include:

a. Single line diagram of the "as-built" building electrical system.

b. Schematic diagram of electrical control system (other than HVAC, covered elsewhere).

c. Manufacturers' operating and maintenance manuals on active electrical equipment.

1.6 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.7 SEISMIC REQUIREMENTS

Seismic details shall conform to Section 26 05 48.00 10, SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Materials, equipment, and devices shall, as a minimum, meet requirements of UL, where UL standards are established for those items, and requirements of NFPA 70.

2.2 CONDUIT AND FITTINGS

Shall conform to the following:

2.2.1 Rigid Metallic Conduit

2.2.1.1 Rigid, Threaded Zinc-Coated Steel Conduit

ANSI C80.1, UL 6.

2.2.1.2 Rigid Aluminum Conduit

ANSI C80.5, UL 6A.

2.2.2 Rigid Nonmetallic Conduit

PVC Type EPC-40, and EPC-80 in accordance with NEMA TC 2,UL 651.

2.2.3 Intermediate Metal Conduit (IMC)

UL 1242, zinc-coated steel only.

2.2.4 Electrical, Zinc-Coated Steel Metallic Tubing (EMT)

UL 797, ANSI C80.3.

2.2.5 Plastic-Coated Rigid Steel and IMC Conduit

NEMA RN 1, Type 40(one millimeter (40 mils) thick).

2.2.6 Flexible Metal Conduit

UL 1.

2.2.6.1 Liquid-Tight Flexible Metal Conduit, Steel

UL 360.

2.2.7 Fittings for Metal Conduit, EMT, and Flexible Metal Conduit

UL 514B. Ferrous fittings shall be cadmium- or zinc-coated in accordance with UL 514B.

2.2.7.1 Fittings for Rigid Metal Conduit and IMC

Threaded-type. Split couplings unacceptable.

2.2.7.2 Fittings for EMT

Die cast compression type.

2.2.8 Fittings for Rigid Nonmetallic Conduit

NEMA TC 3 for PVC and UL 514B.

2.2.9 Liquid-Tight Flexible Nonmetallic Conduit

UL 1660.

2.3 SURFACE RACEWAY

2.3.1 Surface Metal Raceway

UL 5, two-piece painted steel, totally enclosed, snap-cover type. Provide multiple outlet-type raceway with grounding-type receptacle where indicated. Receptacles shall be as specified herein and shall be spaced minimum of one every 455 mm.

2.4 OUTLET BOXES AND COVERS

UL 514A, cadmium or zinc-coated, if ferrous metal. UL 514C, if nonmetallic

2.5 CABINETS, JUNCTION BOXES, AND PULL BOXES

Volume greater than 1640 mL, UL 50, hot-dip, zinc-coated, if sheet steel.

2.6 WIRES AND CABLES

Wires and cables shall meet applicable requirements of NFPA 70 and UL for type of insulation, jacket, and conductor specified or indicated. Wires and cables manufactured more than 12 months prior to date of delivery to site shall not be used.

2.6.1 Conductors

Conductors No. 8 AWG and larger diameter shall be stranded. Conductors No. 10 AWG and smaller diameter shall be solid, except that conductors for remote control, alarm, and signal circuits, classes 1, 2, and 3, shall be stranded unless specifically indicated otherwise. Conductor sizes and capacities shown are based on copper, unless indicated otherwise. All conductors shall be copper.

2.6.1.1 Equipment Manufacturer Requirements

When manufacturer's equipment requires copper conductors at the terminations or requires copper conductors to be provided between components of equipment, provide copper conductors or splices, splice boxes, and other work required to satisfy manufacturer's requirements.

2.6.2 Color Coding

Provide for service, feeder, branch, control, and signaling circuit conductors. Color shall be green for grounding conductors and white for neutrals; except where neutrals of more than one system are installed in same raceway or box, other neutrals shall be white with a different colored (not green) stripe for each. Color of ungrounded conductors in different voltage systems shall be as follows:

a. 400Y/230 volt, three-phase

(1) Phase A - brown

(2) Phase B - orange

(3) Phase C - yellow

2.6.3 Insulation

Unless specified or indicated otherwise or required by NFPA 70, power and lighting wires shall be 600-volt, Type THWN/THHN conforming to UL 83 conforming to UL 44, except that grounding wire may be type TW conforming to UL 83; remote-control and signal circuits shall be Type TW or TF, conforming to UL 83. Where lighting fixtures require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.6.4 Bonding Conductors

ASTM B 1, solid bare copper wire for sizes No. 8 AWG and smaller diameter; ASTM B 8, Class B, stranded bare copper wire for sizes No. 6 AWG and larger diameter.

2.6.5 Service Entrance Cables

Service Entrance (SE) and Underground Service Entrance (USE) Cables, UL 854.

2.6.6 Nonmetallic Sheathed Cable

UL 719, Type NM or NMC.

2.6.7 Metal-Clad Cable

UL 1569; NFPA 70, Type MC cable.

2.6.8 Armored Cable

UL 4; NFPA 70, Type AC cable.

2.6.9 Mineral-Insulated, Metal-Sheathed Cable

UL listed; NFPA 70, Type MI cable. Sheathing containing asbestos fibers shall not be used.

2.6.10 Cable Tray Cable or Power Limited Tray Cable

UL listed; type TC or PLTC.

2.6.11 Cord Sets and Power-Supply Cords

UL 817.

2.7 SPLICES AND TERMINATION COMPONENTS

UL 486A-486B for wire connectors and UL 510 for insulating tapes. Connectors for No. 10 AWG and smaller diameter wires shall be insulated, pressure-type in accordance with UL 486A-486B or UL 486C (twist-on splicing connector). Provide solderless terminal lugs on stranded conductors.

2.8 DEVICE PLATES

Provide UL listed, one-piece device plates for outlets to suit the devices installed. For metal outlet boxes, plates on unfinished walls shall be of zinc-coated sheet steel or cast metal having round or beveled edges. For nonmetallic boxes and fittings, other suitable plates may be provided. Plates on finished walls shall be nylon or lexan, minimum 0.792 mm wall

thickness. Plates shall be same color as receptacle or toggle switch with which they are mounted. Plates on finished walls shall be satin finish stainless steel or brushed-finish aluminum, minimum 0.792 mm thick. Screws shall be machine-type with countersunk heads in color to match finish of plate. Sectional type device plates will not be permitted. Plates installed in wet locations shall be gasketed and UL listed for "wet locations."

2.9 SWITCHES

2.9.1 Toggle Switches

NEMA WD 1, UL 20, single pole, double pole, three-way, and four-way, totally enclosed with bodies of thermoplastic or thermoset plastic and mounting strap with grounding screw. Handles shall be white thermoplastic. Wiring terminals shall be screw-type, side-wired or of the solderless pressure type having suitable conductor-release arrangement. Contacts shall be silver-cadmium and contact arm shall be one-piece copper alloy. Switches shall be rated quiet-type ac only, 120/277 volts, with current rating and number of poles indicated.

2.9.2 Switch with Red Pilot Handle

NEMA WD 1. Provide pilot lights that are integrally constructed as a part of the switch's handle. The pilot light shall be red and shall illuminate whenever the switch is closed or "on". The pilot lighted switch shall be rated 20 amps and 120 volts or 277 volts as indicated. Provide the circuit's neutral conductor to each switch with a pilot light.

2.9.3 Breakers Used as Switches

For 230-Volt fluorescent fixtures, mark breakers "SWD" in accordance with UL 489.

2.9.4 Disconnect Switches

NEMA KS 1. Provide heavy duty-type switches where indicated, where switches are rated higher than 240 volts, and for double-throw switches. Fused switches shall utilize Class R fuseholders and fuses, unless indicated otherwise. Switches serving as motor-disconnect means shall be horsepower rated. Provide switches in NEMA 3R, enclosure per NEMA ICS 6.

2.10 FUSES

NEMA FU 1. Provide complete set of fuses for each fusible switch. Time-current characteristics curves of fuses serving motors or connected in series with circuit breakers or other circuit protective devices shall be coordinated for proper operation. Submit coordination data for approval. Fuses shall have voltage rating not less than circuit voltage.

2.10.1 Fuseholders

Provide in accordance with UL 512.

2.10.2 Cartridge Fuses, Current Limiting Type (Class R)

UL 198M, Class RK-1. Associated fuseholders shall be Class R only.

2.10.3 Cartridge Fuses, High-Interrupting Capacity, Current Limiting Type (Classes J, L, and CC)

UL 198M, Class J for zero to 600 amperes, Class L for 601 to 6,000 amperes, and Class CC for zero to 30 amperes.

2.10.4 Cartridge Fuses, Current Limiting Type (Class T)

UL 198M, Class T for zero to 1,200 amperes, 300 volts; and zero to 800 amperes, 600 volts.

2.11 RECEPTACLES

UL 498, hard use, heavy-duty, grounding-type. Ratings and configurations shall be as indicated. Bodies shall be of ivory as per NEMA WD 1. Face and body shall be thermoplastic supported on a metal mounting strap. Dimensional requirements shall be per NEMA WD 6. Provide screw-type, side-wired wiring terminals or of the solderless pressure type having suitable conductor-release arrangement. Connect grounding pole to mounting strap. The receptacle shall contain triple-wipe power contacts and double or triple-wipe ground contacts.

2.11.1 Switched Duplex Receptacles

Provide separate terminals for each ungrounded pole. Top receptacle shall be switched when installed.

2.11.2 Weatherproof Receptacles

Provide in cast metal box with gasketed, weatherproof, cast-metal cover plate and gasketed cap over each receptacle opening. Provide caps with a spring-hinged flap. Receptacle shall be UL listed for use in "wet locations with plug in use."

2.11.3 Ground-Fault Circuit Interrupter Receptacles

UL 943, duplex type for mounting in standard outlet box. Device shall be capable of detecting current leak of 6 milliamperes or greater and tripping per requirements of UL 943 for Class A GFCI devices. Provide screw-type, side-wired wiring terminals or pre-wired (pigtail) leads.

2.11.4 Plugs

Provide heavy-duty, rubber-covered three-, four-, or five-wire cord of required size, install plugs thereon, and attach to equipment. Plugs shall be UL listed with receptacles, complete with grounding blades. Where equipment is not available, turn over plugs and cord assemblies to the USAid Implementing Partner.

2.12 PANELBOARDS

UL 67 and UL 50 having a short-circuit current rating of 10,000 amperes symmetrical minimum. Panelboards for use as service disconnecting means shall additionally conform to UL 869A. Panelboards shall be circuit breaker-equipped unless indicated otherwise. Design shall be such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the

panelboard schedule on the drawings. Use of "Subfeed Breakers" is not acceptable unless specifically indicated otherwise. Main breaker shall be "separately" mounted "above" or "below" branch breakers. Where "space only" is indicated, make provisions for future installation of breakers. Directories shall indicate load served by each circuit in panelboard. Directories shall also indicate source of service to panelboard (e.g., Panel PA served from Panel MDP). Type directories and mount in holder behind transparent protective covering. Panelboards shall be listed and labeled for their intended use. Panelboard shall have nameplates in accordance with paragraph FIELD FABRICATED NAMEPLATES.

UL 67 and UL 50. Panelboards for use as service disconnecting means shall additionally conform to UL 869A. Panelboards shall be circuit breaker-equipped. Design shall be such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL. Where "space only" is indicated, make provisions for future installation of breaker sized as indicated. Directories shall indicate load served by each circuit of panelboard. Directories shall also indicate source of service (upstream panel, switchboard, motor control center, etc.) to panelboard. Type directories and mount in holder behind transparent protective covering. Panelboard shall have nameplates in accordance with paragraph FIELD FABRICATED NAMEPLATES.

2.12.1 Enclosure

Enclosures shall meet the requirements of UL 50. All cabinets shall be fabricated from sheet steel of not less than 3.5 millimeters (No. 10 gauge if flush-mounted or mounted outdoors, and not less than 2.7 millimeters (No. 12 gauge) if surface-mounted indoors, with full seam-welded box ends. Cabinets mounted outdoors or flush-mounted shall be hot-dipped galvanized after fabrication. Cabinets shall be painted in accordance with paragraph PAINTING. Outdoor cabinets shall be of NEMA 3R raintight with conduit hubs welded to the cabinet. Front edges of cabinets shall be form-flanged or fitted with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front. All cabinets shall be so fabricated that no part of any surface on the finished cabinet shall deviate from a true plane by more than 3 millimeters (1/8 inch). Holes shall be provided in the back of indoor surface-mounted cabinets, with outside spacers and inside stiffeners, for mounting the cabinets with a 15 millimeter (1/2 inch) clear space between the back of the cabinet and the wall surface. Flush doors shall be mounted on hinges that expose only the hinge roll to view when the door is closed. Each door shall be fitted with a combined catch and lock, except that doors over 600 millimeters (24 inches) long shall be provided with a three-point latch having a knob with a T-handle, and a cylinder lock. Two keys shall be provided with each lock, and all locks shall be keyed alike. Finished-head cap screws shall be provided for mounting the panelboard fronts on the cabinets.

2.12.2 Panelboard Buses

Support bus bars on bases independent of circuit breakers. Main buses and back pans shall be designed so that breakers may be changed without machining, drilling, or tapping. Provide isolated neutral bus in each panel for connection of circuit neutral conductors. Provide separate ground bus identified as equipment grounding bus per UL 67 for connecting grounding conductors; bond to steel cabinet.

2.12.3 Circuit Breakers

UL 489, thermal magnetic-type having a minimum short-circuit current rating equal to the short-circuit current rating of the panelboard in which the circuit breaker shall be mounted. Breaker terminals shall be UL listed as suitable for type of conductor provided. Where indicated on the drawings, provide circuit breakers with shunt trip devices. Series rated circuit breakers and plug-in circuit breakers are unacceptable.

2.12.3.1 Multipole Breakers

Provide common trip-type with single operating handle. Breaker design shall be such that overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any three adjacent breaker poles are connected to Phases A, B, and C, respectively.

2.12.3.2 Circuit Breaker With GFCI

UL 943 and NFPA 70. Provide with "push-to-test" button, visible indication of tripped condition, and ability to detect and trip on current imbalance of 6 milliamperes or greater per requirements of UL 943 for Class A GFCI devices, for personnel protection, and 20 milliamperes or greater per requirements of UL 943 for Class B GFCI per equipment protection.

2.12.3.3 Circuit Breakers for HVAC Equipment

Circuit breakers for HVAC equipment having motors (group or individual) shall be marked for use with HACR type and UL listed as HACR type.

2.13 ENCLOSED CIRCUIT BREAKERS

UL 489. Individual molded case circuit breakers with voltage and continuous current ratings, number of poles, overload trip setting, and short circuit current interrupting rating as indicated. Enclosure type as indicated. Provide solid neutral.

2.14 MOTOR SHORT-CIRCUIT PROTECTOR (MSCP)

Motor short-circuit protectors, also called motor circuit protectors (MCPs); shall conform to UL 508 and UL 489 and shall be provided as shown. MSCPs shall consist of an adjustable instantaneous trip circuit breaker used only in conjunction with a combination motor controller which provides coordinated motor branch-circuit overload and short-circuit protection. MSCPs shall be rated in accordance with the requirements of NFPA 70.

2.15 MOTORS

NEMA MG 1; hermetic-type sealed motor compressors shall also comply with UL 984. Provide the size in terms of kW, or kVA, or full-load current, or a combination of these characteristics, and other characteristics, of each motor as indicated or specified. Determine specific motor characteristics to ensure provision of correctly sized starters and overload heaters. Motors for operation on 208-volt, 3-phase circuits shall have terminal voltage rating of 200 volts, and those for operation on 480-volt, 3-phase circuits shall have terminal voltage rating of 460 volts. Motors shall be designed to operate at full capacity with voltage variation of plus or minus 10 percent of motor voltage rating. Unless otherwise indicated, motors rated 745 Watts (1 HP) and above shall be continuous duty type.

Where fuse protection is specifically recommended by the equipment manufacturer, provide fused switches in lieu of non-fused switches indicated.

2.15.1 High Efficiency Single-Phase Motors

Single-phase fractional-horsepower alternating-current motors shall be high efficiency types corresponding to the applications listed in NEMA MG 11. In exception, for motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated.

2.15.2 Premium Efficiency Polyphase Motors

Polyphase motors shall be selected based on high efficiency characteristics relative to typical characteristics and applications as listed in NEMA MG 10. In addition, continuous rated, polyphase squirrel-cage medium induction motors shall meet the requirements for premium efficiency electric motors in accordance with NEMA MG 1, including the NEMA full load efficiency ratings. In exception, for motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated.

2.15.3 Motor Sizes

Provide size for duty to be performed, not exceeding the full-load nameplate current rating when driven equipment is operated at specified capacity under most severe conditions likely to be encountered. When motor size provided differs from size indicated or specified, make adjustments to wiring, disconnect devices, and branch circuit protection to accommodate equipment actually provided. Provide controllers for motors rated 1-hp and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage. Provide protection for motors from immediate restart by a time adjustable restart relay.

2.15.4 Wiring and Conduit

Provide internal wiring for components of packaged equipment as an integral part of the equipment. Provide power wiring and conduit for field-installed equipment, and motor control equipment forming part of motor control centers or switchgear assemblies, the conduit and wiring connecting such centers, assemblies, or other power sources to equipment as specified herein. Power wiring and conduit shall conform to the requirements specified herein. Control wiring shall be provided under, and conform to the requirements of the section specifying the associated equipment.

2.16 MOTOR CONTROLLERS

UL 508, NEMA ICS 1, and NEMA ICS 2. Controllers shall have thermal overload protection in each phase and shall have one spare normally open and one spare normally closed auxiliary contact. Provide controllers for motors rated 1-hp and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage. Provide protection for motors from immediate restart by a time adjustable restart relay. Magnetic-type motor controllers shall have undervoltage protection when used with momentary-contact pushbutton stations or switches and shall have undervoltage release when used with maintained-contact pushbutton stations or switches. When used with pressure, float, or similar

automatic-type or maintained-contact switch, controller shall have hand/off/automatic selector switch. Connections to selector switch shall be such that only normal automatic regulatory control devices are bypassed when switch is in "hand" position. Safety control devices, such as low and high pressure cutouts, high temperature cutouts, and motor overload protective devices, shall be connected in motor control circuit in "hand" and "automatic" positions. Control circuit connections to hand/off/automatic selector switch or to more than one automatic regulatory control device shall be made in accordance with indicated or manufacturer's approved wiring diagram. Selector switch shall have means for locking in any position. For each motor not in sight of controller or where controller disconnecting means is not in sight of motor location and driven machinery location, controller disconnecting means shall be capable of being locked in open position. As an alternative, provide a manually operated, lockable, nonfused switch which disconnects motor from supply source within sight of motor. Overload protective devices shall provide adequate protection to motor windings; be thermal inverse-time-limit type; and include manual reset-type pushbutton on outside of motor controller case. Cover of combination motor controller and manual switch or circuit breaker shall be interlocked with operating handle of switch or circuit breaker so that cover cannot be opened unless handle of switch or circuit breaker is in "off" position. Minimum short circuit withstand rating of combination motor controller shall be 10,000 rms symmetrical amperes.

2.16.1 Control Wiring

All control wire shall be stranded tinned copper switchboard wire with 600-volt flame-retardant insulation Type SIS meeting UL 44, or Type MTW meeting UL 1063, and shall pass the VW-1 flame tests included in those standards. Hinge wire shall have Class K stranding. Current transformer secondary leads shall be not smaller than No. 10 AWG. The minimum size of control wire shall be No. 14 AWG. Power wiring for 480-volt circuits and below shall be of the same type as control wiring and the minimum size shall be No. 12 AWG. Special attention shall be given to wiring and terminal arrangement on the terminal blocks to permit the individual conductors of each external cable to be terminated on adjacent terminal points.

2.16.2 Control Circuit Terminal Blocks

NEMA ICS 4. Control circuit terminal blocks for control wiring shall be molded or fabricated type with barriers, rated not less than 600 volts. The terminals shall be removable binding, fillister or washer head screw type, or of the stud type with contact and locking nuts. The terminals shall be not less than No. 10 in size and shall have sufficient length and space for connecting at least two indented terminals for 10 AWG conductors to each terminal. The terminal arrangement shall be subject to the approval of the Contracting Officer and not less than four (4) spare terminals or 10 percent, whichever is greater, shall be provided on each block or group of blocks. Modular, pull apart, terminal blocks will be acceptable provided they are of the channel or rail-mounted type. The Contractor shall submit data showing that the proposed alternate will accommodate the specified number of wires, are of adequate current-carrying capacity, and are constructed to assure positive contact between current-carrying parts.

2.16.2.1 Types of Terminal Blocks

a. Short-Circuiting Type: Short-circuiting type terminal blocks

shall be furnished for all current transformer secondary leads and shall have provision for shorting together all leads from each current transformer without first opening any circuit. Terminal blocks shall meet the requirements of paragraph CONTROL CIRCUIT TERMINAL BLOCKS above.

b. Load Type: Load terminal blocks rated not less than 600 volts and of adequate capacity shall be provided for the conductors for NEMA Size 3 and smaller motor controllers and for other power circuits, except those for feeder tap units. The terminals shall be of either the stud type with contact nuts and locking nuts or of the removable screw type, having length and space for at least two indented terminals of the size required on the conductors to be terminated. For conductors rated more than 50 amperes, screws shall have hexagonal heads. Conducting parts between connected terminals shall have adequate contact surface and cross-section to operate without overheating. Each connected terminal shall have the circuit designation or wire number placed on or near the terminal in permanent contrasting color.

2.16.3 Control Circuits

Control circuits shall have maximum voltage of 120 volts derived from control transformer in same enclosure. Transformers shall conform to UL 506, as applicable. Transformers, other than transformers in bridge circuits, shall have primaries wound for voltage available and secondaries wound for correct control circuit voltage. Size transformers so that 80 percent of rated capacity equals connected load. Provide disconnect switch on primary side. Provide fuses in each ungrounded primary feeder. One secondary lead shall be fused; other shall be grounded. For designated systems, as indicated, provide backup power supply, including transformers connected to emergency power source. Provide for automatic switchover and alarm upon failure of primary control circuit.

2.16.4 Enclosures for Motor Controllers

NEMA ICS 6.

2.16.5 Multiple-Speed Motor Controllers and Reversible Motor Controllers

Across-the-line-type, electrically and mechanically interlocked. Multiple-speed controllers shall have compelling relays and shall be multiple-button, station-type with pilot lights for each speed.

2.16.6 Pushbutton Stations

Provide with "start/stop" momentary contacts having one normally open and one normally closed set of contacts, and red lights to indicate when motor is running. Stations shall be heavy duty, oil-tight design.

2.16.7 Pilot and Indicating Lights

Provide LED cluster lamps.

2.16.8 Reduced-Voltage Controllers

Provide for polyphase motors 50 kilowatt and larger. Reduced-voltage starters shall be single-step, closed transition autotransformer or as indicated, and shall have adjustable time interval between application of

reduced and full voltages to motors.

2.17 MANUAL MOTOR STARTERS (MOTOR RATED SWITCHES)

Single Double or Three pole designed for surface mounting with overload protection and pilot lights.

2.17.1 Pilot Lights

Provide yoke-mounted, seven element LED cluster light module. Color shall be red in accordance with NEMA ICS 2.

2.18 LOCKOUT REQUIREMENTS

Provide disconnecting means capable of being locked out for machines and other equipment to prevent unexpected startup or release of stored energy in accordance with 29 CFR 1910.147. Mechanical isolation of machines and other equipment shall be in accordance with requirements of Division 23, "Mechanical."

2.19 GROUNDING AND BONDING EQUIPMENT

2.19.1 Ground Rods

UL 467. Ground rods shall be copper-clad steel, with minimum diameter of 19 mm (3/4 inch) and minimum length of 3050 mm.

2.19.2 Ground Bus

A copper ground bus shall be provided in the electrical equipment rooms as indicated.

2.20 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.21 FIELD FABRICATED NAMEPLATES

ASTM D 709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 3 mm (0.125 inch) thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be 25 by 65 mm (one by 2.5 inches). Lettering shall be a minimum of 6.35 mm (0.25 inch) high normal block style.

2.22 WARNING SIGNS

Provide warning signs for flash protection in accordance with NFPA 70E and ANSI Z535.4 for switchboards, panelboards, industrial control panels, and motor control centers that are in other than dwelling occupancies and are likely to require examination, adjustment, servicing, or maintenance while energized. Provide field installed signs to warn qualified persons of potential electric arc flash hazards when warning signs are not provided by

the manufacturer. The marking shall be clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

2.23 SURGE PROTECTIVE DEVICES

Provide parallel type surge protective devices which comply with UL 1449 at the service entrance and panelboards. Provide surge protectors in a NEMA 1 enclosure per NEMA ICS 6. Provide the following modes of protection:

FOR SINGLE PHASE AND THREE PHASE WYE CONNECTED SYSTEMS-
Each phase to neutral (L-N)
Neutral to ground (N-G)
Phase to ground (L-G)

Surge protective devices at the service entrance shall have a minimum surge current rating of 80,000 amperes per mode minimum and downstream protectors shall be rated 40,000 amperes per mode minimum. The maximum line to neutral (L-N) Suppressed Voltage Rating (SVR) shall be:

900V for 400Y/230V, three phase system

The minimum MCOV (Maximum Continuous Operating Voltage) rating shall be:

600/320V for 400Y/230V, three phase system

EMI/RFI filtering shall be provided for each mode with the capability to attenuate high frequency noise. Minimum attenuation shall be 20db.

2.24 FACTORY APPLIED FINISH

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test and the additional requirements as specified herein. Interior and exterior steel surfaces of equipment enclosures shall be thoroughly cleaned and then receive a rust-inhibitive phosphatizing or equivalent treatment prior to painting. Exterior surfaces shall be free from holes, seams, dents, weld marks, loose scale or other imperfections. Interior surfaces shall receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice. Exterior surfaces shall be primed, filled where necessary, and given not less than two coats baked enamel with semigloss finish. Equipment located indoors shall be ANSI Light Gray, and equipment located outdoors shall be ANSI Light Gray. Provide manufacturer's coatings for touch-up work and as specified in paragraph FIELD APPLIED PAINTING.

2.25 SOURCE QUALITY CONTROL

2.25.1 Transformer Factory Tests

Submittal shall include routine NEMA ST 20 transformer test results on each transformer and also contain the results of NEMA "design" and "prototype" tests that were made on transformers electrically and mechanically equal to those specified.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations, including weatherproof and hazardous locations

and ducts, plenums and other air-handling spaces, shall conform to requirements of NFPA 70 and IEEE C2 and to requirements specified herein.

3.1.1 Underground Service

Underground service conductors and associated conduit shall be continuous from service entrance equipment to outdoor power system connection.

3.1.2 Service Entrance Identification

Service entrance disconnect devices, switches, and enclosures shall be labeled and identified as such.

3.1.2.1 Labels

Wherever work results in service entrance disconnect devices in more than one enclosure, as permitted by NFPA 70, each enclosure, new and existing, shall be labeled as one of several enclosures containing service entrance disconnect devices. Label, at minimum, shall indicate number of service disconnect devices housed by enclosure and shall indicate total number of enclosures that contain service disconnect devices. Provide laminated plastic labels conforming to paragraph FIELD FABRICATED NAMEPLATES. Use lettering of at least 6.35 mm in height, and engrave on black-on-white matte finish. Service entrance disconnect devices in more than one enclosure, shall be provided only as permitted by NFPA 70.

3.1.3 Wiring Methods

Provide insulated conductors installed in rigid steel conduit, IMC, rigid nonmetallic conduit, or EMT, except where specifically indicated or specified otherwise or required by NFPA 70 to be installed otherwise. Grounding conductor shall be separate from electrical system neutral conductor. Provide insulated green equipment grounding conductor for circuit(s) installed in conduit and raceways. Shared neutral, or multi-wire branch circuits, are not permitted with arc-fault circuit interrupters. Minimum conduit size shall be 16 mm (1/2 inch) in diameter for low voltage lighting and power circuits. Vertical distribution in multiple story buildings shall be made with metal conduit in fire-rated shafts. Metal conduit shall extend through shafts for minimum distance of 150 mm (6 inches).

3.1.3.1 Pull Wire

Install pull wires in empty conduits. Pull wire shall be plastic having minimum 890-N (200-pound) force tensile strength. Leave minimum 915 mm (36 inches) of slack at each end of pull wire.

3.1.3.2 Metal Clad Cable

Install in accordance with NFPA 70, Type MC cable.

3.1.3.3 Armored Cable

Install in accordance with NFPA 70, Type AC cable.

3.1.4 Conduit Installation

Unless indicated otherwise, conceal conduit under floor slabs and within finished walls, ceilings, and floors. Keep conduit minimum 150 mm (6

inches) away from parallel runs of flues and steam or hot water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit will be visible after completion of project. Run conduits under floor slab as if exposed.

3.1.4.1 Restrictions Applicable to Aluminum Conduit

a. Do not install underground or encase in concrete or masonry.

b. Do not use brass or bronze fittings.

c. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.4.2 Restrictions Applicable to EMT

a. Do not install underground.

b. Do not encase in concrete, mortar, grout, or other cementitious materials.

c. Do not use in areas subject to severe physical damage including but not limited to equipment rooms where moving or replacing equipment could physically damage the EMT.

d. Do not use in hazardous areas.

e. Do not use outdoors.

f. Do not use in fire pump rooms.

g. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.4.3 Restrictions Applicable to Nonmetallic Conduit

a. PVC Schedule 40 and PVC Schedule 80

(1) Do not use in areas where subject to severe physical damage, including but not limited to, mechanical equipment rooms, electrical equipment rooms, hospitals, power plants, missile magazines, and other such areas.

(2) Do not use in hazardous (classified) areas.

(3) Do not use in fire pump rooms.

(4) Do not use in penetrating fire-rated walls or partitions, or fire-rated floors.

(5) Do not use above grade, except where allowed in this section for rising through floor slab or indicated otherwise.

(6) Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

b. Electrical Nonmetallic Tubing

(1) Do not install underground.

(2) Do not encase in concrete except when provided with fittings identified for this purpose are used for connections.

(3) Do not use in areas where subject to severe physical damage, including but not limited to, mechanical equipment rooms, electrical equipment rooms, hospitals, power plants, missile magazines, and other such areas.

(4) Do not use in hazardous areas.

(5) Do not use outdoors.

(6) Do not use in sizes larger than 53 mm (2 inch).

(7) Do not run exposed in buildings exceeding three floors above grade, where "first floor" is as defined in NFPA 70.

(8) Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.4.4 Restrictions Applicable to Flexible Conduit

Use only as specified in paragraph FLEXIBLE CONNECTIONS. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.4.5 Service Entrance Conduit, Overhead

Rigid steel or IMC from service entrance to service entrance fitting or weatherhead outside building.

3.1.4.6 Service Entrance Conduit, Underground

PVC, Type-EPC 40, galvanized rigid steel or steel IMC. Underground portion shall be encased in minimum of 75 mm of concrete and shall be installed minimum 460 mm below slab or grade.

3.1.4.7 Underground Conduit Other Than Service Entrance

Plastic-coated rigid steel; plastic-coated steel IMC; PVC, Type EPC-40. Convert nonmetallic conduit, other than PVC Schedule 40 or 80, to plastic-coated rigid, or IMC, steel conduit before rising through floor slab. Plastic coating shall extend minimum 150 mm above floor.

3.1.4.8 Conduit for Circuits Rated Greater Than 600 Volts

Rigid metal conduit or IMC only.

3.1.4.9 Conduit Installed Under Floor Slabs

Conduit run under floor slab shall be located a minimum of 305 mm below the vapor barrier. Seal around conduits at penetrations thru vapor barrier.

3.1.4.10 Conduit Through Floor Slabs

Where conduits rise through floor slabs, curved portion of bends shall not be visible above finished slab.

3.1.4.11 Conduit Installed in Concrete Floor Slabs

Rigid steel; steel IMC; fiberglass, or PVC, Type EPC-40. Locate so as not to adversely affect structural strength of slabs. Install conduit within middle one-third of concrete slab. Do not stack conduits more than two diameters high with minimum vertical separation of 50 mm (2 inches). Space conduits horizontally not closer than three diameters, except at cabinet locations. Curved portions of bends shall not be visible above finish slab. Increase slab thickness as necessary to provide minimum 25 mm cover over conduit. Where embedded conduits cross building and/or expansion joints, provide suitable watertight expansion/deflection fittings and bonding jumpers. Expansion/deflection fittings shall allow horizontal and vertical movement of raceway. Conduit larger than 27 mm (one inch) trade size shall be parallel with or at right angles to main reinforcement; when at right angles to reinforcement, conduit shall be close to one of supports of slab. Where nonmetallic conduit is used, raceway shall be converted to plastic coated rigid steel or plastic coated steel IMC before rising above floor, unless specifically indicated.

3.1.4.12 Stub-Ups

Provide conduits stubbed up through concrete floor for connection to free-standing equipment with adjustable top or coupling threaded inside for plugs, set flush with finished floor. Extend conductors to equipment in rigid steel conduit, except that flexible metal conduit may be used 150 mm (6 inches) above floor. Where no equipment connections are made, install screwdriver-operated threaded flush plugs in conduit end.

3.1.4.13 Conduit Support

Support conduit by pipe straps, wall brackets, hangers, or ceiling trapeze. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded threaded studs, or spring-tension clamps on steel work. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. Load applied to fasteners shall not exceed one-fourth proof test load. Fasteners attached to concrete ceiling shall be vibration resistant and shock-resistant. Holes cut to depth of more than 40 mm in reinforced concrete beams or to depth of more than 20 mm in concrete joints shall not cut main reinforcing bars. Fill unused holes. In partitions of light steel construction, use sheet metal screws. In suspended-ceiling construction, run conduit above ceiling. Do not support conduit by ceiling support system. Conduit and box systems shall be supported independently of both (a) tie wires supporting ceiling grid system, and (b) ceiling grid system into which ceiling panels are placed. Supporting means shall not be shared between electrical raceways and mechanical piping or ducts. Installation shall be coordinated with above-ceiling mechanical systems to assure maximum accessibility to all systems. Spring-steel fasteners may be used for lighting branch circuit conduit supports in suspended ceilings in dry locations. Where conduit crosses building expansion joints, provide suitable watertight expansion fitting that maintains conduit electrical continuity by bonding jumpers or other means. For conduits greater than 63 mm (2 1/2 inches) inside diameter, provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.4.14 Directional Changes in Conduit Runs

Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt, or trash from lodging in conduits, boxes, fittings, and equipment during construction. Free clogged conduits of obstructions.

3.1.4.15 Locknuts and Bushings

Fasten conduits to sheet metal boxes and cabinets with two locknuts where required by NFPA 70, where insulated bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, use at least minimum single locknut and bushing. Locknuts shall have sharp edges for digging into wall of metal enclosures. Install bushings on ends of conduits, and provide insulating type where required by NFPA 70.

3.1.4.16 Flexible Connections

Provide flexible steel conduit between 915 and 1830 mm (3 and 6 feet) in length for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for motors. Install flexible conduit to allow 20 percent slack. Minimum flexible steel conduit size shall be 16 mm (1/2 inch) diameter. Provide liquidtight flexible nonmetallic conduit in wet and damp locations for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections.

3.1.5 Boxes, Outlets, and Supports

Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures. Boxes for metallic raceways shall be cast-metal, hub-type when located in wet locations, when surface mounted on outside of exterior surfaces, when surface mounted on interior walls exposed up to 2135 mm above floors and walkways and when specifically indicated. Boxes in other locations shall be sheet steel, except that aluminum boxes may be used with aluminum conduit, and nonmetallic boxes may be used with nonmetallic sheathed cable conduit system. Each box shall have volume required by NFPA 70 for number of conductors enclosed in box. Boxes for mounting lighting fixtures shall be minimum 100 mm (4 inches) square, or octagonal, except that smaller boxes may be installed as required by fixture configurations, as approved. Boxes for use in masonry-block or tile walls shall be square-cornered, tile-type, or standard boxes having square-cornered, tile-type covers. Provide gaskets for cast-metal boxes installed in wet locations and boxes installed flush with outside of exterior surfaces. Provide separate boxes for flush or recessed fixtures when required by fixture terminal operating temperature; fixtures shall be readily removable for access to boxes unless ceiling access panels are provided. Support boxes and pendants for surface-mounted fixtures on suspended ceilings independently of ceiling supports. Fasten boxes and supports with wood screws on wood, with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel. Threaded studs driven in by powder charge and provided with lockwashers and nuts or nail-type nylon anchors may be used in lieu of wood screws, expansion shields, or machine screws. In open overhead spaces, cast boxes threaded to raceways need not be separately supported except where used for fixture support; support sheet metal boxes directly from building structure or by

bar hangers. Where bar hangers are used, attach bar to raceways on opposite sides of box, and support raceway with approved-type fastener maximum 610 mm from box. When penetrating reinforced concrete members, avoid cutting reinforcing steel.

3.1.5.1 Boxes

Boxes for use with raceway systems shall be minimum 40 mm (1 1/2 inches) deep, except where shallower boxes required by structural conditions are approved. Boxes for other than lighting fixture outlets shall be minimum 100 mm (4 inches) square, except that 100 by 50 mm (4 by 2 inch) boxes may be used where only one raceway enters outlet. Mount outlet boxes flush in finished walls.

3.1.5.2 Pull Boxes

Construct of at least minimum size required by NFPA 70 of code-gauge aluminum or galvanized sheet steel, except where cast-metal boxes are required in locations specified herein. Provide boxes with screw-fastened covers. Where several feeders pass through common pull box, tag feeders to indicate clearly electrical characteristics, circuit number, and panel designation.

3.1.5.3 Extension Rings

Extension rings are not permitted for new construction. Use only on existing boxes in concealed conduit systems where wall is furred out for new finish.

3.1.6 Mounting Heights

Mount panelboards, enclosed circuit breakers, motor controller and disconnecting switches so height of operating handle at its highest position is maximum 1980 mm above floor. Mount lighting switches 1220 mm above finished floor. Mount receptacles 460 mm above finished floor, unless otherwise indicated. Mount other devices as indicated. Measure mounting heights of wiring devices and outlets in non-hazardous areas to center of device or outlet.

3.1.7 Nonmetallic Sheathed Cable Installation

Where possible, install cables concealed behind ceiling or wall finish. Thread cables through holes bored on approximate centerline of wood members; notching of end surfaces is not permitted. Provide sleeves through concrete or masonry for threading cables. Install exposed cables parallel to or at right angles to walls or structural members. Protect exposed nonmetallic sheathed cables less than 1220 mm above floors from mechanical injury by installation in conduit or tubing. When cable is used in metal stud construction, insert plastic stud grommets in studs at each point through which cable passes, prior to installation of cable.

3.1.8 Mineral Insulated, Metal Sheathed (Type MI) Cable Installation

Mineral-insulated, metal-sheathed cable system, Type MI, may be used in lieu of exposed conduit and wiring. Conductor sizes shall be not less than those indicated for the conduit installation. Cables shall be fastened within 305 mm of each turn or offset and at 830 mm maximum intervals. Make cable terminations in accordance with NFPA 70 and cable manufacturer's recommendations. Single-conductor cables of a circuit, having capacities

of more than 50 amperes, shall terminate in a single box or cabinet opening. Individual conductors in all outlets and cabinets shall be color-coded.

3.1.9 Conductor Identification

Provide conductor identification within each enclosure where tap, splice, or termination is made. For conductors No. 6 AWG and smaller diameter, color coding shall be by factory-applied, color-impregnated insulation. For conductors No. 4 AWG and larger diameter, color coding shall be by plastic-coated, self-sticking markers; colored nylon cable ties and plates; or heat shrink-type sleeves.

3.1.9.1 Marking Strips

White or other light-colored plastic marking strips, fastened by screws to each terminal block, shall be provided for wire designations. The wire numbers shall be made with permanent ink. The marking strips shall be reversible to permit marking both sides, or two marking strips shall be furnished with each block. Marking strips shall accommodate the two sets of wire numbers. Each device to which a connection is made shall be assigned a device designation in accordance with NEMA ICS 1 and each device terminal to which a connection is made shall be marked with a distinct terminal marking corresponding to the wire designation used on the Contractor's schematic and connection diagrams. The wire (terminal point) designations used on the Contractor's wiring diagrams and printed on terminal block marking strips may be according to the Contractor's standard practice; however, additional wire and cable designations for identification of remote (external) circuits shall be provided for the USAid Implementing Partner wire designations. Prints of the marking strips drawings submitted for approval will be so marked and returned to the Contractor for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

3.1.10 Splices

Make splices in accessible locations. Make splices in conductors No. 10 AWG and smaller diameter with insulated, pressure-type connector. Make splices in conductors No. 8 AWG and larger diameter with solderless connector, and cover with insulation material equivalent to conductor insulation.

3.1.11 Terminating Aluminum Conductors

3.1.11.1 Termination to Copper Bus

Terminate aluminum conductors to copper bus either by: (a) inline splicing a copper pigtail, of ampacity at least that of aluminum conductor, or (b) utilizing circumferential, compression-type, aluminum-bodied terminal lug UL listed for AL/CU, and steel Belleville cadmium-plated hardened steel spring washers, flat washers, bolts, and nuts. Carefully install Belleville spring washers with crown up toward nut or bolt head, with concave side of Belleville bearing on heavy-duty, wide series flat washer of larger diameter than Belleville. Tighten nuts sufficiently to flatten Belleville, and leave in position. Lubricate hardware with joint compound prior to making connection. Wire brush and apply joint compound to conductor prior to inserting in lug.

3.1.11.2 Termination to Aluminum Bus

Terminate aluminum conductors to aluminum bus by using aluminum nuts, bolts, washers, and compression lugs. Wire brush and apply joint compound to conductor prior to inserting in lug. Lubricate hardware with joint compound prior to making connection. When bus contact surface is unplated, scratch-brush and coat with joint compound, without grit.

3.1.12 Covers and Device Plates

Install with edges in continuous contact with finished wall surfaces without use of mats or similar devices. Plaster fillings are not permitted. Install plates with alignment tolerance of 0.58 mm (1/16 inch). Use of sectional-type device plates are not permitted. Provide gasket for plates installed in wet locations.

3.1.13 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated walls, partitions, floors, or ceilings in accordance with Section 07 84 00, FIRESTOPPING.

3.1.14 Grounding and Bonding

Provide In accordance with NFPA 70 and NFPA 780. Ground exposed, non-current-carrying metallic parts of electrical equipment, access flooring support system, metallic raceway systems, grounding conductor in metallic and nonmetallic raceways, telecommunications system grounds, grounding conductor of nonmetallic sheathed cables, and neutral conductor of wiring systems. Make ground connection at main service equipment, and extend grounding conductor to point of entrance of metallic water service. Make connection to water pipe by suitable ground clamp or lug connection to plugged tee. If flanged pipes are encountered, make connection with lug bolted to street side of flanged connection. Supplement metallic water service grounding system with additional made electrode in compliance with NFPA 70. Make ground connection to driven ground rods on exterior of building. Interconnect all grounding media in or on the structure to provide a common ground potential. This shall include lightning protection, electrical service, telecommunications system grounds, as well as underground metallic piping systems. Interconnection to the gas line shall be made on the customer's side of the meter. Use main size lightning conductors for interconnecting these grounding systems to the lightning protection system. In addition to the requirements specified herein, provide telecommunications grounding in accordance with TIA J-STD-607-A. Where ground fault protection is employed, ensure that connection of ground and neutral does not interfere with correct operation of fault protection.

3.1.14.1 Ground Rods

Provide cone pointed ground rods. The resistance to ground shall be measured using the fall-of-potential method described in IEEE 81. The maximum resistance of a driven ground shall not exceed 25 ohms under normally dry conditions. If this resistance cannot be obtained with a single rod, additional rods not less than 1830 mm (6 feet) on centers, or if sectional type rods are used, additional sections may be coupled and driven with the first rod. In high-ground-resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, notify the USAid Implementing Partner who will decide on the number of ground rods to add.

3.1.14.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, excepting specifically those connections for which access for periodic testing is required, by exothermic weld or compression connector.

a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.

b. Make compression connections using a hydraulic compression tool to provide the correct circumferential pressure. Tools and dies shall be as recommended by the manufacturer. An embossing die code or other standard method shall provide visible indication that a connector has been adequately compressed on the ground wire.

3.1.14.3 Ground Bus

A copper ground bus shall be provided in the electrical equipment rooms as indicated. Noncurrent-carrying metal parts of electrical equipment shall be effectively grounded by bonding to the ground bus. The ground bus shall be bonded to both the entrance ground, and to a ground rod or rods as specified above having the upper ends terminating approximately 100 mm (4 inches) above the floor. Connections and splices shall be of the brazed, welded, bolted, or pressure-connector type, except that pressure connectors or bolted connections shall be used for connections to removable equipment.

3.1.14.4 Resistance

Maximum resistance-to-ground of grounding system shall not exceed 5 ohms under dry conditions. Where resistance obtained exceeds 5 ohms, contact USAid Implementing Partner for further instructions.

3.1.15 Equipment Connections

Provide power wiring for the connection of motors and control equipment under this section of the specification. Except as otherwise specifically noted or specified, automatic control wiring, control devices, and protective devices within the control circuitry are not included in this section of the specifications but shall be provided under the section specifying the associated equipment.

3.1.16 Repair of Existing Work

Repair of existing work, demolition, and modification of existing electrical distribution systems shall be performed as follows:

3.1.16.1 Workmanship

Lay out work in advance. Exercise care where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, or other surfaces is necessary for proper installation, support, or anchorage of conduit, raceways, or other electrical work. Repair damage to buildings, piping, and equipment using skilled craftsmen of trades involved.

3.1.16.2 Existing Concealed Wiring to be Removed

Existing concealed wiring to be removed shall be disconnected from its source. Remove conductors; cut conduit flush with floor, underside of floor, and through walls; and seal openings.

3.1.16.3 Removal of Existing Electrical Distribution System

Removal of existing electrical distribution system equipment shall include equipment's associated wiring, including conductors, cables, exposed conduit, surface metal raceways, boxes, and fittings, back to equipment's power source as indicated.

3.1.16.4 Continuation of Service

Maintain continuity of existing circuits of equipment to remain. Existing circuits of equipment shall remain energized. Circuits which are to remain but were disturbed during demolition shall have circuits wiring and power restored back to original condition.

3.1.17 Watthour Meters

ANSI C12.1.

3.1.18 Surge Protective Devices

Connect the surge protective devices in parallel to the power source, keeping the conductors as short and straight as practically possible.

3.2 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.3 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side. Space the signs in accordance with NFPA 70E.

3.4 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09 90 00, PAINTS AND COATINGS. Where field painting of enclosures for panelboards, load centers or the like is specified to match adjacent surfaces, to correct damage to the manufacturer's factory applied coatings, or to meet the indicated or specified safety criteria, provide manufacturer's recommended coatings and apply in accordance to manufacturer's instructions.

3.5 FIELD QUALITY CONTROL

Furnish test equipment and personnel and submit written copies of test results. Give USAid Implementing Partner 5 working days notice prior to each test.

3.5.1 Devices Subject to Manual Operation

Each device subject to manual operation shall be operated at least five times, demonstrating satisfactory operation each time.

3.5.2 600-Volt Wiring Test

Test wiring rated 600 volt and less to verify that no short circuits or accidental grounds exist. Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 500 volts to provide direct reading of resistance. Minimum resistance shall be 250,000 ohms.

3.5.3 Transformer Tests

Perform the standard, not optional, tests in accordance with the Inspection and Test Procedures for transformers, dry type, air-cooled, 600 volt and below; as specified in NETA ATS. Measure primary and secondary voltages for proper tap settings. Tests need not be performed by a recognized independent testing firm or independent electrical consulting firm.

3.5.4 Ground-Fault Receptacle Test

Test ground-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed.

3.5.5 Grounding System Test

Test grounding system to ensure continuity, and that resistance to ground is not excessive. Test each ground rod for resistance to ground before making connections to rod; tie grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Submit written results of each test to Contracting Officer, and indicate location of rods as well as resistance and soil conditions at time measurements were made.

3.5.6 Watthour Meter

a. Visual and mechanical inspection

(1) Examine for broken parts, shipping damage, and tightness of connections.

(2) Verify that meter type, scales, and connections are in accordance with approved shop drawings.

b. Electrical tests

(1) Determine accuracy of meter.

(2) Calibrate watthour meters to one-half percent.

(3) Verify that correct multiplier has been placed on face of meter, where applicable.

-- End of Section --

SECTION 26 23 00

SWITCHBOARDS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C39.1	(1981; R 1992) Requirements for Electrical Analog Indicating Instruments

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M	(2009) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153/A 153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 167	(1999; R 2009) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A 653/A 653M	(2009a) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A 780/A 780M	(2001; R 2006) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM D 1535	(2008) Specifying Color by the Munsell System
ASTM D 709	(2001; R 2007) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2007; Errata 2006 & 2007; INT 44-56 2007; INT 47, 49, 50, 52-56 2008; INT 57, 58, 51, 48, 59 2009) National Electrical Safety Code
IEEE C57.12.28	(2005) Standard for Pad-Mounted Equipment - Enclosure Integrity

IEEE Std 100	(2000) The Authoritative Dictionary of IEEE Standards Terms
IEEE Std 81	(1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1)Normal Measurements

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2009) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C12.1	(2008) Electric Meters; Code for Electricity Metering
NEMA ICS 6	(1993; R 2006) Standard for Industrial Controls and Systems Enclosures
NEMA LI 1	(1998) Industrial Laminated Thermosetting Products
NEMA PB 2	(2006) Deadfront Distribution Switchboards
NEMA PB 2.1	(2007) General Instructions for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2008; AMD 1 2008) National Electrical Code - 2008 Edition

UNDERWRITERS LABORATORIES (UL)

UL 467	(2007) Standard for Grounding and Bonding Equipment
UL 489	(2009) Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 891	(2005) Dead-Front Switchboards

1.2 RELATED REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section, with the additions and modifications specified herein.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE Std 100.

1.4 SUBMITTALS

Contractor shall submit the following using submittal procedures as specified in the Contract Documents.

SD-02 Shop Drawings

Switchboard Drawings

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

SD-03 Product Data

Switchboard

SD-06 Test Reports

Switchboard design tests

Switchboard production tests

Acceptance checks and tests

SD-10 Operation and Maintenance Data

Switchboard Operation and Maintenance, Submit operation and maintenance data in accordance with the Contract Documents.

SD-11 Closeout Submittals

Assembled Operation and Maintenance Manuals

Equipment Test Schedule

Request for Settings

1.5 QUALITY ASSURANCE

1.5.1 Switchboard Product Data

Each submittal shall include manufacturer's information for each component, device and accessory provided with the switchboard including:

a. Circuit breaker type, interrupting rating, and trip devices, including available settings

b. Manufacturer's instruction manuals and published time-current curves (on full size logarithmic paper) of the main secondary breaker and largest secondary feeder device.

1.5.2 Switchboard Drawings

Drawings shall include, but are not limited to the following:

a. One-line diagram including breakers, fuses, current transformers, and meters

b. Outline drawings including front elevation, section views, footprint, and overall dimensions

c. Bus configuration including dimensions and ampere ratings of bus bars

d. Markings and NEMA nameplate data, including fuse information (manufacturer's name, catalog number, and ratings)

e. Circuit breaker type, interrupting rating, and trip devices, including available settings

f. Three-line diagrams and elementary diagrams and wiring diagrams with terminals identified, and indicating prewired interconnections between items of equipment and the interconnection between the items.

g. Manufacturer's instruction manuals and published time-current curves (on full size logarithmic paper) of the main secondary breaker and largest secondary feeder device. These shall be used by the designer of record to provide breaker settings that will ensure protection and coordination are achieved.

1.5.3 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the USAID Implementing Partner. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.5.4 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.4.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than

6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.6 MAINTENANCE

1.6.1 Switchboard Operation and Maintenance Data

Submit Operation and Maintenance Manuals in accordance with the requirements of the Contract Documents.

1.6.2 Assembled Operation and Maintenance Manuals

Manuals shall be assembled and bound securely in durable, hard covered, water resistant binders. The manuals shall be assembled and indexed in the following order with a table of contents. The contents of the assembled operation and maintenance manuals shall be as follows:

a. Manufacturer's O&M information required by the paragraph entitled "SD-10, Operation and Maintenance Data".

b. Catalog data required by the paragraph entitled, "SD-03, Product Data".

c. Drawings required by the paragraph entitled, "SD-02, Shop Drawings".

d. Prices for spare parts and supply list.

e. Information on metering

f. Design test reports

g. Production test reports

1.6.3 Spare Parts

Spare parts shall be furnished as specified below. All spare parts shall be of the same material and workmanship, shall meet the same requirements, and shall be interchangeable with the corresponding original parts furnished.

a. 2 - Fuses of each type and size.

1.7 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be switchboards and related accessories are specified in Section 33 71 02.00 20 UNDERGROUND ELECTRICAL

DISTRIBUTION and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.2 SWITCHBOARD

NEMA PB 2 and UL 891.

2.2.1 Ratings

The voltage rating of the switchboard shall be 400Y/230 volts AC, 4-wire 3 phase. The continuous current rating of the main bus shall be as indicated. The short-circuit current rating shall be as indicated. The switchboard shall be UL listed and labeled for its intended use.

2.2.2 Construction

Switchboard shall consist of vertical sections bolted together to form a rigid assembly and shall be front and rear aligned. All circuit breakers shall be front accessible. Front and rear aligned switchboards shall have rear accessible load connections. Where indicated, "space for future" or "space" shall mean to include bus, device supports, and connections. Provide insulating barriers in accordance with NEMA LI 1, Type GPO-3, 6.35 mm (0.25 inch) minimum thickness. Apply moisture resistant coating to all rough-cut edges of barriers. Switchboard shall be completely factory engineered and assembled, including protective devices and equipment indicated with necessary interconnections, instrumentation, and control wiring.

2.2.2.1 Enclosure

The switchboard enclosure shall be a outdoor NEMA ICS 6 Type 3R as indicated fabricated entirely of 12 gauge ASTM A 167 type 304 stainless steel. Enclosure shall be bolted together with removable bolt-on side and rear covers, and sloping roof downward toward rear. Front and rear doors shall be provided with stainless steel padlockable vault handles with a three point catch. Bases, frames and channels of enclosure shall be corrosion resistant and shall be fabricated of ASTM A 167 type 304 stainless steel or galvanized steel. Base shall include any part of enclosure that is within 75 mm of concrete pad. Galvanized steel shall be ASTM A 123/A 123M, ASTM A 653/A 653M G90 coating, and ASTM A 153/A 153M, as applicable. Galvanize after fabrication where practicable. Paint enclosure, including bases, ASTM D 1535 light gray No. 61 or No. 49. Paint coating system shall comply with IEEE C57.12.28 for galvanized steel.

2.2.2.2 Bus Bars

Bus bars shall be copper with silver-plated contact surfaces. Plating shall be a minimum of 0.005 mm (0.0002 inch) thick. Make bus connections and joints with hardened steel bolts. The through-bus shall be rated at the full ampacity of the main throughout the switchboard. Provide minimum 6.35 mm by 50.8 mm (one-quarter by 2 inch) copper ground bus secured to each vertical section along the entire length of the switchboard. The neutral bus shall be rated 50 percent of the main bus continuous current rating.

2.2.2.3 Main Section

The main section shall consist of an individually mounted insulated-case circuit breaker or molded-case circuit breaker.

2.2.2.4 Distribution Sections

The distribution section(s) shall consist of molded-case circuit breakers as indicated.

2.2.2.5 Combination Sections

Combination sections shall consist of molded-case circuit breakers for the branch devices as indicated.

2.2.2.6 Auxiliary Sections

Auxiliary sections shall consist of instruments, metering equipment, control equipment, transformer, and current transformer compartments as indicated.

2.2.2.7 Handles

Handles for individually mounted devices shall be of the same design and method of external operation. Label handles prominently to indicate device ampere rating, color coded for device type. Identify ON-OFF indication by handle position and by prominent marking.

2.2.3 Protective Device

Provide main and branch protective devices as indicated.

2.2.3.1 Molded-Case Circuit Breaker

UL 489. UL listed and labeled, 100 percent rated, stationary,230 Vac, electrically operated, low voltage molded-case circuit breaker, with a short-circuit current rating of 30,000 rms symmetrical amperes at 400 volts. Breaker frame size shall be as indicated. Series rated circuit breakers are unacceptable.

2.2.4 Instruments

ANSI C39.1 for electrical indicating switchboard instruments, with 2 percent accuracy. The ac ammeters and voltmeters shall be a minimum of 50.8 mm square (2 inches square), with 4.36 rad (250-degree) scale. Provide single phase indicating instruments with flush-mounted transfer switches for reading three phases.

2.2.4.1 Ac Ammeters

Transformer rated, 5-ampere input, for use with a 1,000 to 5-ampere current transformer ratio, 0 to 1,000-ampere scale range, 50 hertz.

2.2.4.2 Ac Voltmeters

Self-contained.

2.2.4.3 Instrument Control Switches

Provide rotary cam-operated type with positive means of indicating contact positions. Switches shall have silver-to-silver contacts enclosed in a protective cover which can be removed to inspect the contacts.

2.2.5 Terminal Boards

Provide with engraved plastic terminal strips and screw type terminals for external wiring between components and for internal wiring between removable assemblies. Terminal boards associated with current transformers shall be short-circuiting type. Terminate conductors for current transformers with ring-tongue lugs. Terminal board identification shall be identical in similar units. External wiring shall be color coded consistently for similar terminal boards.

2.2.6 Wire Marking

Mark control and metering conductors at each end. Provide factory-installed, white, plastic tubing, heat stamped with black block type letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Each sleeve shall contain a single letter or number, shall be elliptically shaped to securely grip the wire, and shall be keyed in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Each wire marker shall indicate the device or equipment, including specific terminal number to which the remote end of the wire is attached.

2.3 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable. This nameplate and method of attachment may be the manufacturer's standard if it contains the required information.

2.4 FIELD FABRICATED NAMEPLATES

ASTM D 709. Provide laminated plastic nameplates for each switchboard, equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 3 mm thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be 25 by 65 mm. Lettering shall be a minimum of 6.35 mm high normal block style.

2.5 SOURCE QUALITY CONTROL

2.5.1 Equipment Test Schedule

The USAID Implementing Partner reserves the right to witness tests. Provide equipment test schedules for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the USAID Implementing Partner 30 calendar days before scheduled test date. Notify USAID Implementing Partner 15 calendar days in advance of changes to scheduled date.

a. Test Instrument Calibration

1. The manufacturer shall have a calibration program which assures that all applicable test instruments are maintained within rated

accuracy.

2. The accuracy shall be directly traceable to the National Institute of Standards and Technology.

3. Instrument calibration frequency schedule shall not exceed 12 months for both test floor instruments and leased specialty equipment.

4. Dated calibration labels shall be visible on all test equipment.

5. Calibrating standard shall be of higher accuracy than that of the instrument tested.

6. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

   (a) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

   (b) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.5.2 Switchboard Design Tests

NEMA PB 2 and UL 891.

2.5.2.1 Design Tests

Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification.

a. Short-circuit current test

b. Enclosure tests

c. Dielectric test

2.5.2.2 Additional design tests

In addition to normal design tests, perform the following tests on the actual equipment. Furnish reports which include results of design tests performed on the actual equipment.

a. Temperature rise tests

b. Continuous current

2.5.3 Switchboard Production Tests

NEMA PB 2 and UL 891. Furnish reports which include results of production tests performed on the actual equipment for this project. These tests include:

a. 50-hertz dielectric tests

b. Mechanical operation tests

c. Electrical operation and control wiring tests

d. Ground fault sensing equipment test

2.6 COORDINATED POWER SYSTEM PROTECTION

Provide a power system study as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations shall conform to IEEE C2, NFPA 70, and to the requirements specified herein.

3.2 GROUNDING

NFPA 70 and IEEE C2, except that grounds and grounding systems shall have a resistance to solid earth ground not exceeding 5 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of the ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Equipment Grounding

Provide bare copper cable not smaller than No. 4/0 AWG not less than 610 mm below grade connecting to the indicated ground rods. When work in addition to that indicated or specified is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" shall apply.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Exothermic welds and compression connectors shall be installed as specified in Section 33 71 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION, paragraph entitled "Grounding Connections."

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect equipment furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.3.1 Switchboard

NEMA PB 2.1.

3.3.2 Meters and Instrument Transformers

NEMA C12.1.

3.3.3 Field Applied Painting

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.3.4 Galvanizing Repair

Repair damage to galvanized coatings using ASTM A 780/A 780M, zinc rich paint, for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that repair paint has been applied to.

3.3.5 Field Fabricated Nameplate Mounting

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

3.4.1 Exterior Location

Mount switchboard on concrete slab. Unless otherwise indicated, the slab shall be at least 200 mm thick, reinforced with a 150 by 150 mm (6 by 6 inch) No. 6 mesh placed uniformly 100 mm from the top of the slab. Slab shall be placed on a 150 mm thick, well-compacted gravel base. The top of the concrete slab shall be approximately 100 mm above the finished grade. Edges above grade shall have 15 mm chamfer. The slab shall be of adequate size to project at least 200 mm beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm above slab surface. Concrete work shall be as specified in Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE.

3.5 FIELD QUALITY CONTROL

Contractor shall submit request for settings of breakers to the USAID Implementing Partner after approval of switchboard and at least 30 days in advance of their requirement.

3.5.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.5.1.1 Switchboard Assemblies

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical, electrical, and mechanical condition.

3. Confirm correct application of manufacturer's recommended lubricants.

4. Verify appropriate anchorage, required area clearances, and correct alignment.

5. Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.

6. Verify that circuit breaker sizes and types correspond to approved shop drawings.

7. Verify that current transformer ratios correspond to approved shop drawings.

8. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

9. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

10. Clean switchboard.

11. Inspect insulators for evidence of physical damage or contaminated surfaces.

12. Verify correct barrier and shutter installation and operation.

13. Exercise all active components.

14. Inspect all mechanical indicating devices for correct operation.

15. Verify that vents are clear.

16. Test operation, alignment, and penetration of instrument transformer withdrawal disconnects.

17. Inspect control power transformers.

b. Electrical Tests

1. Perform insulation-resistance tests on each bus section.

2. Perform overpotential tests.

3. Perform insulation-resistance test on control wiring; Do not perform this test on wiring connected to solid-state components.

4. Perform control wiring performance test.

5. Perform primary current injection tests on the entire current circuit in each section of assembly.

6. Verify operation of switchboard heaters.

3.5.1.2 Circuit Breakers

Low Voltage - Insulated-Case and Low Voltage Molded Case with Solid State Trips

a. Visual and Mechanical Inspection

1. Compare nameplate data with specifications and approved shop drawings.

2. Inspect circuit breaker for correct mounting.

3. Operate circuit breaker to ensure smooth operation.

4. Inspect case for cracks or other defects.

5. Inspect all bolted electrical connections for high resistance using low resistance ohmmeter, verifying tightness of accessible bolted connections and/or cable connections by calibrated torque-wrench method, or performing thermographic survey.

6. Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests

1. Perform contact-resistance tests.

2. Perform insulation-resistance tests.

3. Perform Breaker adjustments for final settings in accordance with Government provided settings.

4. Perform long-time delay time-current characteristic tests

5. Determine short-time pickup and delay by primary current injection.

6. Determine ground-fault pickup and time delay by primary current injection.

7. Determine instantaneous pickup current by primary injection.

8. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and anti-pump function.

3.5.1.3 Current Transformers

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Verify correct connection.

4. Verify that adequate clearances exist between primary and secondary circuit.

5. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

6. Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

1. Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

2. Perform insulation-resistance tests.

3. Perform polarity tests.

4. Perform ratio-verification tests.

3.5.1.4 Metering and Instrumentation

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Verify tightness of electrical connections.

b. Electrical Tests

1. Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.

2. Calibrate watthour meters according to manufacturer's published data.

3. Verify all instrument multipliers.

4. Electrically confirm that current transformer and voltage transformer secondary circuits are intact.

3.5.1.5 Grounding System

a. Visual and Mechanical Inspection

1. Inspect ground system for compliance with contract plans and specifications.

b. Electrical Tests

1. IEEE Std 81. Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground testing megger in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument shall be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

2. Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.5.2 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Circuit breakers shall be tripped by operation of each protective device. Test shall require each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, the USAID Implementing Partner shall be given 5 working days advance notice of the dates and times for checks, settings, and tests.

-- End of Section --

SECTION 26 28 01.00 10

COORDINATED POWER SYSTEM PROTECTION

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2007; Errata 2006 & 2007; INT 44-56 2007; INT 47, 49, 50, 52-56 2008; INT 57, 58, 51, 48, 59 2009) National Electrical Safety Code
IEEE C37.13	(2008; INT 2009) Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.16	(2009) Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors, - Preferred Ratings, Related Requirements, and Application
IEEE C37.2	(2008) Electrical Power System Device Function Numbers and Contact Designations
IEEE C37.46	(2000) For High Voltage Expulsion and Current-Limiting Type Power Class Fuses and Fuse Disconnecting Switches
IEEE C37.90	(2005) Standard for Relays and Relay Systems Associated With Electric Power Apparatus
IEEE C57.13	(2008) Standard Requirements for Instrument Transformers
IEEE Std 242	(2001; Errata 2003) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - Buff Book
IEEE Std 399	(1997) Recommended Practice for Power Systems Analysis - Brown Book

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA AB 1	(2002) Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures

NEMA C12.11	(2007) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)
NEMA C37.50	(1989; R 2000) Low-Voltage AC Power Circuit Breakers Used in Enclosures - Test Procedures
NEMA FU 1	(2002; R 2007) Low Voltage Cartridge Fuses
NEMA ICS 1	(2000; R 2005; R 2008) Standard for Industrial Control and Systems General Requirements
NEMA ICS 2	(2000; R 2005; Errata 2008) Standard for Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated Not More than 2000 Volts AC or 750 Volts DC: Part 8 - Disconnect Devices for Use in Industrial Control Equipment
NEMA ICS 3	(2005) Standard for Industrial Control and Systems: Medium Voltage Controllers Rated 2001 to 7200 Volts AC
NEMA ICS 6	(1993; R 2006) Standard for Industrial Controls and Systems Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2008; AMD 1 2008) National Electrical Code - 2008 Edition

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2007) Seismic Design for Buildings

UNDERWRITERS LABORATORIES (UL)

UL 198M	(2003; Rev thru Oct 2007) Mine-Duty Fuses
UL 486E	(2009) Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
UL 489	(2009) Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 508	(1999; Rev thru Sep 2008) Standard for Industrial Control Equipment
UL 845	(2005; Rev thru Aug 2006) Standard for Motor Control Centers
UL 877	(1993; Rev thru Dec 2009) Circuit Breakers and Circuit-Breaker Enclosures for Use in Hazardous (Classified) Locations

1.2 SYSTEM DESCRIPTION

The power system covered by this specification consists of: Generators, Primary switchgear, transformer, secondary synchronizing switchgear and distribution section.

1.3 SUBMITTALS

Contractor shall submit the following using submittal procedures as specified in the Contract Documents.

SD-03 Product Data

Fault Current Analysis
Protective Device Coordination Study

The study along with protective device equipment submittals. No time extensions or similar contact modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed will be based on recommendations of this study. The USAID Implementing Partner shall not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study.

Equipment

Data consisting of manufacturer's time-current characteristic curves for individual protective devices, recommended settings of adjustable protective devices, and recommended ratings of non-adjustable protective devices.

System Coordinator

Verification of experience and license number, of a registered Professional Engineer with at least 3 years of current experience in the design of coordinated power system protection. Experience data shall include at least five references for work of a magnitude comparable to this contract, including points of contact, addresses and telephone numbers. This engineer must perform items required by this section to be performed by a registered Professional Engineer.

Protective Relays

Data including calibration and testing procedures and instructions pertaining to the frequency of calibration, inspection, adjustment, cleaning, and lubrication.

Installation

Procedures including diagrams, instructions, and precautions required to properly install, adjust, calibrate, and test the devices and equipment.

SD-06 Test Reports

Field Testing

The proposed test plan, prior to field tests, consisting of complete field test procedure including tests to be performed, test equipment required, and tolerance limits, including complete testing and verification of the ground fault protection equipment, where used. Performance test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall indicate the final position of controls.

SD-07 Certificates

Devices and Equipment

Certificates certifying that all devices or equipment meet the requirements of the contract documents.

1.4 QUALITY ASSURANCE

1.4.1 System Coordinator

System coordination, recommended ratings and settings of protective devices, and design analysis shall be accomplished by a registered professional electrical power engineer with a minimum of 3 years of current experience in the coordination of electrical power systems.

1.4.2 System Installer

Calibration, testing, adjustment, and placing into service of the protective devices shall be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of two years of current product experience in protective devices.

1.5 DELIVERY, STORAGE, AND HANDLING

Devices and equipment shall be visually inspected when received and prior to acceptance from conveyance. Protect stored items from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced.

1.6 PROJECT/SITE CONDITIONS

Devices and equipment furnished under this section shall be suitable for the following site conditions. Seismic details shall conform to UFC 3-310-04 and Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT, 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT AND 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

a. Altitude: 1,800-m

b. Ambient Temperature: -10C through 40C

c. Frequency: 50-Hz

d. Fungus Control: None

e. Hazardous Classification: None

f. Humidity Control: None

g. Ventilation: None

h. Seismic Parameters: See specification section

i. Other: None

PART 2 PRODUCTS

2.1 STANDARD PRODUCT

Provide protective devices and equipment which are the standard product of a manufacturer regularly engaged in the manufacture of the product and that essentially duplicate items that have been in satisfactory utility type use for at least two years prior to bid opening.

2.2 NAMEPLATES

Provide nameplates to identify all protective devices and equipment. Nameplate information shall be in accordance with NEMA AB 1.

2.3 CORROSION PROTECTION

Metallic materials shall be protected against corrosion. Ferrous metal hardware shall be zinc or chrome-plated.

2.4 MOTOR CONTROLS AND MOTOR CONTROL CENTERS

Motor controls and motor control centers shall be in accordance with NEMA ICS 1, NEMA ICS 2, NEMA ICS 3 and NEMA ICS 6, and UL 508and UL 845.

2.4.1 Motor Starters

Provide combination starters with circuit breakers.

2.4.2 Reduced-Voltage Starters

Provide reduced-voltage starters for polyphase motors 10 kW or larger, of the single-step autotransformer, reactor, or resistor type having an adjustable time interval between application of reduced and full voltages to the motors. Wye-delta reduced voltage starter or part winding increment starters having an adjustable time delay between application of voltage to first and second winding of motor, may be used in lieu of the reduced voltage starters specified above for starting of motor-generator sets, centrifugally operated equipment or reciprocating compressors provided with automatic unloaders.

2.4.3 Thermal-Overload Protection

Each motor of 93 W or larger shall be provided with thermal-overload protection. Polyphase motors shall have overload protection in each ungrounded conductor. The overload-protection device shall be provided either integral with the motor or controller, or shall be mounted in a separate enclosure. Unless otherwise specified, the protective device shall be of the manually reset type. Single or double pole tumbler switches specifically designed for alternating-current operation only may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating.

2.4.4 Low-Voltage Motor Overload Relays

2.4.4.1 General

Thermal and magnetic current overload relays shall conform to NEMA ICS 2 and UL 508. Overload protection shall be provided either integral with the motor or controller, and shall be rated in accordance with the requirements of NFPA 70. Standard units shall be used for motor starting times up to 7 second.Quick trip units shall be used on hermetically sealed, submersible pumps, and similar motors.

2.4.4.2 Construction

Manual reset type thermal relays shall be bimetallic construction. Automatic reset type relays shall be bimetallic construction. Magnetic current relays shall consist of a contact mechanism and a dash pot mounted on a common frame.

2.4.4.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Trip current ratings shall be established by selection of the replaceable overload device and shall not be adjustable. Where the controller is remotely-located or difficult to reach, an automatic reset, non-compensated overload relay shall be provided. Manual reset overload relays shall be provided otherwise, and at all locations where automatic starting is provided. Where the motor is located in a constant ambient temperature, and the thermal device is located in an ambient temperature that regularly varies by more than minus 10 degrees C, an ambient temperature-compensated overload relay shall be provided.

2.4.5 Automatic Control Devices

2.4.5.1 Direct Control

Automatic control devices (such as thermostats, float or pressure switches) which control the starting and stopping of motors directly shall be designed for that purpose and have an adequate kilowatt rating.

2.4.5.2 Pilot-Relay Control

Where the automatic-control device does not have such a rating, a magnetic starter shall be used, with the automatic-control device actuating the pilot-control circuit.

2.4.5.3 Manual/Automatic Selection

a. Where combination manual and automatic control is specified and the automatic-control device actuates the pilot control circuit of a magnetic starter, the magnetic starter shall be provided with a three-position selector switch marked MANUAL-OFF-AUTOMATIC.

b. Connections to the selector switch shall only allow the normal automatic regulatory control devices to be bypassed when the switch is in the Manual position; all safety control devices, such as low-or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the Manual and the Automatic positions of the selector switch. Control circuit connections to any MANUAL-OFF-AUTOMATIC switch or to

more than one automatic regulatory control device shall be made in accordance with wiring diagram approved by the contracting Officer unless such diagram is included on the drawings. All controls shall be 120 volts or less unless otherwise indicated.

2.4.6 Motor Control Centers

Control centers shall be indoor type and shall contain combination starters and other equipment as indicated. Control centers shall be NEMA ICS 2. Each control center shall be mounted on floor sills or mounting channels. Each circuit shall have a suitable metal or laminated plastic nameplate with white cut letters. Motor control centers shall be provided with a full-length ground bus bar.

2.5 LOW-VOLTAGE FUSES

2.5.1 General

Low-voltage fuses shall conform to NEMA FU 1. Time delay and nontime delay options shall be as specified. Equipment provided under this contract shall be provided with a complete set of properly rated fuses when the equipment manufacturer utilizes fuses in the manufacture of the equipment, or if current-limiting fuses are required to be installed to limit the ampere-interrupting capacity of circuit breakers or equipment to less than the maximum available fault current at the location of the equipment to be installed. Fuses shall have a voltage rating of not less than the phase-to-phase circuit voltage, and shall have the time-current characteristics requires for effective power system coordination.

2.5.2 Cartridge Fuses; Noncurrent-Limiting Type

Cartridge fuses of the noncurrent-limiting type shall be Class H, nonrenewable, dual element, time lag type and shall have interrupting capacity of 10,000 amperes. Class H Fuses shall conform to UL 198M. At 500 percent current, cartridge fuses shall not blow in less than 10 seconds. Cartridge fuses shall be used for circuits rated in excess of 30 amperes, 125 volts, except where current-limiting fuses are indicated.

2.5.3 Cartridge Fuses; Current-Limiting Type

Cartridge fuses, current-limiting type, Class J shall have tested interrupting capacity not less than 100,000 amperes. Fuse holders shall be the type that will reject Class H fuses.

a. Class J fuses shall conform to UL 198M.

2.5.3.1 Continuous Current Ratings (600 amperes and smaller)

Service entrance and feeder circuit fuses (600 amperes and smaller) shall be Class J, current-limiting, time-delay with 200,000 amperes interrupting capacity.

2.5.3.2 Continuous Current Ratings (greater than 600 amperes)

Service entrance and feeder circuit fuses (greater than 600 amperes) shall be Class L, current-limiting, time-delay with 200,000 amperes interrupting capacity.

2.5.3.3 Motor and Transformer Circuit Fuses

Motor, motor controller, transformer, and inductive circuit fuses shall be Class RK1 or RK5, current-limiting, time-delay with 200,000 amperes interrupting capacity.

2.6 MEDIUM-VOLTAGE AND HIGH-VOLTAGE FUSES

2.6.1 General

Medium-voltage and high-voltage fuses shall be distribution fuse cutouts or power fuses, E-rated, C-rated, or R-rated current-limiting fuses as shown.

2.6.2 Construction

Units shall be suitable for outdoor use. Fuses shall have integral blown-fuse indicators. All ratings shall be clearly visible.

2.6.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Continuous-current ratings shall be as shown.

2.6.3.1 Fuse Cutouts

Medium-voltage fuses and cutouts shall be of the loadbreak enclosed type construction rated 27 kV and of the normal -duty type ratings and types indicated. Open-link cutouts are not acceptable. Fuses shall be either indicating or dropout type. Fuse ratings shall be as indicated. Fuses cutouts shall be equipped with mounting brackets suitable for the indicated installations.

2.6.3.2 E-Rated, Current-Limiting Power Fuses

E-rated, current-limiting, power fuses shall conform to IEEE C37.46.

2.6.3.3 C-Rated, Current-Limiting Fuses

C-rated, current-limiting, power fuses shall open in 1000 seconds at currents between 170 and 240 percent of the C rating.

2.6.3.4 R-Rated, Current-Limiting Fuses

R-rated, current-limiting, fuses shall be used with medium-voltage motor controllers only. R-rated fuses shall conform to IEEE C37.46.

2.7 MOTOR SHORT-CIRCUIT PROTECTOR (MSCP)

2.7.1 General

Motor short-circuit protectors shall conform to UL 508 and shall be provided as shown. Protectors shall be used only as part of a combination motor controller which provides coordinated motor branch-circuit overload and short-circuit protection, and shall be rated in accordance with the requirements of NFPA 70.

2.7.2 Construction

Motor short-circuit protector bodies shall be constructed of high

temperature, dimensionally stable, long life, nonhygroscopic materials. Protectors shall fit special MSCP mounting clips and shall not be interchangeable with any commercially available fuses. Protectors shall have 100 percent one-way interchangeability within the A-Y letter designations. All ratings shall be clearly visible.

2.7.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Letter designations shall be A through Y for motor controller Sizes 0, 1, 2, 3, 4, and 5, with 100,000 amperes interrupting capacity rating. Letter designations shall correspond to controller sizes as follows:

CONTROLLER SIZE	MSCP DESIGNATION
NEMA 0	A-N
NEMA 1	A-P
NEMA 2	A-S
NEMA 3	A-U
NEMA 4	A-W
NEMA 5	A-Y

2.8 MOLDED-CASE CIRCUIT BREAKERS

2.8.1 General

Molded-case circuit breakers shall conform to NEMA AB 1 and UL 489. Circuit breakers may be installed in panelboards, switchboards, enclosures, motor control centers, or combination motor controllers. Circuit breakers and circuit breaker enclosures located in hazardous (classified) areas shall conform to UL 877.

2.8.2 Construction

Molded-case circuit breakers shall be assembled as an integral unit in a supporting and enclosing housing of glass reinforced insulating material providing high dielectric strength. Circuit breakers shall be suitable for mounting and operating in any position. Lugs shall be listed for copper conductors only in accordance with UL 486E. Single-pole circuit breakers shall be full module size with not more than one pole per module. Multi-pole circuit breakers shall be of the common-trip type having a single operating handle such that an overload or short circuit on any one pole will result in all poles opening simultaneously. Sizes of 100 amperes or less may consist of single-pole breakers permanently factory assembled into a multi-pole unit having an internal, mechanical, nontamperable common-trip mechanism and external handle ties. All circuit breakers shall have a quick-make, quick-break overcenter toggle-type mechanism, and the handle mechanism shall be trip-free to prevent holding the contacts closed against a short-circuit or sustained overload. All circuit breaker handles shall assume a position between "ON" and "OFF" when tripped automatically. All ratings shall be clearly visible.

2.8.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. The interrupting rating of the circuit breakers shall be at least equal to the available short-circuit current at the line terminals of the circuit breaker and correspond to the UL listed integrated short-circuit current rating specified for the panelboards and switchboards. Molded-case circuit breakers shall have nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings in accordance with NEMA AB 1. Ratings shall be coordinated with system X/R ratio.

2.8.4 Cascade System Ratings

Circuit breakers used in series combinations shall be in accordance with UL 489. Equipment, such as switchboards and panelboards, which house series-connected circuit breakers shall be clearly marked accordingly. Series combinations shall be listed in the UL Recognized Component Directory under "Circuit Breakers-Series Connected."

2.8.5 Thermal-Magnetic Trip Elements

Thermal magnetic circuit breakers shall be provided as shown. Automatic operation shall be obtained by means of thermal-magnetic tripping devices located in each pole providing inverse time delay and instantaneous circuit protection. The instantaneous magnetic trip shall be adjustable and accessible from the front of all circuit breakers on frame sizes above 150 amperes.

2.8.6 Solid-State Trip Elements

Solid-state circuit breakers shall be provided as shown. All electronics shall be self-contained and require no external relaying, power supply, or accessories. Printed circuit cards shall be treated to resist moisture absorption, fungus growth, and signal leakage. All electronics shall be housed in an enclosure which provides protection against arcs, magnetic interference, dust, and other contaminants. Solid-state sensing shall measure true RMS current with error less than one percent on systems with distortions through the 13th harmonic. Peak or average actuating devices are not acceptable. Current sensors shall be toroidal construction, encased in a plastic housing filled with epoxy to protect against damage and moisture and shall be integrally mounted on the breaker. Where indicated on the drawings, circuit breaker frames shall be rated for 100 percent continuous duty. Circuit breakers shall have tripping features as shown on the drawings and as described below:

a. Long-time current pick-up, adjustable from 50 percent to 100 percent of continuous current rating.

b. Fixed long-time delay.

c. Short-time current pick-up, adjustable from 1.5 to 9 times long-time current setting.

d. Fixed short-time delay.

e. Instantaneous current pick-up, adjustable from 1.5 to 9 times long-time current setting.

f. Ground-fault pick-up, adjustable from 20 percent to 60 percent of

sensor rating, but in no case greater than 1200 amperes. Sensing of ground-fault current at the main bonding jumper or ground strap shall not be permitted.

i. Fixed ground-fault delay.

2.8.7 Current-Limiting Circuit Breakers

Current-limiting circuit breakers shall be provided as shown. Current-limiting circuit breakers shall limit the let-through I square times t to a value less than the I square times t of one-half cycle of the symmetrical short-circuit current waveform. On fault currents below the threshold of limitation, breakers shall provide conventional overload and short-circuit protection. Integrally-fused circuit breakers shall not be used.

2.8.8 SWD Circuit Breakers

Circuit breakers rated 15 amperes or 20 amperes and intended to switch 277 volts or less fluorescent lighting loads shall be marked "SWD."

2.8.9 HACR Circuit Breakers

Circuit breakers 60 amperes or below, 240 volts, 1-pole or 2-pole, intended to protect multi-motor and combination-load installations involved in heating, air conditioning, and refrigerating equipment shall be marked "Listed HACR Type."

2.8.10 Motor Circuit Protectors (MCP)

Motor circuit protectors shall conform to NEMA AB 1 and UL 489 and shall be provided as shown. MCPs shall consist of an adjustable instantaneous trip circuit breaker in conjunction with a combination motor controller which provides coordinated motor circuit overload and short-circuit protection. Motor Circuit Protectors shall be rated in accordance with NFPA 70.

2.9 LOW-VOLTAGE POWER CIRCUIT BREAKERS

2.9.1 Construction

Low-voltage power circuit breakers shall conform to IEEE C37.13 and IEEE C37.16 and shall be three-pole, single-throw, stored energy, electrically operated, with drawout mounting. Solid-state trip elements which require no external power connections shall be provided. Circuit breakers shall have an open/close contact position indicator, charged/discharged stored energy indicator, primary disconnect devices, and a mechanical interlock to prevent making or breaking contact of the primary disconnects when the circuit breaker is closed. Control voltage shall be 220 Vac. The circuit breaker enclosure shall be suitable for its intended location.

2.9.2 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Circuit breakers shall be rated for 100 percent continuous duty and shall have trip current ratings and frame sizes as shown. Nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings shall be in accordance with IEEE C37.16. Tripping features shall be as follows:

a. Long-time current pick-up, adjustable from 50 percent to 100 percent of sensor current rating.

b. Adjustable long-time delay.

c. Short-time current pick-up, adjustable from 1.5 to 9 times long-time current setting.

d. Adjustable short-time delay.

e. Short-time I square times t switch.

f. Instantaneous current pick-up, adjustable from 1.5 to 9 times long-time current setting.

g. Ground-fault pick-up, adjustable from 20 percent to 60 percent of sensor rating, but in no case greater than 1200 amperes. Sensing of ground-fault current at the main bonding jumper or ground strap shall not be permitted.

h. Adjustable ground-fault delay.

i. Ground-fault I square times t switch.

j. Overload, Short-circuit and Ground-fault trip indicators shall be provided.

2.10 SUBSTATION AND SWITCHGEAR PROTECTIVE RELAYS

Microprocessor-based protective relays shall be as shown and shall be of a type specifically designed for use on power switchgear or associated electric power apparatus. Protective relays shall conform to IEEE C37.90. Relays and auxiliaries shall suitable for operation with the instrument transformer ratios and connections provided.

2.10.1 Construction

Relays for installation in metal-clad switchgear shall be of the semi-flush, rectangular, back-connected, dustproof, switchboard type. Cases shall have a black finish and window-type removable covers capable of being sealed against tampering. Relays shall be of a type that can be withdrawn, through approved sliding contacts, from fronts of panels or doors without opening current transformer secondary circuits, disturbing external circuits, or requiring disconnection of any relay leads. Necessary test devices shall be incorporated within each relay and shall provide a means for testing either from an external source of electric power or from associated instrument transformers. Each relay shall be provided with an operation indicator and an external target reset device. Relays shall have necessary auxiliaries for proper operation. Relays and auxiliaries shall be suitable for operation with the instrument transformer ratios and connections provided.

2.10.2 Ratings

Relays shall be the manufacturer's standard items of equipments with appropriate ranges for time dial, tap, and other settings. Relay device numbers shall correspond to the function names and descriptions of IEEE C37.2.

2.10.3 Overcurrent Relays

Overcurrent relays shall be as follows:

a. Phase overcurrent relays for main circuit breakers shall be single-phases, nondirectional, microprocessor-based type, time delay, device 51, current taps as indicated.

b. Ground overcurrent relays for main circuit breakers shall be microprocessor-based type, time delay, device 51G wired to a current transformer in the source transformer neutral-to-ground connection and 51N, residually connected, with current taps.

c. Ground overcurrent relays for tie circuit breakers shall be microprocessor-based type, time delay, device 51N, residually connected, with current taps.

d. Phase overcurrent relays for feeder circuit breakers shall be microprocessor-based type, device 50/51, with instantaneous-current as indicated.

e. Ground overcurrent relays for feeder circuit breakers shall be microprocessor-based type instantaneous, device 50GS wires to a ground sensor current transformer.

2.11 INSTRUMENT TRANSFORMERS

2.11.1 General

Instrument transformers shall comply with NEMA C12.11 and IEEE C57.13. Instrument transformers shall be configured for mounting in/on the device to which they are applied. Polarity marks on instrument transformers shall be visually evident and shown on the drawings.

2.11.2 Current Transformers

Unless otherwise indicated, bar, wound, or window-type transformers are acceptable; and except for window-type units installed over insulated buses, transformers shall have a BIL rating consistent with the rated BIL of the associated switchgear or electric power apparatus bushings, buses or conductors. Current transformers shall have the indicated ratios. The continuous thermal-current rating factor shall be not less than 1.0. Other thermal and mechanical ratings of current transformers and their primary leads shall be coordinated with the design of the circuit breaker and shall be not less than the momentary rating of the associated circuit breaker. Circuit protectors shall be provided across secondary leads of the current transformers to prevent the accidental open-circuiting of the transformers while energized. Each terminal of each current transformer shall be connected to a short-circuiting terminal block in the circuit interrupting mechanism cabinet, power transformer terminal cabinet, and in the associated instrument and relay cabinets.

2.11.2.1 For kW Hour and Demand Metering (Low Voltage)

Current transformers shall conform to IEEE C57.13. Current transformers with a metering accuracy with 600-volt insulation, and 10 kV BIL shall be provided. Butyl-molded, window-type current transformers mounted in the current transformer cabinet shall be provided.

2.11.2.2 Voltage Transformers

Voltage transformers shall have indicated ratios. Voltage transformers shall be of the drawout type having current-limiting fuses in both primary and secondary circuits. Mechanical interlocks shall prevent removal of fuses, unless the associated voltage transformer is in a drawout position. Voltage transformer compartments shall have hinged doors.

2.12 COORDINATED POWER SYSTEM PROTECTION

Analyses shall be prepared to demonstrate that the equipment selected and system constructed meet the contract requirements for ratings, coordination, and protection. They shall include a load flow analysis, a fault current analysis, and a protective device coordination study. The studies shall be performed by a registered professional engineer with demonstrated experience in power system coordination in the last 3 years. Provide a list of references complete with points of contact, addresses and telephone numbers. The selection of the engineer is subject to the approval of the USAID Implementing Partner.

2.12.1 Scope of Analyses

The fault current analysis, and protective device coordination study shall begin at: the source bus and extend down to system buses where fault availability is 10,000 amperes (symmetrical) for building/facility 600 volt level distribution buses.

2.12.2 Determination of Facts

The time-current characteristics, features, and nameplate data for each existing protective device shall be determined and documented. Coordinate with the commercial power company for fault current availability at the site.

2.12.3 Single Line Diagram

A single line diagram shall be prepared to show the electrical system buses, devices, transformation points, and all sources of fault current (including generator and motor contributions). A fault-impedance diagram or a computer analysis diagram may be provided. Each bus, device or transformation point shall have a unique identifier. If a fault-impedance diagram is provided, impedance data shall be shown. Location of switches, breakers, and circuit interrupting devices shall be shown on the diagram together with available fault data, and the device interrupting rating.

2.12.4 Fault Current Analysis

2.12.4.1 Method

The fault current analysis shall be performed in accordance with methods described in IEEE Std 242, and IEEE Std 399.

2.12.4.2 Data

Actual data shall be utilized in fault calculations. Bus characteristics and transformer impedance shall be those proposed. Data shall be documented in the report.

2.12.4.3 Fault Current Availability

Balanced three-phase fault, bolted line-to-line fault, and line-to-ground fault current values shall be provided at each voltage transformation point and at each power distribution bus. The maximum and minimum values of fault available at each location shall be shown in tabular form on the diagram or in the report.

2.12.5 Coordination Study

The study shall demonstrate that the maximum possible degree of selectivity has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions. The study shall include a description of the coordination of the protective devices in this project. A written narrative shall be provided describing: which devices may operate in the event of a fault at each bus; the logic used to arrive at device ratings and settings; situations where system coordination is not achievable due to device limitations (an analysis of any device curves which overlap); coordination between upstream and downstream devices; and relay settings. Recommendations to improve or enhance system reliability, and detail where such changes would involve additions or modifications to the contract and cost damages (addition or reduction) shall be provided. Composite coordination plots shall be provided on log-log graph paper.

2.12.6 Study report

a. The report shall include a narrative describing: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.

b. The study shall include descriptive and technical data for existing devices and new protective devices proposed. The data shall include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices.

c. The report shall document utility company data including system voltages, fault MVA, system X/R ratio, time-current characteristic curves, current transformer ratios, and relay device numbers and settings.

d. The report shall contain fully coordinated composite time-current characteristics curves for each bus in the system, as required to ensure coordinated power system protection between protective devices or equipment. The report shall include recommended ratings and settings of all protective devices in tabulated form.

e. The report shall provide the calculation performed for the analyses, including computer analysis programs utilized. The name of the software package, developer, and version number shall be provided.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with details of the work, verify dimensions in the field, and advise the USAID Implementing Partner of any discrepancy before performing any work.

3.2 INSTALLATION

Install protective devices in accordance with the manufacturer's published instructions and in accordance with the requirements of NFPA 70 and IEEE C2.

3.3 FIELD TESTING

3.3.1 General

Perform field testing in the presence of the USAID Implementing Partner. Notify the USAID Implementing Partner 7 days prior to conducting tests. Furnish all materials, labor, and equipment necessary to conduct field tests. Perform all tests and inspections recommended by the manufacturer unless specifically waived by the USAID Implementing Partner. Maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results.

3.3.2 Safety

Provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. Replace any devices or equipment which are damaged due to improper test procedures or handling.

3.3.3 Molded-Case Circuit Breakers

Circuit breakers shall be visually inspected, operated manually, and connections checked for tightness. Current ratings shall be verified and adjustable settings incorporated in accordance with the coordination study.

3.3.4 Power Circuit Breakers

3.3.4.1 General

Visually inspect the circuit breaker and operate the circuit breaker manually; adjust and clean primary contacts in accordance with manufacturer's published instructions; check tolerances and clearances; check for proper lubrication; and ensure that all connections are tight. For electrically operated circuit breakers, verify operating voltages on closing and tripping coils. Verify fuse ratings in control circuits; electrically operate the breaker, where applicable; and implement settings in accordance with the coordination study.

3.3.4.2 Power Circuit Breaker Tests

The following power circuit breakers shall be tested in accordance with NEMA C37.50.

3.3.5 Protective Relays

Protective relays shall be visually and mechanically inspected, adjusted, tested, and calibrated in accordance with the manufacturer's published instructions. Tests shall include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Relay settings shall be implemented in accordance with the coordination study. Relay contacts shall be manually or electrically operated to verify that the proper breakers and alarms initiate. Relaying current transformers shall be field tested in accordance with IEEE C57.13.

-- End of Section --

SECTION 26 32 15.00 10

DIESEL-GENERATOR SET STATIONARY 100-2500 KW, WITH AUXILIARIES

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C39.1	(1981; R 1992) Requirements for Electrical Analog Indicating Instruments

ASME INTERNATIONAL (ASME)

ASME B16.11	(2009) Forged Fittings, Socket-Welding and Threaded
ASME B16.3	(2006) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2009) Standard for Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24
ASME B31.1	(2007; Addenda 2008; Addenda 2009) Power Piping
ASME BPVC SEC IX	(2007; Addenda 2008) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications
ASME BPVC SEC VIII D1	(2007; Addenda 2008) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8	(2000) Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM A 106/A 106M	(2008) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A 181/A 181M	(2006) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A 234/A 234M	(2007) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature

	Service
ASTM A 53/A 53M	(2007) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM B 395/B 395M	(2008) Standard Specification for U-Bend Seamless Copper and Copper Alloy Heat Exchanger and Condenser Tubes
ASTM D 975	(2009b) Standard Specification for Diesel Fuel Oils

ELECTRICAL GENERATING SYSTEMS ASSOCIATION (EGSA)

EGSA 101P	(1995) Engine Driven Generator Sets

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2007; Errata 2006 & 2007; INT 44-56 2007; INT 47, 49, 50, 52-56 2008; INT 57, 58, 51, 48, 59 2009) National Electrical Safety Code
IEEE C57.13	(2008) Standard Requirements for Instrument Transformers
IEEE C57.13.1	(2006) Guide for Field Testing of Relaying Current Transformers
IEEE Std 1	(2000; R 2005) General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation
IEEE Std 100	(2000) The Authoritative Dictionary of IEEE Standards Terms
IEEE Std 115	(1995; R 2002) Test Procedures for Synchronous Machines: Part I: Acceptance and Performance Testing; Part II: Test Procedures and Parameter Determination for Dynamic Analysis
IEEE Std 120	(1989; R 2007) Master Test Guide for Electrical Measurements in Power Circuits
IEEE Std 404	(2006) Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V Through 500 000 V
IEEE Std 43	(2000; R 2006) Testing Insulation Resistance of Rotating Machinery
IEEE Std 48	(2009) Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV through 765 kV
IEEE Std 484	(2002; R 2008) Recommended Practice for

	Installation Design and Implementation of Vented Lead-Acid Batteries for Stationary Applications
IEEE Std 485	(1997; R 2003; INT 2008) Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications
IEEE Std 519	(1992; Errata 2004) Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
IEEE Std 81	(1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1)Normal Measurements

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2009) Standard for Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-69	(2003; R 2004) Standard for Pipe Hangers and Supports - Selection and Application
MSS SP-80	(2008) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C12.11	(2007) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)
NEMA ICS 2	(2000; R 2005; Errata 2008) Standard for Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated Not More than 2000 Volts AC or 750 Volts DC: Part 8 - Disconnect Devices for Use in Industrial Control Equipment
NEMA ICS 6	(1993; R 2006) Standard for Industrial Controls and Systems Enclosures
NEMA MG 1	(2007; Errata 2008) Standard for Motors and Generators
NEMA PB 1	(2006; Errata 2008) Standard for Panelboards
NEMA PB 2	(2006) Deadfront Distribution Switchboards
NEMA SG 6	(2000) Standard for Power Switching Equipment
NEMA WC 74	(2006) Standard for 5-46 kV Shielded Power

	Cable for use in the Transmission and Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 30	(2007; Errata 2008) Flammable and Combustible Liquids Code
NFPA 37	(2010) Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 70	(2008; AMD 1 2008) National Electrical Code - 2008 Edition

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J537	(2000) Storage Batteries

THE EUROPEAN PARLIAMENT AND THE COUNCIL

2000/14/EC	(8 May 2000) Noise Emission in the Environment by Equipment for Use Outdoors

UNDERWRITERS LABORATORIES (UL)

UL 1236	(2006; Rev thru Jan 2010) Standard for Safety Battery Chargers for Charging Engine-Starter Batteries
UL 891	(2005) Dead-Front Switchboards

1.2 SYSTEM DESCRIPTION

a. Provide and install each engine-generator set complete and totally functional, with all necessary ancillary equipment to include: air filtration; starting system; generator controls, protection, and isolation; instrumentation; lubrication; fuel system; cooling system; and engine exhaust system. Each engine-generator set shall satisfy the requirements specified in the Engine-Generator Parameter Schedule.

b. Each set shall consist of one engine, one generator, and one exciter mounted, assembled, and aligned on one base; and other necessary ancillary equipment which may be mounted separately. Sets having a capacity of 750 kW or smaller shall be assembled and attached to the base prior to shipping. Sets over 750 kW capacity may be shipped in sections. Each set component shall be environmentally suitable for the location shown and shall be the manufacturer's standard product offered in catalogs for commercial or industrial use. Any nonstandard products or components and the reason for their use shall be specifically identified in paragraph SUBMITTALS.

1.2.1 Engine-Generator Parameter Schedule

ENGINE-GENERATOR PARAMETER SCHEDULE

Power Rating	See drawings
Overload Capacity (Prime applications only)	110 percent of Service Load for 1 hour in 12 consecutive hours

ENGINE-GENERATOR PARAMETER SCHEDULE

Service Load	See drawings kVA (maximum) See drawings kVA (continuous
Motor Starting kVA (Max.)	389 kVA
Power Factor	0.8 lagging
Engine-Generator Applications	parallel with other generators on an infinite bus
Maximum Speed	1500 rpm
Heat Exchanger Type	fin-tube (radiator)
Governor Type	Isochronous
Frequency Bandwidth (steady state)	± 0.4%
Governor Type	Droop
Frequency Regulation (droop) (No Load to Full Load)	3 percent (maximum)
Frequency Bandwidth (steady state)	± 0.4 %
Voltage Regulation (No Load to Full Load) (Stand alone applications)	± 2 percent (maximum)
Voltage Bandwidth (steady state)	± 1 percent
Frequency	50 Hz
Voltage	400 volts
Phases	3 Phase, Wye
Minimum Generator Subtransient Reactance	15 percent
Nonlinear Loads	50 kVA
Max Step Load Increase	50 % of Service Load at 80 PF
Transient Recovery Time with Step Load Increase (Voltage)	1 seconds
Transient Recovery Time with Step Load Increase (Frequency)	1 seconds
Maximum Voltage Deviation with	30 % of rated

ENGINE-GENERATOR PARAMETER SCHEDULE

Step Load Increase	voltage
Maximum Frequency Deviation with Step Load Increase	2.5 percent of rated frequency
Max Step Load Decrease (without shutdown)	100 percent of Service Load at 0.4 PF
Max Time to Start and be Ready to Assume Load	10 seconds
Max Summer Indoor Temp (Prior to Genset Operation)	40C degrees
Min Winter Indoor Temp (Prior to Genset Operation)	-10C degrees
Max Allowable Heat Transferred To Engine Generator Space at Rated Output Capacity	1,763 MBTU/hr
Max Summer Outdoor Temp (Ambient)	40C degrees
Min Winter Outdoor Temp (Ambient)	-10C degrees
Installation Elevation	1,800-m above sea level

1.2.2 Rated Output Capacity

Each engine-generator-set shall provide power equal to the sum of Service Load plus the machine's efficiency loss and associated ancillary equipment loads. Rated output capacity shall also consider engine and/or generator oversizing required to meet requirements in paragraph Engine-Generator Parameter Schedule.

1.2.3 Power Ratings

Power ratings shall be in accordance with EGSA 101P.

1.2.4 Transient Response

The engine-generator set governor and voltage regulator shall cause the engine-generator set to respond to the maximum step load changes such that output voltage and frequency recover to and stabilize within the operational bandwidth within the transient recovery time. The engine-generator set shall respond to maximum step load changes such that the maximum voltage and frequency deviations from bandwidth are not exceeded.

1.2.5 Reliability and Durability

Each prime engine-generator set shall have both an engine and a generator capable of delivering the specified power on a prime basis with an anticipated mean time between overhauls of not less than 10,000 hours operating with a 70 percent load factor. Two like engines and two like

generators shall be cited that have performed satisfactorily in a stationary power plant, independent from the physical location of the manufacturer's and assembler's facilities. The engine and generators should have been in operation for a minimum of 8000 actual hours at a minimum load of 70 percent of the rated output capacity. During two consecutive years of service, the units should not have experienced any failure resulting in a downtime in excess of 72 hours. Like engines shall be of the same model, speed, bore, stroke, number and configuration of cylinders and rated output capacity. Like generators shall be of the same model, speed, pitch, cooling, exciter, voltage regulator and rated output capacity.

1.2.6 Parallel Operation

Each engine-generator set specified for parallel operation shall be configured for a commercial power source on an infinite bus and with one or more sets on an isolated bus.

1.2.7 Load Sharing

Each engine-generator set specified for parallel operation shall be configured to automatically load share with other sets by proportional loading. Proportional loading shall load each set to within 5 percent of its fair share. A set's fair share is its nameplate-rated capacity times the total load, divided by the sum of all nameplate-rated capacities of on-line sets. Load sharing shall incorporate both the real and reactive components of the load.

1.2.8 Engine-Generator Set Enclosure

The engine-generator set enclosure shall be corrosion resistant and fully weather resistant. The enclosure shall contain all set components and provide ventilation to permit operation at Service Load under secured conditions. Doors shall be provided for access to controls and equipment requiring periodic maintenance or adjustment. Removable panels shall be provided for access to components requiring periodic replacement. The enclosure shall be capable of being removed without disassembly of the engine-generator set or removal of components other than the exhaust system. The enclosure shall reduce the noise of the generator set to within the limits specified in the paragraph SOUND LIMITATIONS.

1.2.9 Vibration Isolation

The engine-generator set shall be provided with a vibration-isolation system in accordance with the manufacturer's standard recommendation. Vibration-isolation systems shall be designed and qualified (as an integral part of the base and mounting system in accordance with the seismic parameters specified. Where the vibration-isolation system does not secure the base to the structure floor or unit foundation, seismic restraints shall be provided in accordance with the seismic parameters specified.

1.2.10 Fuel Consumption

Engine fuel consumption shall not exceed the following maximum limits based on the conditions listed below.

Size Range Net kW	% of Rated Output capacity	Fuel Usage kg/kWH (lbs/kWH)
100 - 299	75 and 100	0.272 (0.600)
	50	0.292 (0.643)
300 - 999	75 and 100	0.261 (0.575)
	50	0.272 (0.600)
1000 - 2500	75 and 100	0.243 (0.536)
	50	0.260 (0.573)

Conditions:

a. Net kW of the Set corrected for engine auxiliaries that are electrically driven, where kW is electrical kilowatt hours.

b. 45 MJ/kg (19,350 Btu/pound) high-heat value for fuel used.

c. Sea level operation.

d. Intake-air temperature not over 32 degrees C.

e. Barometric pressure of intake air not less than 95.7 kPa of mercury.

1.2.11 Fuel-Consumption Rebates

Fuel consumption rebates shall be assessed for failure of engine generator set to meet guaranteed rates. If the guaranteed fuel-consumption rate for 100 percent rated output capacity is verified in the tests but the rates for 75 or 50 percent rated output capacity are not verified, the appropriate 75 or 50 percent rate differences shall be used in assessing the rebates. If more than one fuel consumption guarantee is not met, rebates shall be computed for 100, 75, and 50 percent rated output capacity, and the highest computed figure shall be used in assessing the rebates.

Rebate = H x C x D x N where:

C = Local fuel costs in dollars per kg (pound)
D = A - G
A = Measured fuel consumption in kgs per second (pounds per hour)
G = kW x R = Guaranteed fuel consumption in kgs per second(pounds per hour)
N = Number of generator sets provided
H = Operating hours over a projected period of 15 years

Adjust fuel costs to the heat value kJ/kg for the fuel used in the test (requires fuel laboratory test) rationed to the 45,000 kJ/kg heat value used as the basis of the guarantee.

1.2.12 Harmonic Requirements

Non-linear loads to be served by each engine-generator set are as indicated. The maximum linear load demand (kVA @ PF) when non-linear loads will also be in use is as indicated.

1.2.13 Starting Time Requirements

Upon receipt of a signal to start, each engine generator set will start, reach rated frequency and voltage and be ready to assume load within the time specified. For standby sets used in emergency power applications, each engine generator set will start, reach rated frequency and voltage, and power will be supplied to the load terminals of the automatic transfer switch within the starting time specified.

1.3 SUBMITTALS

Contractor shall submit the following using submittal procedures as specified in the Contract Documents.

SD-02 Shop Drawings

Detailed Drawings

Detailed drawings, as specified.

Acceptance

Drawings which accurately depict the as-built configuration of the installation, upon acceptance of the diesel-generator set installation. Revise layout drawings to reflect the as-built conditions and submit them with the as-built drawings.

SD-03 Product Data

Harmonic Requirements
Engine-Generator Parameter Schedule

Description of the generator features which mitigate the effects of the non-linear loads listed.

Heat Exchanger

Manufacturers data to quantify heat rejected to the space with the engine generator set at rated capacity.

Generator

Manufacturer's standard data for each generator (prototype data at the specified rating or above is acceptable), listing the following information:

a. Direct-Axis subtransient reactance (per unit).

b. The generator kW rating and short circuit current capacity (both symmetric and asymmetric).

Manufacturer's Catalog

Manufacturer's standard catalog data describing and depicting each engine-generator set and all ancillary equipment in sufficient detail to demonstrate complete specification compliance.

Site Welding

A copy of qualifying procedures and a list of names and identification symbols of qualified welders and welding operators. A letter listing the welder qualifying procedures for each welder, complete with supporting data such as test procedures used, what was tested to, and a list of the names of all welders and their identification symbols.

Spare Parts

List of spare parts, as specified.

Onsite Training

A letter giving the date proposed for conducting the onsite training course, the agenda of instruction, a description of the video taping service to be provided, and the kind and quality of the tape to be left with the Contracting Officer at the end of the instructional period.

Vibration-Isolation

Vibration isolation system performance data for the range of frequencies generated by the engine-generator set during operation from no load to full load and the maximum vibration transmitted to the floor. Description of seismic qualification of the engine-generator mounting, base, and vibration isolation.

Posted Data and Instructions

Posted data including wiring and control diagrams showing the key mechanical and electrical control elements, and a complete layout of the entire system.

Instructions

Instructions including: the manufacturers pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions. Instructions shall include procedures for interrelated equipment (such as heat recovery systems, co-generation, load-shedding, and automatic transfer switches). Instructions shall be weatherproof, laminated in plastic, and posted where directed.

Experience

Statement showing that each component manufacturer has a minimum of 3 years experience in the manufacture, assembly and sale of components used with stationary diesel engine-generator sets for commercial and industrial use. The engine-generator set manufacturer/assembler has a minimum of 3 years experience in the manufacture, assembly and sale of stationary diesel engine-generator sets for commercial and industrial use.

Field Engineer

A letter listing the qualifications, schools, formal training, and experience of the field engineer.

General Installation

A copy of the manufacturer's installation procedures and a detailed description of the manufacturer's recommended break-in procedure.

SD-05 Design Data

Performance Criteria

Calculations of the engine and generator output power capability, including efficiency and parasitic load data.

Sound Limitations

Sound power level data for the packaged unit operating at 100 percent load in a free field environment. The data should demonstrate compliance with the sound limitation requirements of this specification.

Integral Main Fuel Storage Tank
Day Tank

Calculations for the capacity of each day tank, including allowances for recirculated fuel, usable tank capacity, and duration of fuel supply.

Power Factor

The generator capability curve showing generator kVA output capability (kW vs. kvar) for both leading and lagging power factors ranging from 0 to 1.0.

Time-Delay on Alarms

The magnitude of monitored values which define alarm or action set points, and the tolerance (plus and/or minus) at which the devices activate the alarm or action for items contained within the alarm panels.

Battery Charger

Battery charger sizing calculations.

SD-06 Test Reports

Factory Inspection and Tests

Six complete reproducible copies of the factory inspection result on the checklist format specified in paragraph FACTORY INSPECTION AND TESTS.

Factory Tests

a. A letter giving notice of the proposed dates of factory inspections and tests at least 14 days prior to beginning tests.

b. A detailed description of the manufacturer's procedures for factory

tests at least 14 days prior to beginning tests.

c. Six copies of the Factory Test data described below in 215.9 by 279.4 mm binders having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs. Data plots shall be full size (215.9 by 279.4 mm minimum), showing grid lines, with full resolution.

(1) A detailed description of the procedures for factory tests.

(2) A list of equipment used, with calibration certifications.

(3) A copy of measurements taken, with required plots and graphs.

(4) The date of testing.

(5) A list of the parameters verified.

(6) The condition specified for the parameter.

(7) The test results, signed and dated.

(8) A description of adjustments made.

Onsite Inspection and Tests

a. A letter giving notice of the proposed dates of onsite inspections and tests at least 14 days prior to beginning tests.

b. A detailed description of the Contractor's procedures for onsite tests including the test plan and a listing of equipment necessary to perform the tests. Submission shall be at least 7 days prior to beginning tests.

c. Six copies of the onsite test data described below in 215.9 by 279.4 mm binders having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs. Data plots shall be full size (215.9 by 279.4 mm minimum), showing grid lines, with full resolution.

(1) A detailed description of the procedures for onsite tests.

(2) A list of equipment used, with calibration certifications.

(3) A copy of measurements taken, with required plots and graphs.

(4) The date of testing.

(5) A list of the parameters verified.

(6) The condition specified for the parameter.

(7) The test results, signed and dated.

(8) A description of adjustments made.

SD-07 Certificates

Cooling System

A letter which certifies that the engine-generator set and cooling system function properly in the ambient temperature specified, stating the following values:

a. The maximum allowable inlet temperature of the coolant fluid.

b. The minimum allowable inlet temperature of the coolant fluid.

c. The maximum allowable temperature rise in the coolant fluid through the engine.

Vibration Isolation

Torsional analysis including prototype testing or and calculations which certify and demonstrate that no damaging or dangerous torsional vibrations will occur when the prime mover is connected to the generator, at synchronous speeds, $\pm$ 10 percent.

Prototype Test

Manufacturer's standard certification that prototype tests were performed for the generator model proposed.

Reliability and Durability

A reliability and durability certification letter from the manufacturer and assembler to prove that existing facilities are and have been successfully utilizing the same components proposed to meet this specification, in similar service. Certification may be based on components, i.e. engines used with different models of generators and generators used with different engines, and does not exclude annual technological improvements made by a manufacturer in the basic standard-model component on which experience was obtained, provided parts interchangeability has not been substantially affected and the current standard model meets the performance requirements specified. Provide a list with the name of the installations, completion dates, and name and telephone number of a point of contact.

Emissions

A certification from the engine manufacturer stating that the engine exhaust emissions meet the federal, state, and local regulations and restrictions specified. At a minimum this certification shall include emission factors for criteria pollutants including nitrogen oxides, carbon monoxide, particulate matter, sulfur dioxide, non-methane hydrocarbon, and for hazardous air pollutants (HPAs).

Sound Limitations

A certification from the manufacturer stating that the sound emissions meet the specification.

Site Visit

A letter stating the date the site was visited and listing discrepancies found.

Current Balance

A certification stating that the flywheel has been statically and dynamically balanced and is capable of being rotated at 125 percent of rated speed without vibration or damage.

Materials and Equipment

A certification stating that where materials or equipment are specified to comply with requirements of UL, written proof of such compliance has been obtained. The label or listing of the specified agency, or a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency are acceptable as proof.

Inspections

A letter certifying that all facilities are complete and functional; that each system is fully functional; and that each item of equipment is complete, free from damage, adjusted, and ready for beneficial use.

Cooling System

Certification that the engine-generator set and cooling system function properly in the ambient temperatures specified.

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

Six copies of the operation manual (approved prior to commencing onsite tests) in 215.9 by 279.4 mm binders, having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section for each system or subsystem. Sections shall be separated by heavy plastic dividers with tabs which identify the material in the section. Drawings shall be folded blue lines, with the title block visible, and placed in 215.9 by 279.4 mm plastic pockets with reinforced holes. One full size reproducible mylar of each drawing shall accompany the booklets. Mylars shall be rolled and placed in a heavy cardboard tube with threaded caps on each end. The manual shall include: step-by-step procedures for system startup, operation, and shutdown; drawings, diagrams, and single-line schematics to illustrate and define the electrical, mechanical, and hydraulic systems together with their controls, alarms, and safety systems; the manufacturer's name, model number, and a description of equipment in the system. Each booklet shall include a CDROM containing an ASCII file of the procedures.

Maintenance Procedures

Six copies of the maintenance manual containing the information described below in 215.9 by 279.4 mm binders having a minimum of

three rings from which material may readily be removed and replaced, including a separate section for each item listed. Each section shall be separated by a heavy plastic divider with tabs. Drawings shall be folded, with the title block visible, and placed in plastic pockets with reinforced holes.

a. Procedures for each routine maintenance item.

b. Procedures for troubleshooting.

c. Factory-service, take-down overhaul, and repair service manuals, with parts lists.

d. A copy of the posted instructions.

e. A component list which includes the manufacturer's name, address, type or style, model or serial number, rating, and catalog number for the major components specified for nameplates.

f. Six complete reproducible copies of the final relay and protective device settings. The settings shall be recorded with the name of the company and individual responsible for their accuracy.

Special Tools

Two complete sets of special tools required for maintenance (except for electronic governor handset). Special tools are those that only the manufacturer provides, for special purposes, or to reach otherwise inaccessible parts. The tools shall be supplied complete with a suitable tool box. One handset shall be provided for each electronic governor when required to indicate and/or change governor response settings.

Filters

Two complete sets of filters, required for maintenance, shall be supplied in a suitable storage box. These filters shall be in addition to filters replaced after testing.

1.4 QUALITY ASSURANCE

1.4.1 Conformance to Codes and Standards

Where equipment is specified to conform to requirements of any code or standard such as UL, NEMA, etc., the design, fabrication and installation shall also conform to the code.

1.4.2 Site Welding

Qualify procedures and welders in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by a previously qualified employer may be accepted as permitted by ASME B31.1. Perform welder qualification tests for each welder whose qualifications are not in compliance with the referenced standards. Notify the Contracting Officer 24 hours in advance of qualification tests which shall be performed at the work site, if practical. The welder or welding operator shall apply the personally assigned symbol near each weld made as a permanent record.

1.4.3 Vibration Limitation

The maximum engine-generator set vibration in the horizontal, vertical, and axial directions shall be limited to 0.15 mm (peak-peak RMS), with an overall velocity limit of 24 mm/second RMS, for all speeds through 110 percent of rated speed.

1.4.4 Seismic Requirements

Seismic requirements shall be in accordance with 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT .

1.4.5 Experience

Each component manufacturer shall have a minimum of 3 years experience in the manufacture, assembly and sale of components used with stationary diesel engine-generator sets for commercial and industrial use. The engine-generator set manufacturer/assembler shall have a minimum of 3 years experience in the manufacture, assembly and sale of stationary diesel engine-generator sets for commercial and industrial use.

1.4.6 Field Engineer

The engine-generator set manufacturer or assembler shall furnish a qualified field engineer to supervise the complete installation of the engine-generator set, assist in the performance of the onsite tests, and instruct personnel as to the operational and maintenance features of the equipment. The field engineer shall have attended the engine generator manufacturer's training courses on installation and operation and maintenance of engine generator sets.

1.4.7 Detailed Drawings

Submit detailed drawings showing the following:

a. Base-mounted equipment, complete with base and attachments, including anchor bolt template and recommended clearances for maintenance and operation.

b. Complete starting system.

c. Complete fuel system.

d. Complete cooling system.

e. Complete exhaust system.

f. Layout of relays, breakers, programmable controllers,switchgear, and switches including applicable single line and wiring diagrams with written description of sequence of operation and the instrumentation provided.

g. The complete lubrication system, including piping, pumps, strainers, filters, heat exchangers for lube oil and turbocharger cooling, electric heater, controls and wiring.

h. Location, type, and description of vibration isolation devices for all applications.

i. The safety system, together with a detailed description of how it is to work. Wiring schematics, safety devices with a listing of their normal ranges, alarm and shutdown values (to include operation parameters such as pressures, temperatures voltages, currents, and speeds) shall be included.

j. One-line schematic and wiring diagrams of the generator, exciter, regulator, governor, and instrumentation.

k. Layout of each panel.

l. Mounting and support for each panel and major piece of electrical equipment.

m. Engine-generator set lifting points and rigging instructions.

1.5 DELIVERY, STORAGE, AND HANDLING

Properly protect material and equipment, in accordance with the manufacturers recommended storage procedures,before, during, and after installation. Protect stored items from the weather and contamination. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

1.6 EXTRA MATERIALS

Submit a complete list of spare parts for each piece of equipment and a complete list of all material and supplies needed for continued operation. Lists shall include supply source and current prices. Separate each list into two parts, those elements recommended by the manufacturer to be replaced after 3 years of service, and the remaining elements.

PART 2 PRODUCTS

2.1 NAMEPLATES

Each major component of this specification shall have the manufacturer's name, type or style, model or serial number and rating on a plate secured to the equipment. As a minimum, nameplates shall be provided for:

Engines	Relays
Generators	Transformers (CT & PT)
Regulators	Day tanks
Pumps and pump motors	Governors
Generator Breaker	Air Starting System
Economizers	Heat exchangers (other than base mounted)

Where the following equipment is not provided as a standard component by the diesel engine generator set manufacturer, the nameplate information may be provided in the maintenance manual in lieu of nameplates.

Battery charger	Heaters
Switchboards	Exhaust mufflers
Switchgear	Silencers
Battery	Exciters

2.2 SAFETY DEVICES

Exposed moving parts, parts that produce high operating temperatures, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. The safety devices shall be installed so that proper operation of the equipment is not impaired.

2.3 MATERIALS AND EQUIPMENT

2.3.1 Filter Elements

Fuel-oil, lubricating-oil, and combustion-air filter elements shall be manufacturer's standard.

2.3.2 Instrument Transformers

NEMA C12.11.

2.3.3 Revenue Metering

IEEE C57.13.

2.3.4 Pipe (Fuel/Lube-Oil, Compressed Air, Coolant, and Exhaust)

ASTM A 53/A 53M, or ASTM A 106/A 106M steel pipe. Pipe smaller than 50 mm shall be Schedule 80. Pipe 50 mm and larger shall be Schedule 40.

a. Flanges and Flanged Fittings: ASTM A 181/A 181M, Class 60, or ASME B16.5, Grade 1, Class 150.

b. Pipe Welding Fittings: ASTM A 234/A 234M, Grade WPB or WPC, Class 150 or ASME B16.11, 1360.7 kg.

c. Threaded Fittings: ASME B16.3, Class 150.

d. Valves: MSS SP-80, Class 150.

e. Gaskets: Manufacturer's standard.

2.3.5 Pipe Hangers

MSS SP-58 and MSS SP-69.

2.3.6 Electrical Enclosures

NEMA ICS 6.

2.3.6.1 Power Switchgear Assemblies

NEMA SG 6.

2.3.6.2 Switchboards

NEMA PB 2.

2.3.6.3 Panelboards

NEMA PB 1.

2.3.7 Electric Motors

Electric motors shall conform to the requirements of NEMA MG 1. Motors shall have sealed ball bearings and a maximum speed of 1500 rpm. Motors used indoors shall have drip-proof frames; those used outside shall be totally enclosed. Alternating current motors larger than 373 W shall be of the squirrel-cage induction type for operation on 230 volts or higher, 50 Hz, and three-phase power. Alternating current motors 373 W or smaller, shall be suitable for operation on 230 volts, 50 Hz, and single-phase power. Direct current motors shall be suitable for operation on 125 volts.

2.3.8 Motor Controllers

Motor controllers and starters shall conform to the requirements of NFPA 70 and NEMA ICS 2.

2.4 ENGINE

Each engine shall operate on No. 2-D diesel fuel conforming to ASTM D 975, shall be designed for stationary applications and shall be complete with ancillaries. The engine shall be a standard production model described in the manufacturer's catalog. The engine shall be naturally aspirated, supercharged, or turbocharged. The engine shall be 2- or 4-stroke-cycle and compression-ignition type. The engine shall be vertical in-line, V- or opposed-piston type, with a solid cast block or individually cast cylinders. The engine shall have a minimum of two cylinders. Opposed-piston type engines shall have not less than four cylinders. Each block shall have a coolant drain port. Each engine shall be equipped with an overspeed sensor.

2.5 FUEL SYSTEM

The entire fuel system for each engine-generator set shall conform to the requirements of NFPA 30 and NFPA 37 and contain the following elements.

2.5.1 Pumps

2.5.1.1 Main Pump

Each engine shall be provided with an engine driven pump. The pump shall supply fuel at a minimum rate sufficient to provide the amount of fuel required to meet the performance indicated within the parameter schedule. The fuel flow rate shall be based on meeting the load requirements and all necessary recirculation.

2.5.1.2 Auxiliary Fuel Pump

Provide auxiliary fuel pumps to maintain the required engine fuel pressure, if either required by the installation or indicated on the drawings. The auxiliary pump shall be driven by a dc electric motor powered by the starting/station batteries. The auxiliary pump shall be automatically actuated by a pressure-detecting device.

2.5.2 Fuel Filter

Provide a minimum of one full-flow fuel filter for each engine. The filter shall be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. The filter shall

have inlet and outlet connections plainly marked.

2.5.3 Relief/Bypass Valve

Provide a relief/bypass valve to regulate pressure in the fuel supply line, return excess fuel to a return line and prevent the build-up of excessive pressure in the fuel system.

2.5.4 Integral Main Fuel Storage Tank

Provide each engine with an integral main fuel tank. Each tank shall be factory installed and provided as an integral part of the diesel generator manufacturer's product. Each tank shall be provided with connections for fuel supply line, fuel return line, local fuel fill port, gauge, vent line, and float switch assembly. A fuel return line cooler shall be provided as recommended by the manufacturer and assembler. The temperature of the fuel returning to the tank shall be below the flash point of the fuel. Each engine-generator set provided with weatherproof enclosures shall have its tank mounted within the enclosure. The fuel fill line shall be accessible without opening the enclosure.

2.5.4.1 Capacity

Each tank shall have capacity as shown at 100 percent rated load without being refilled.

2.5.4.2 Local Fuel Fill

Each local fuel fill port on the day tank shall be provided with a screw-on cap.

2.5.4.3 Fuel Level Controls

Each tank shall have a float-switch assembly to perform the following functions:

a. Activate the "Low Fuel Level" alarm at 70 percent of the rated tank capacity.

b. Activate the "Overfill Fuel Level" alarm at 95 percent of the rated tank capacity.

2.5.4.4 Arrangement

Integral tanks may allow gravity flow into the engine. Gravity flow tanks and any tank that allows a fuel level above the fuel injectors shall be provided with an internal or external factory installed valve located as near as possible to the shell of the tank. The valve shall close when the engine is not operating. Integral day tanks shall be provided with any necessary pumps to supply fuel to the engine as recommended by the generator set manufacturer. The fuel supply line from the tank to the manufacturer's standard engine connection shall be welded pipe.

2.5.5 Day Tank

Each engine shall be provided with integral day tank. Each day tank shall be provided with connections for fuel supply line, fuel overflow line, local fuel fill port, gauge, vent line, drain line, and float switch assembly for control. Each engine-generator set provided with

weatherproof enclosures shall have its day tank mounted within the enclosure. The fuel fill line shall be accessible without opening the enclosure.

2.5.5.1 Capacity, Prime

Each day tank shall have capacity as shown .

2.5.5.2 Capacity, Standby

Each day tank shall have capacity as shown.

2.5.5.3 Drain Line

Each day tank drain line shall be accessible and equipped with a shutoff valve. Self-supporting day tanks shall be arranged to allow drainage into a 305 mm tall bucket.

2.5.5.4 Local Fuel Fill

Each local fuel fill port on the day tank shall be provided with a screw-on cap.

2.5.5.5 Fuel Level Controls

Each day tank shall have a float-switch assembly to perform the following functions:

a. Start the supply of fuel into the day tank when the fuel level is at the "Low" level mark, 75 percent of the rated tank capacity.

b. Stop the supply of fuel into the day tank when the fuel level is at 90 percent of the rated tank capacity.

c. Activate the "Overfill Fuel Level" alarm at 95 percent of the rated tank capacity.

d. Activate the "Low Fuel Level" alarm at 70 percent of the rated tank capacity.

e. Activate the automatic fuel supply shut-off valve located on the fill line of the day tank and shut down the fuel pump which supplies fuel to the day tank at 95 percent of the rated tank capacity. The flow of fuel shall be stopped before any fuel can be forced into the fuel overflow line.

2.5.5.6 Arrangement

Integral day tanks may allow gravity flow into the engine. Gravity flow tanks shall be provided with an internal or external valve located as near as possible to the shell of the tank. The valve shall close when the engine is not operating. Integral day tanks shall be provided with any necessary pumps to supply fuel to the engine as recommended by the generator set manufacturer. The overflow connection and the fuel supply line for integral day tanks which do not rely upon gravity flow shall be arranged so that the highest possible fuel level is below the fuel injectors. When the main fuel storage tanks are located below the day tank, a check valve shall be provided in the fuel supply line entering the day tank. The fuel supply line from the day tank to the manufacturer's

standard engine connection shall be welded pipe.

2.5.6 Fuel Supply System

The fuel supply from the main storage of fuel to the day tank shall be as specified in Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

2.6 LUBRICATION

Each engine shall have a separate lube-oil system conforming to NFPA 30 and NFPA 37. Each system shall be pressurized by engine-driven pumps. System pressure shall be regulated as recommended by the engine manufacturer. A pressure relief valve shall be provided on the crankcase for closed systems. The crankcase shall be vented in accordance with the manufacturer's recommendation except that it shall not be vented to the engine exhaust system. Crankcase breathers, if provided on engines installed in buildings or enclosures, shall be piped to vent to the outside. The system shall be readily accessible for service such as draining, refilling, etc. Each system shall permit addition of oil and have oil-level indication with the set operating. The system shall utilize an oil cooler as recommended by the engine manufacturer.

2.6.1 Lube-Oil Filter

Provide one full-flow filter for each pump. The filter shall be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. The filter shall have inlet and outlet connections plainly marked.

2.6.2 Lube-Oil Sensors

Equip each engine with lube-oil pressure sensors located downstream of the filters and provide signals for required indication and alarms.

2.6.3 Precirculation Pump

Provide a motor-driven precirculation pump powered by the station battery, complete with motor starter, if recommended by the engine manufacturer.

2.7 COOLING SYSTEM

Provide each engine with its own cooling system to operate automatically while its engine is running. The cooling system coolant shall use a combination of water and ethylene-glycol sufficient for freeze protection at the minimum winter outdoor temperature specified. The maximum temperature rise of the coolant across each engine shall not exceed that recommended and submitted in paragraph SUBMITTALS.

2.7.1 Coolant Pumps

Coolant pumps shall be the centrifugal type. Each engine shall have an engine-driven primary pump. Secondary pumps shall be electric motor driven and have automatic controllers. Raw-water circulating pump shall be controlled by manual-off-automatic controllers and shall be electric motor or engine driven.

2.7.2 Heat Exchanger

Each heat exchanger shall be of a size and capacity to limit the maximum

allowable temperature rise in the coolant across the engine to that recommended and submitted in paragraph SUBMITTALS for the maximum summer outdoor design temperature and site elevation. Each heat exchanger shall be corrosion resistant, suitable for service in ambient conditions of application.

2.7.2.1 Fin-Tube-Type Heat Exchanger (Radiator)

Heat exchanger may be factory coated with corrosive resistant film, provided that correction measures are taken to restore the heat rejection capability of the radiator to the initial design requirement via over sizing, or other compensating methods. Internal surfaces shall be compatible with liquid fluid coolant used. Materials and coolant are subject to approval by the Contracting Officer. Heat exchangers shall be pressure type incorporating a pressure valve, vacuum valve and a cap. Caps shall be designed for pressure relief prior to removal. Each heat exchanger and the entire cooling system shall be capable of withstanding a minimum pressure of 48 kPa and shall be protected with a strong grille or screen guard. Each heat exchanger shall have at least two tapped holes; one tapped hole shall be equipped with a drain cock, the rest shall be plugged.

2.7.2.2 Shell and U-Tube Type Heat Exchanger

Heat exchanger shall be multiple pass shell and U-tube type. Exchanger shall operate with low temperature water in the shell and high temperature water in the tubes. Exchangers shall be constructed in accordance with ASME BPVC SEC VIII D1 and certified with ASME stamp secured to the unit. U-tube bundles shall be completely removable for cleaning and tube replacement and shall be free to expand with the shell. Shells shall be constructed of seamless steel pipe or welded steel. Tubes shall be cupronickel or inhibited admiralty, constructed in accordance with ASTM B 395/B 395M, suitable for the temperatures and pressures specified. Tubes shall not be less than 19 mm unless otherwise indicated. Shell side and tube side shall be designed for 1.03 MPa working pressure and factory tested at 2.06 MPa. High and low temperature water and pressure relief connections shall be located in accordance with the manufacturers standard practice. Water connections larger than 75 mm shall be ASME Class 150 flanged. Water pressure loss through clean tubes shall be as recommended by the engine manufacturer. Minimum water velocity through tubes shall be 300 mm/sec and assure turbulent flow. One or more pressure relief valves shall be provided for each heat exchanger in accordance with ASME BPVC SEC VIII D1. The aggregate relieving capacity of the relief valves shall be not less than that required by the above code. Discharge from the valves shall be installed as indicated. The relief valves shall be installed on the heat exchanger shell. A drain connection with 19 mm hose bib shall be installed at the lowest point in the system near the heat exchanger. Additional drain connection with threaded cap or plug shall be installed wherever required for thorough draining of the system.

2.7.3 Expansion Tank

The cooling system shall include an air expansion tank which will accommodate the expanded water of the system generated within the normal operating temperature range, limiting the pressure increase at all components in the system to the maximum allowable pressure at those components. The tank shall be suitable for operating temperature of 121 degrees C and a working pressure of 0.86 MPa. The tank shall be constructed of welded steel, tested and stamped in accordance with

ASME BPVC SEC VIII D1 for the stated working pressure. A bladder type tank shall not used. The tank shall be supported by steel legs or bases for vertical or steel saddles for horizontal installation.

2.7.4 Thermostatic Control Valve

A modulating type, thermostatic control valve shall be provided in the coolant system to maintain the coolant temperature range submitted in paragraph SUBMITTALS.

2.7.5 Ductwork

Ductwork shall be as specified in Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM except that a flexible connection shall be used to connect the duct to the diesel engine radiator. Material for the connection shall be wire-reinforced glass. The connection shall be rendered as airtight as possible.

2.7.6 Temperature Sensors

Each engine shall be equipped with coolant temperature sensors. Temperature sensors shall provide signals for pre-high and high indication and alarms.

2.8 SOUND LIMITATIONS

Maximum sound pressure levels in accordance with European noise directive, 2000/14/EC

15-m, 75% load, 63.4-dBA; 100% load 64.0-dBA

7-m, 75% load, 69.4-dBA; 100% load 70.0-dBA

1-m, 75% load, 79.2-dBA; 100% load 79.9-dBA

2.9 AIR INTAKE EQUIPMENT

Filters and silencers shall be provided in locations that are convenient for servicing. The silencer shall be of the high-frequency filter type, located in the air intake system as recommended by the engine manufacturer. Silencer shall be capable of reducing the noise level at the air intake so that the indicated pressure levels specified in paragraph SOUND LIMITATIONS will not be exceeded. A combined filter-silencer unit meeting requirements for the separate filter and silencer items may be provided. Expansion elements in air-intake lines shall be rubber.

2.10 EXHAUST SYSTEM

The system shall be separate and complete for each engine. Piping shall be supported to minimize vibration. Where a V-type engine is provided, a V-type connector, with necessary flexible sections and hardware, shall connect the engine exhaust outlets.

2.10.1 Flexible Sections and Expansion Joints

A flexible section shall be provided at each engine and an expansion joint at each muffler. Flexible sections and expansion joints shall have flanged connections. Flexible sections shall be made of convoluted seamless tube

without joints or packing. Expansion joints shall be the bellows type. Expansion and flexible elements shall be stainless steel suitable for diesel-engine exhaust gas at the maximum exhaust temperature that is specified by the engine manufacturer. Expansion and flexible elements shall be capable of absorbing vibration from the engine and compensation for thermal expansion and contraction.

2.10.2 Exhaust Muffler

A chamber type exhaust muffler shall be provided. The muffler shall be constructed of welded steel and designed for horizontal mounting. Eyebolts, lugs, flanges, or other items shall be provided as necessary for support in the location and position indicated. Pressure drop through the muffler shall not exceed the recommendations of the engine manufacturer. Outside mufflers shall be zinc coated or painted with high temperature minimum, 100 degrees C, resisting paint. The muffler and exhaust piping together shall reduce the noise level to less than the maximum acceptable level listed for sound limitations in paragraph SOUND LIMITATIONS. The muffler shall have a drain valve, nipple, and cap at the low-point of the muffler.

2.10.3 Exhaust Piping

Horizontal sections of exhaust piping shall be sloped downward away from the engine to a drip leg for collection of condensate with drain valve and cap. Changes in direction shall be long radius. Exhaust piping, mufflers and silencers installed inside any building shall be insulated in accordance with paragraph THERMAL INSULATION and covered to protect personnel. Vertical exhaust piping shall be provided with a hinged, gravity-operated, self-closing, rain cover.

2.11 PYROMETER

A pyrometer, multi-point selector switch, and individual thermocouples and thermocouple with calibrated leads shall be provided to show the temperature in each engine cylinder and the combined exhaust. For a supercharged engine, additional points, thermocouples and leads shall be provided to show the temperature in the turbocharger exhaust gas outlet and combustion air discharge passages. Graduated scale length shall be not less than 150 mm. The selector switch shall be double pole, with an "off" position, one set of points for each thermocouple, and suitable indicating dial. The pyrometer, thermocouples, leads and compensating devices shall be calibrated to show true exhaust temperature within plus or minus 1 percent above the highest temperature encountered at 110 percent load conditions.

2.12 EMISSIONS

The finished installation shall comply with national regulations and restrictions regarding the limits of emissions.

2.13 STARTING SYSTEM

The starting system for engine generator sets used in non-emergency applications shall be as follows.

2.13.1 Controls

An engine control switch shall be provided with functions including:

run/start(manual), off/reset, and, automatic mode. Start-stop logic shall be provided for adjustable cycle cranking and cooldown operation. The logic shall be arranged for fully automatic starting in accordance with paragraph AUTOMATIC ENGINE-GENERATOR-SET SYSTEM OPERATION. Electrical starting systems shall be provided with an adjustable cranking limit device to limit cranking periods from 1 second up to the maximum duration.

2.13.2 Capacity

The starting system shall be of sufficient capacity, at the maximum outdoor summer temperature specified to crank the engine without damage or overheating. The system shall be capable of providing a minimum of three cranking periods with 15 second intervals between cranks. Each cranking period shall have a maximum duration of 15 seconds.

2.13.3 Electrical Starting

Manufacturers recommended dc system, utilizing a negative circuit ground.

2.13.3.1 Battery

A starting battery system shall be provided and shall include the battery, battery rack, intercell connectors, spacers, automatic battery charger with overcurrent protection, metering and relaying. The battery shall be in accordance with SAE J537. Critical system components (rack, protection, etc.) shall be sized to withstand the seismic acceleration forces specified. The battery shall be lead-acid, with sufficient capacity, at the minimum outdoor and maximum outdoor temperature specified, to provide the specified cranking periods. Valve-regulated lead-acid batteries are not acceptable.

2.13.3.2 Battery Charger

A current-limiting battery charger, conforming to UL 1236, shall be provided and shall automatically recharge the batteries. The charger shall be capable of an equalize-charging rate for recharging fully depleted batteries within 24 hours and a floating charge rate for maintaining the batteries at fully charged condition. An ammeter shall be provided to indicate charging rate. A voltmeter shall be provided to indicate charging voltage. A timer shall be provided for the equalize-charging-rate setting. A battery is considered to be fully depleted when the output voltage falls to a value which will not operate the engine generator set and its components.

2.13.4 Starting Aids

The manufacturer shall provide one or more of other following methods to assist engine starting.

2.13.4.1 Glow Plugs

Glow plugs shall be designed to provide sufficient heat for combustion of fuel within the cylinders to guarantee starting at an ambient temperature of -32 degrees C.

2.13.4.2 Jacket-Coolant Heaters

A thermostatically controlled electric heater shall be mounted in the engine coolant jacketing to automatically maintain the coolant within plus

or minus 1.7 degrees C of the control temperature. The heater shall operate independently of engine operation so that starting times are minimized. Power for the heaters shall be 230 volts ac.

a. Prime Rated Sets: The control temperature shall be the higher of the manufacturer's recommended temperature or the minimum coolant inlet temperature of the engine recommended in paragraph SUBMITTALS.

b. Standby Rated Sets: The control temperature shall be the temperature recommended by the engine manufacturer to meet the starting time specified at the minimum winter outdoor temperature.

2.13.4.3 Lubricating-Oil Heaters

A thermostatically controlled electric heater shall be mounted in the engine lubricating-oil system to automatically maintain the oil temperature within plus or minus 1.7 degrees C of the control temperature. The heater shall operate independently of engine operation so that starting times are minimized. Power for the heaters shall be 230 volts ac.

2.14 GOVERNOR

Each engine shall be provided with a governor which maintains the frequency within a bandwidth of the rated frequency, over a steady-state load range of zero to 100 percent of rated output capacity. The governor shall be configured for safe manual adjustment of the speed/frequency during operation of the engine-generator set, without special tools, from 90 to 110 percent of the rated speed/frequency, over a steady state load range of 0 to 100 percent or rated capacity. Isochronous governors shall maintain the midpoint of the frequency bandwidth at the same value for steady-state loads over the range of zero to 100 percent of rated output capacity.

2.15 GENERATOR

Each generator shall be of the synchronous type, one or two bearing, conforming to the performance criteria in NEMA MG 1, equipped with winding terminal housings in accordance with NEMA MG 1, equipped with an amortisseur winding, and directly connected to the engine. Insulation shall be Class H. Generator design shall protect against mechanical, electrical and thermal damage due to vibration, 25 percent overspeeds, or voltages and temperatures at a rated output capacity of 110 percent for prime applications and 100 percent for standby applications. Generator ancillary equipment shall meet the short circuit requirements of NEMA MG 1. Frames shall be the drip-proof type.

2.15.1 Current Balance

At 100 percent rated output capacity, and load impedance equal for each of the 3 phases, the permissible current difference between any 2 phases shall not exceed 2 percent of the largest current on either of the 2 phases.

2.15.2 Voltage Balance

At any balanced load between 75 and 100 percent of rated output capacity, the difference in line-to-neutral voltage among the 3 phases shall not exceed 1 percent of the average line-to-neutral voltage. For a single-phase load condition, consisting of 25 percent load at unity power factor placed between any phase and neutral with no load on the other 2 phases, the maximum simultaneous difference in line-to-neutral voltage

between the phases shall not exceed 3 percent of rated line to neutral voltage. The single-phase load requirement shall be valid utilizing normal exciter and regulator control. The interpretation of the 25 percent load for single phase load conditions means 25 percent of rated current at rated phase voltage and unity power factor.

2.15.3 Waveform

The deviation factor of the line-to-line voltage at zero load and at balanced rated output capacity shall not exceed 10 percent. The RMS of all harmonics shall be less than 5.0 percent and that of any one harmonic less than 3.0 percent of the fundamental at rated output capacity. Each engine-generator shall be designed and configured to meet the total harmonic distortion limits of IEEE Std 519.

2.16 EXCITER

The generator exciter shall be of the brushless type. Semiconductor rectifiers shall have a minimum safety factor of 300 percent for peak inverse voltage and forward current ratings for all operating conditions, including 110 percent generator output at 4O degrees C ambient. The exciter and regulator in combination shall maintain generator-output voltage within the limits specified.

2.17 VOLTAGE REGULATOR

Each generator shall be provided with a solid-state voltage regulator, separate from the exciter. The regulator shall maintain the voltage within a bandwidth of the rated voltage, over a steady-state load range of zero to 100 percent of rated output capacity. Regulator shall be configured for safe manual adjustment of the engine-generator voltage output without special tools, during operation, from 90 to 110 percent of the rated voltage over the steady state load range of 0 to 100 percent of rated output capacity. Regulation drift shall not exceed plus or minus 0.5 percent for an ambient temperature change of 20 degrees C. Reactive droop compensation or reactive differential compensation shall load share the reactive load proportionally between sets during parallel operation. The voltage regulator shall have a maximum droop of 2 percent of rated voltage over a load range from 0 to 100 percent of rated output capacity and automatically maintain the generator output voltage within the specified operational bandwidth.

2.18 GENERATOR ISOLATION AND PROTECTION

Devices necessary for electrical protection and isolation of each engine-generator set and its ancillary equipment shall be provided. The generator circuit breaker (IEEE Device 52) ratings shall be consistent with the generator rated voltage and frequency, with continuous, short circuit withstand, and interrupting current ratings to match the generator capacity. The generator circuit breaker shall be manually operated. A set of surge capacitors, to be mounted at the generator terminals shall be provided. Monitoring and control devices shall be as specified in paragraph GENERATOR PANEL.

2.18.1 Switchboards

Switchboards shall be free-standing, metal-enclosed, general purpose, 3-phase, 4-wire, 600 volt rated, with neutral bus and continuous ground bus, conforming to NEMA PB 2 and UL 891. Neutral bus and ground bus

capacity shall be full capacity. Panelboards shall conform to NEMA PB 1. Enclosure designs, construction, materials and coatings shall be suitable for the application and environment. Bus continuous current rating shall be at least equal to the generator rating and correspond to the UL listed current ratings specified for panelboards and switchboards. Current withstand (short circuit rating) shall be equal to the breaker interrupting rating. Buses shall be copper.

2.18.2 Devices

Switches, circuit breakers, switchgear, fuses, relays, and other protective devices shall be as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

2.19 SAFETY SYSTEM

Devices, wiring, remote panels, local panels, etc. shall be provided and installed as a complete system to automatically activate the appropriate signals and initiate the appropriate actions. The safety system shall be provided with a self-test method to verify its operability. Alarm signals shall have manual acknowledgment and reset devices. The alarm signal systems shall reactivate for new signals after acknowledgment is given to any signal. The systems shall be configured so that loss of any monitoring device shall be dealt with as an alarm on that system element.

2.19.1 Audible Signal

The audible alarm signal shall sound at a frequency of 70 Hz at a volume of 75 dB at 3.1 m. The sound shall be continuously activated upon alarm and silenced upon acknowledgment. Signal devices shall be located as shown.

2.19.2 Visual Signal

The visual alarm signal shall be a panel light. The light shall be normally off, activated to be blinking upon alarm. The light shall change to continuously lit upon acknowledgement. If automatic shutdown occurs, the display shall maintain activated status to indicate the cause of failure and shall not be reset until cause of alarm has been cleared and/or restored to normal condition. Shutdown alarms shall be red; all other alarms shall be amber.

2.19.3 Alarms and Action Logic

2.19.3.1 Shutdown

Simultaneous activation of the audible signal, activation of the visual signal, stopping the engine, and opening the generator main circuit breakers shall be accomplished.

2.19.3.2 Problem

Activation of the visual signal shall be accomplished.

2.19.4 Local Alarm Panel

A local alarm panel shall be provided with the following shutdown and alarm functions as indicated and including the listed Corps of Engineer requirements mounted either on or adjacent to the engine generator set.

Device/Condition /Function	What/Where/Size	NFPA 99	NFPA 110 Level 1	NFPA 110 Level 2	Corps of Engrs Required
Shutdowns w/Alarms					
High engine temperature	Automatic/jacket/ water/cylinder	SD/CP VA	SD/CP VA	SD/CP VA	SD VA
Low lube-oil pressure	Automatic/pressure/ level	SD/CP VA	SD/CP VA	SC/CP VA	SD VA
Overspeed Shutdown& Alarm	(110 percent (± 2 percent of rated speed)	SD/CP VA	SD/CP VA	SD/CP VA	SD VA
Overcrank, Failure to start	Automatic/Failure to start	SD/CP VA	SD/CP VA	SD/CP VA	
	when used		SD/CP VA	SD/CP VA	
Air shutdown damper (200-600kW)	When Used		SD/CP VA	SD/CP VA	
Day tank overfill limit indication & transfer pump shutdown (95 percent volume)	Automatic/Day Tank/Level				SD(Pump) CP VA
Red emergency stop switch	Manual Switch		SD/CP VA	SD/CP VA	SD VA
Alarms					
Day Tank integral main fuel storage tank (Low fuel Limit indication) (70 percent volume remaining)	Automatic/Day Tank Level				CP VA
Low fuel level	Main tank, 3 hrs remaining	VA/AA	CP VA	CP VAO	CP VA
Integral Main Fuel Storage Tank High Fuel Level	95 percent volume				CP VA
Low Coolant Temperature	jacket water	CP VA	CP VA	CP VA	
Pre-High					

Device/Condition /Function	What/Where/Size	NFPA 99	NFPA 110 Level 1	NFPA 110 Level 2	Corps of Engrs Required
Temperature	jacket water/ cylinder	CP VA	CP VA	CP VAO	CP VA
Pre-Low Lube-oil Pressure		CP VA			CP VA
High battery Voltage			CP VA	CP VAO	
Low battery Voltage			CP VA	CP VAO	
Battery charger AC Failure	AC supply not available		CP VA	CP VAO	
Control switch not in AUTO			CP VA	CP VAO	
Low starting Air pressure			CP VA	CP VAO	
Low starting hydraulic pressure			CP VA	CP VAO	

SD - Shut Down
CP - On Control Panel
VA - Visual Alarm
AA - Audible Alarm
O - Optional

2.19.5 Time-Delay on Alarms

For startup of the engine-generator set, time-delay devices shall be installed bypassing the low lubricating oil pressure alarm during cranking, and the coolant-fluid outlet temperature alarm. The lube-oil time-delay device shall return its alarm to normal status after the engine starts. The coolant time-delay device shall return its alarm to normal status 5 minutes after the engine starts.

2.19.6 Remote Alarm Panel

Provide a remote alarm panel as indicated. and as follows.

Device/Condition/Function	What/Where/Size	NFPA 99	NFPA 110 Level 1	NFPA 110 Level 2
Remote annunciator panel	Battery Powered		Alarms	
Loads on genset		VA		
Battery charger malfunction		VA		
Low lube-oil	Pressure/level	VA/AA	AA	AAO
Low temperature	Jacket water	VA/AA	AA	AAO
High temperature	Jacket water/ cylinder	VA/AA	AA	AAO
Low fuel level	Main tank, 3 hrs remaining	VA/AA	AA	AAO

Device/Condition/Function	What/Where/Size	NFPA 99	NFPA 110 Level 1	NFPA 110 Level 2
Overcrank	Failure to start	VA/AA	AA	AAO
Overspeed		VA/AA	AA	AAO
Pre-high temperature	Jacket water/ cylinder		AA	
Control switch not in AUTO			AA	
Common alarm contacts for local & remote common alarm			X	X
Audible alarm silencing switch			X	O
Air shutdown damper	When used		AA	AAO
Common fault alarm			AA	

X - Required
SD - Shutdown
CP - On Control Panel
VA - Visual Alarm
AA - Audible Alarm
O - Optional

2.20 ENGINE GENERATOR SET CONTROLS AND INSTRUMENTATION

Devices, wiring, remote panels, local panels, etc. shall be provided and installed as a complete system to automatically activate the appropriate signals and initiate the appropriate actions.

2.20.1 Controls

Provide a local control panel with controls as indicated mounted as indicated. Provide a remote control panel with devices as indicated.

Device/Condition/ Function	Corps Requirement	NFPA 110 Level 1	NFPA 110 Level 2	MFG Offering
Controls				
Switch: run/start - off/reset - auto	CP			CP/STD
Emergency stop switch & alarm	CP			CP/STD
Lamp test/indicator test	CP	CP VA	CP VA	CP/STD
Common alarm contacts/ fault relay		X	X	CP/O
Panel lighting	CP			CP/STD
Audible alarm & silencing/reset switch	CP			
Voltage adjust for voltage regulator	CP			CP/STD
Pyrometer display w/selector switch	CP			
Remote emergency stop switch		CP VA	CP VA	
Remote fuel shutoff switch				
Remote lube-oil shutoff switch				

2.20.2 Engine Generator Set Metering and Status Indication

Provide a local panel with devices fully redundant to the local control panel.

Device/Condition/ Function	Corps Requirement	NFPA 110 Level 1	NFPA 110 Level 2	MFG Offering
Genset Status & Metering				
Genset supplying load		CP VA	CP VAO	CP VAO
System ready				CP/STD
Engine oil pressure	CP			CP/STD
Engine coolant temperature	CP			CP/STD
Engine RPM (tachometer)	CP			CP/STD
Engine run hours	CP			CP/STD
Pyrometer display w/selector switch	CP			
AC volts (generator), 3-phase	CP			CP/STD
AC amps (generator), 3 - phase	CP			CP/STD
Generator Frequency	CP			CP/STD
Phase selector switches (amps & volts)	CP			CP/STD
Watts/kW				CP/VA-O
Voltage Regulator Adjustment	CP			

X - Required

CP - On Control Panel
VA - Visual Alarm
AA - Audible Alarm
STD- Manufacturers Standard Offering
O - Optional

2.21 SYNCHRONIZING PANEL

The panel shall be as specified in paragraph PANELS and shall provide controls, gauges, meters, and displays to include:

a. Frequency meters, dial type, with a range of 90 to 110 percent of rated frequency. Vibrating-reed type meters shall not be used. One shall monitor generator output frequency ("Generator Frequency Meter") and the other shall monitor the frequency of the parallel source ("Bus Frequency Meter").

b. Voltmeters, ac, dial type, 3-phase, with 4-position selector switch for the generator output ("Generator Volt Meter") and for the parallel power source ("Bus volt meter").

c. Automatic synchronizer.

d. Manual synchronizing controls.

e. Indicating lights for supplementary indication of synchronization.

f. Synchroscope.

g. Wattmeter, indicating.

2.22 PANELS

Each panel shall be of the type and kind necessary to provide specified functions. Panels shall be mounted on the engine-generator set base by vibration/shock absorbing type mountings. Instruments shall be mounted flush or semiflush. Convenient access to the back of panels shall be provided to facilitate maintenance. Instruments shall be calibrated using recognized industry calibration standards. Each panel shall be provided with a panel identification plate which clearly identifies the panel function. Each instrument and device on the panel shall be provided with a plate which clearly identifies the device and its function as indicated. Switch plates shall clearly identify the switch-position function.

2.22.1 Enclosures

Enclosures shall be designed for the application and environment, conforming to NEMA ICS 6. Locking mechanisms shall be keyed alike.

2.22.2 Analog

Analog electrical indicating instruments shall be in accordance with ANSI C39.1 with semiflush mounting. Switchboard, switchgear, and control-room panel-mounted instruments shall have 250 degree scales with an accuracy of not less than 99 percent. Unit-mounted instruments shall be the manufacturer's standard with an accuracy of not less than 98 percent. The instrument's operating temperature range shall be minus 20 to plus 65 degrees C. Distorted generator output voltage waveform of a crest factor less than 5 shall not affect metering accuracy for phase voltages, hertz and amps.

2.22.3 Electronic

Electronic indicating instruments shall be true RMS indicating instruments, 100 percent solid state, state-of-the-art, microprocessor controlled to provide specified functions. Control, logic, and function devices shall be compatible as a system, sealed, dust and water tight, and shall utilize modular components with metal housings and digital instrumentation. An interface module shall be provided to decode serial link data from the electronic panel and translate alarm, fault and status conditions to set of relay contacts. Instrument accuracy shall be not less than 98 percent for unit mounted devices and 99 percent for control room, panel mounted devices, throughout a temperature range of minus 20 to plus 65 degrees C. Data display shall utilize LED or back lit LCD. Additionally, the display shall provide indication of cycle programming and diagnostic codes for troubleshooting. Numeral height shall be 13 mm.

2.22.4 Parameter Display

Indication or readouts of the tachometer, lubricating-oil pressure, ac voltmeter, ac ammeter, frequency meter, and safety system parameters shall be provided. A momentary switch shall be specified for other panels.

2.23 AUTOMATIC ENGINE-GENERATOR-SET SYSTEM OPERATION

Fully automatic operation shall be provided for the following operations: engine-generator set starting and load transfer upon loss of normal source; retransfer upon restoration of the normal source; sequential starting; paralleling, and load-sharing for multiple engine-generator sets; and stopping of each engine-generator set after cool-down. Devices shall automatically reset after termination of their function.

2.24 MANUAL ENGINE-GENERATOR-SET SYSTEM OPERATION

Complete facilities shall be provided for manual starting and testing of each set without load, loading and unloading of each set, and synchronization of each set with an energized bus.

2.25 STATION BATTERY SYSTEM

A station battery system shall be provided to include the battery, battery rack, spacers, automatic battery charger and distribution panelboard with overcurrent protection, metering and relaying. Components shall be sized to withstand the seismic acceleration forces specified. The batteries shall have a rated life of 20 years and a manufacturer's 5-year, no cost replacement guarantee.

2.25.1 Battery

The battery shall be lead-acid, sized in accordance with IEEE Std 485 and conform to the requirements of IEEE Std 484. Valve-regulated lead-acid batteries are not acceptable.The battery environment temperature shall range between -10 C and 40 C degrees. The battery shall be rated for at least 60 ampere hours at the 8-hour rate.

2.25.2 Battery Charger

A current-limiting, 24-volt battery charger shall be furnished to automatically recharge the batteries. The charger shall be capable of an equalize charging rate for recharging fully depleted batteries within 8 hours which is continuously adjustable and a floating-charge rate for maintaining the batteries in a fully charged condition. The charger shall be equipped with a low-voltage alarm relay, 0- to 24-hour equalizing timer, an ammeter to indicate charging rate, and necessary circuit breakers. The charger shall conform to the requirements of UL 1236. A battery is considered to be fully depleted when the voltage falls to a level incapable of operating the equipment loads served by the battery.

2.26 BASE

The base shall be constructed of steel. The base shall be designed to rigidly support the engine-generator set, ensure permanent alignment of rotating parts, be arranged to provide easy access to allow changing of lube-oil, and ensure that alignment is maintained during shipping and normal operation. The base shall permit skidding in any direction during installation and shall withstand and mitigate the affects of synchronous vibration of the engine and generator. The base shall be provided with suitable holes for anchor bolts.

2.27 PAINTING AND FINISHING

The engine-generator set shall be cleaned, primed and painted in accordance

with the manufacturer's standard color and practice.

2.28 FACTORY INSPECTION AND TESTS

Perform the factory tests on each engine-generator set. The component manufacturer's production line test is acceptable as noted. Each engine-generator set shall be run not less than 1 hour at rated output capacity prior to inspections. Inspections shall be completed and all necessary repairs made, prior to testing. Engine generator controls and protective devices that are provided by the generator set manufacturer as part of the standard package shall be used for factory tests. When controls and switchgear are not provided as part of the generator set manufacturer's standard package, the actual controls and protective devices provided for the project are not required to be used during the factory test. The Contracting Officer may provide one or more representatives to witness inspections and tests.

2.28.1 Factory Inspection

Inspections shall be performed prior to beginning and after completion of testing of the assembled engine-generator set. Inspectors shall look for leaks, looseness, defects in components, proper assembly, etc. and any item found to be in need of correction shall be noted as a necessary repair. The following checklist shall be used for the inspection:

INSPECTION ITEM	GOOD	BAD	NOTES
1. Drive belts			
2. Governor and adjustments			
3. Engine timing mark			
4. Starting motor			
5. Starting aids			
6. Coolant type and concentration			
7. Radiator drains			
8. Block coolant drains			
9. Coolant fill level			
10. All coolant line connections			
11. All coolant hoses			
12. Combustion air filter			
13. Combustion air silencer			
14. Lube oil type			
15. Lube oil sump drain			
16. Lube-oil filter			
17. Lube-oil-level indicator			
18. Lube-oil-fill level			
19. All lube-oil line connections			
20. All lube-oil lines			
21. Fuel type and amount			
22. All fuel-line connections			
23. All fuel lines			
24. Fuel filter			
25. Coupling and shaft alignment			
26. Voltage regulators			
27. Battery-charger connections			
28. All wiring connections			
29. Instrumentation			
30. Hazards to personnel			
31. Base			
32. Nameplates			

33. Paint
34. Exhaust-heat recovery unit
35. Switchboard
36. Switchgear

2.28.2 Factory Tests

On engine-generator set tests where the engine and generator are required to be connected and operated together, the load power factor shall be the power factor specified in the engine generator set parameter schedule. For engine-generator set with dual-fuel operating capability the following tests shall be performed using the primary fuel type. Electrical measurements shall be performed in accordance with IEEE Std 120. Definitions of terms are in accordance with IEEE Std 100. Temperature limits in the rating of electrical equipment and for the evaluation of electrical insulation shall be in accordance with IEEE Std 1. In the following tests where measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.), stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. Tests specifically for the generator may be performed utilizing any prime mover.

a. Insulation Resistance for Stator and Exciter Test, IEEE Std 115 and IEEE Std 43, to the performance criteria in NEMA MG 1, Part 22. Generator manufacturer's production line test is acceptable.

b. High Potential Test, in accordance with IEEE Std 115 and NEMA MG 1, test voltage in accordance with NEMA MG 1. Generator manufacturer's production line test is acceptable.

c. Winding Resistance Test, Stator and Exciter, in accordance with IEEE Std 115. Generator manufacturer's production line test is acceptable.

d. Overspeed Vibration Test, in accordance with IEEE Std 115 to the performance criteria in NEMA MG 1. The test shall be performed at 110 percent of rated speed for 5 minutes. The vibration shall be measured at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Vibration amplitude and speed shall be recorded at one minute intervals.

e. Phase Balance Voltage Test, to the performance criteria specified in paragraph GENERATOR. This test can be performed with any prime mover. Generator manufacturer's production line test results are acceptable.

(1) Start and operate the generator at no load.

(2) Adjust a regulated phase voltage (line-to-neutral) to rated voltage.

(3) Read and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(4) Apply 75 percent rated load and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(5) Apply rated load and record the generator frequency,

line-to-neutral voltages, and the line-to-line voltages.

(6) Calculate average line-neutral voltage and percent deviation of individual line-neutral voltages from average for each load condition.

f. Current Balance on Stator Winding Test, by measuring the current on each phase of the winding with the generator operating at 100 percent of Rated Output Capacity, with the load impedance equal for each of the three phases: to the performance criteria specified in paragraph GENERATOR.

g. Voltage Waveform Deviation and Distortion Test in accordance with IEEE Std 115 to the performance criteria specified in paragraph GENERATOR. High-speed recording instruments capable of recording voltage waveform deviation and all distortion, including harmonic distortion shall be used. Representation of results shall include appropriate scales to provide a means to measure and interpret results.

h. Voltage and Frequency Droop Test. Verify that the output voltage and frequency are within the specified parameters as follows:

(1.) With the generator operating at no load, adjust voltage and frequency to rated voltage and frequency. Record the generator output frequency and line-line and line-neutral voltages.

(2.) Increase load to Rated Output Capacity. Record the generator output frequency and line-line and line-neutral voltages.

3. Calculate the percent droop for voltage and frequency with the following equations:

$$\text{Voltage droop percent} = \frac{\text{(No-Load Volts)} - \text{(Rated Capacity volts)}}{\text{(Service-Load Volts)}} \times 100$$

$$\text{Frequency droop percent} = \frac{\text{(No-Load Hertz)} - \text{(Rated Capacity hertz)}}{\text{(Service-Load hertz)}} \times 100$$

4. Repeat steps 1 through 3 two additional times without making any adjustments.

i. Frequency and Voltage Stability and Transient Response. Verify that the engine-generator set responds to addition and dropping of blocks of load in accordance with the transient response requirements. Document maximum voltage and frequency variation from bandwidth and verify that voltage and frequency return to and stabilize within the specified bandwidth, within the specified response time period. Document results in tabular form and with high resolution, high speed strip chart recorders or comparable digital recorders, as approved by the Contracting Officer. Tabular data shall include the following:

1. Ambient temperature (at 15 minute intervals).

2. Generator output current (before and after load changes).

3. Generator output voltage (before and after load changes).

4. Frequency (before and after load changes).

5. Generator output power (before and after load changes).

6. Graphic representations shall include the actual instrument trace of voltage and frequency showing: charts marked at start of test; observed steady-state band; mean of observed band; momentary overshoot and undershoot (generator terminal voltage and frequency) and recovery time for each load change together with the voltage and frequency maximum and minimum trace excursions for each steady state load condition prior to and immediately following each load change. Generator terminal voltage and frequency transient recovery time for each step load increase and decrease.

(1.) Perform and record engine manufacturer's recommended prestarting checks and inspections.

(2.) Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period and no load. Verify stabilization of voltage and frequency within specified bandwidths.

(3.) With the unit at no load, apply the Maximum Step Load Increase.

(4.) Apply load in steps equal to the Maximum Step Load Increase until the addition of one more step increase will exceed the Service Load.

(5.) Decrease load to the unit such that addition of the Maximum Step Load Increase will load the unit to 100 percent of Service Load.

(6.) Apply the Maximum Step Load Increase.

(7.) Decrease load to zero percent in steps equal to the Maximum Step Load Decrease.

(8.) Repeat steps 3. through 7.

j. Test Voltage Unbalance with Unbalanced Load (Line-to-Neutral) to the performance criteria specified in paragraph GENERATOR. Prototype test data is acceptable in lieu of the actual test. This test may be performed using any prime mover.

(1.) Start and operate the generator set at rate voltage, no load, rated frequency, and under control of the voltage regulator. Read and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(2.) Apply the specified load between terminals L_1-L_2, L_2-L_0, and L_3-L_0 in turn. Record all instrument readings at each line-neutral condition.

(3.) Express the greatest difference between any two of the line-to-line voltages and any two of the line-to-neutral voltages as a percent of rated voltage.

(4.) Compare the largest differences expressed in percent with the maximum allowable difference specified.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the job, perform a Site Visit to verify the information shown on the drawings, before performing any work. Notify the Contracting Officer in writing of any discrepancies.

3.2 GENERAL INSTALLATION

Installation shall provide clear space for operation and maintenance in accordance with NFPA 70 and IEEE C2. Installation of pipe, duct, conduit, and ancillary equipment shall be configured to facilitate easy removal and replacement of major components and parts of the engine-generator set.

3.3 PIPING INSTALLATION

Piping shall be welded. Connections at valves shall be flanged. Connections at equipment shall be flanged except that connections to the diesel engine may be threaded if the diesel-engine manufacturers standard connection is threaded. Except where otherwise specified, welded flanged fittings shall be utilized to allow for complete dismantling and removal of each piping system from the facility without disconnecting or removing any portion of any other system's equipment or piping. Connections to equipment shall be made with vibration-isolation-type flexible connectors. Piping and tubing shall be supported and aligned to prevent stressing of flexible hoses and connectors. Pipes extending through the roof shall be properly flashed. Piping shall be installed clear of windows, doors and openings, to permit thermal expansion and contraction without damage to joints or hangers, and shall be installed with a 13 mm drain valve with cap at each low point.

3.3.1 Support

Hangers, inserts, and supports shall be of sufficient size to accommodate any insulation and shall conform to MSS SP-58 and MSS SP-69. Supports shall be spaced not more than 2.1 m on center for pipes 50 mm in diameter or less, not more than 3.6 m on center for pipes larger than 50 mm but smaller than 100 mm in diameter, and not more than 5.2 m on center for pipes larger than 100 mm in diameter. Supports shall be provided at pipe bends or change of direction.

3.3.1.1 Ceiling and Roof

Exhaust piping shall be supported with appropriately sized Type 41 single pipe roll and threaded rods; all other piping shall be supported with appropriately sized Type 1 clevis and threaded rods.

3.3.1.2 Wall

Wall supports for pipe shall be made by suspending the pipe from appropriately sized Type 33 brackets with the appropriate ceiling and roof pipe supports.

3.3.2 Flanged Joints

Flanges shall be Class 125 type, drilled, and of the proper size and configuration to match the equipment and diesel engine connections. Flanged joints shall be gasketed and made up square and tight.

3.3.3 Cleaning

After fabrication and before assembly, piping interiors shall be manually wiped clean of debris.

3.3.4 Pipe Sleeves

Pipes passing through construction such as ceilings, floors, or walls shall be fitted with sleeves. Each sleeve shall extend through and be securely fastened in its respective structure and shall be cut flush with each surface. The structure shall be built tightly to the sleeve. The inside diameter of each sleeve shall be minimum 13 mm, and where pipes pass through combustible materials 25 mm larger than the outside diameter of the passing pipe or pipe insulation/covering.

3.4 ELECTRICAL INSTALLATION

Electrical installation shall comply with NFPA 70, IEEE C2, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. For vibration isolation, flexible fittings shall be provided for conduit, cable trays, and raceways attached to engine-generator sets; metallic conductor cables installed on the engine generator set and from the engine generator set to equipment not mounted on the engine generator set shall be flexible stranded conductor; and terminations of conductors on the engine generator set shall be crimp-type terminals or lugs.

3.5 FIELD PAINTING

Field painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.6 ONSITE INSPECTION AND TESTS

3.6.1 Test Conditions

3.6.1.1 Data

Measurements shall be made and recorded of all parameters necessary to verify that each set meets specified parameters. If the results of any test step are not satisfactory, adjustments, replacements, or repairs shall be made and the step repeated until satisfactory results are obtained. Unless otherwise indicated, data shall be recorded in 15 minute intervals during engine-generator set operation and shall include: readings of all engine-generator set meters and gauges for electrical and power parameters; oil pressure; ambient temperature; and engine temperatures available from meters and gauges supplied as permanent equipment on the engine-generator set.Electrical measurements shall be performed in accordance with IEEE Std 120. Definitions of terms are in accordance with IEEE Std 100. Temperature limits in the rating of electrical equipment and for the evaluation of electrical insulations shall be in accordance with IEEE Std 1.

3.6.1.2 Power Factor

For all engine-generator set operating tests the load power factor shall be 0.8 power factor.

3.6.1.3 Contractor Supplied Items

Provide equipment and supplies required for inspections and tests including fuel, test instruments, and loadbanks at the specified power factors.

3.6.1.4 Instruments

Readings of panel gauges, meters, displays, and instruments provided as permanent equipment shall be verified during test runs, using test instruments of greater precision and accuracy. Test instrument accuracy shall be within the following: current plus or minus 1.5 percent, voltage plus or minus 1.5 percent, real power plus or minus 1.5 percent, reactive power plus or minus 1.5 percent, power factor plus or minus 3 percent, frequency plus or minus 0.5 percent. Test instruments shall be calibrated by a recognized standards laboratory within 30 days prior to testing.

3.6.1.5 Sequence

The sequence of testing shall be as specified in the approved testing plan unless variance is authorized by the Contracting Officer. Field testing shall be performed in the presence of the Contracting Officer. Tests may be scheduled and sequenced in order to optimize run-time periods; however, the following general order of testing shall be followed: Construction Tests; Inspections; Pre-operational Tests; Safety Run Tests; Performance Tests; and Final Inspection.

3.6.2 Construction Tests

Individual component and equipment functional tests for fuel piping, coolant piping, and lubricating-oil piping, electrical circuit continuity, insulation resistance, circuit protective devices, and equipment not provided by the engine-generator set manufacturer shall be performed prior to connection to the engine-generator set.

3.6.2.1 Piping Test

a. Lube-oil and fuel-oil piping shall be flushed with the same type of fluid intended to flow through the piping, until the outflowing fluid has no obvious sediment or emulsion.

b. Fuel piping which is external to the engine-generator set shall be tested in accordance with NFPA 30. All remaining piping which is external to the engine-generator set shall be pressure tested with air pressure at 150 percent of the maximum anticipated working pressure, but not less than 1.03 MPa, for a period of 2 hours to prove the piping has no leaks. If piping is to be insulated, the test shall be performed before the insulation is applied.

3.6.2.2 Electrical Equipment Tests

a. Low-voltage cable insulation integrity tests shall be performed for cables connecting the generator breaker to the distribution bus. Low-voltage cable, complete with splices, shall be tested for insulation resistance after the cables are installed, in their final

configuration, ready for connection to the equipment, and prior to energization. The test voltage shall be 500 volts dc, applied for one minute between each conductor and ground and between all possible combinations conductors in the same trench, duct, or cable, with all other conductors in the same trench, duct, or conduit. The minimum value of insulation shall be:

1. R in megohms = (rated voltage in kV + 1) x 304,800/(length of cable in meters)

2. R in megohms = (rated voltage in kV + 1) x 1000/(length of cable in feet)

3. Each cable failing this test shall be repaired or replaced. The repair cable shall be retested until failures have been eliminated.

b. Medium-voltage cable insulation integrity tests shall be performed for cables connecting the generator breaker to the generator switchgear. After installation and before the operating test or connection to an existing system, the medium-voltage cable system shall be given a high potential test. Direct-current voltage shall be applied on each phase conductor of the system by connecting conductors as one terminal and connecting grounds of metallic shieldings or sheaths of the cable as the other terminal for each test. Prior to making the test, the cables shall be isolated by opening applicable protective devices and disconnecting equipment. The test shall be conducted with all splices, connectors, and terminations in place. The method, voltage, length of time, and other characteristics of the test for initial installation shall be in accordance with NEMA WC 74 for the particular type of cable installed, except that 28kV and 35kV insulation test voltages shall be in accordance with either AEIC CS8 or AEIC CS8 as applicable, and shall not exceed the recommendations of IEEE Std 404 cable joints and IEEE Std 48 for cable terminations unless the cable and accessory manufacturers indicate higher voltages are acceptable for testing. Should any cable fail due to a weakness of conductor insulation or due to defects or injuries incidental to the installation or because of improper installation of cable, cable joints, terminations, or other connections, make necessary repairs or replace cables as directed. Repaired or replaced cables shall be retested.

c. Ground-Resistance Tests. The resistance of each grounding electrode systemthe ground ring shall be measured using the fall-of-potential method defined in IEEE Std 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the requirements resistance, but the specified number of electrodes must still be provided as follows:

(1.) Single rod electrode - 25 ohms.

(2.) Multiple rod electrodes - 10 ohms.

d. Circuit breakers and switchgear shall be examined and tested in accordance with the manufacturer's published instructions for functional testing.

3.6.3 Inspections

Perform the following inspections jointly by the Contracting Officer and the Contractor, after complete installation of each engine-generator set and its associated equipment, and prior to startup of the engine-generator set. Checks applicable to the installation shall be performed. The results of those which are physical inspections (I) shall be documented and submitted in accordance with paragraph SUBMITTALS. Present manufacturer's data for the inspections designated (D) at the time of inspection. Inspections shall verify that equipment type, features, accessibility, installation and condition are in accordance with the contract specification. Manufacturer's statements shall certify provision of features which cannot be verified visually.

1. Drive belts. (I)
2. Governor type and features. (I)
3. Engine timing mark. (I)
4. Starting motor. (I)
5. Starting aids. (I)
6. Coolant type and concentration. (D)
7. Radiator drains. (I)
8. Block coolant drains. (I)
9. Coolant fill level. (I)
10. Coolant line connections. (I)
11. Coolant hoses. (I)
12. Combustion air filter. (I)
13. Intake air silencer. (I)
14. Lube oil type. (D)
15. Lube oil sump drain. (I)
16. Lube-oil filter. (I)
17. Lube-oil level indicator. (I)
18. Lube-oil fill level. (I)
19. Lube-oil line connections. (I)
20. Lube-oil lines. (I)
21. Fuel type. (D)
22. Fuel-level. (I)
23. Fuel-line connections. (I)
24. Fuel lines. (I)
25. Fuel filter. (I)
26. Access for maintenance. (I)
27. Voltage regulator. (I)
28. Battery-charger connections. (I)
29. Wiring & terminations. (I)
30. Instrumentation. (I)
31. Hazards to personnel. (I)
32. Base. (I)
33. Nameplates. (I)
34. Paint. (I)
35. Exhaust-heat system. (I)
36. Exhaust muffler. (I)
37. Switchboard. (I)
38. Switchgear. (I)
39. Access provided to controls. (I)
40. Enclosure is weather resistant. (I)
41. Engine & generator mounting bolts (application). (I)

3.6.4 Pre-operational Tests

3.6.4.1 Protective Relays

Protective relays shall be visually and mechanically inspected, adjusted, tested, and calibrated in accordance with the manufacturer's published instructions. Tests shall include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Relay settings shall be implemented in accordance with the installation coordination study. Relay contacts shall be manually or electrically operated to verify that the proper breakers and alarms initiate. Relaying current transformers shall be field tested in accordance with IEEE C57.13.1.

3.6.4.2 Insulation Test

Generator and exciter circuits insulation resistance shall be tested in accordance with IEEE Std 43. Stator readings shall be taken at the circuit breaker, to include generator leads to switchboard. Results of insulation resistance tests shall be recorded. Readings shall be within limits specified by the manufacturer. Mechanical operation, insulation resistance, protective relay calibration and operation, and wiring continuity of switchboard assembly shall be verified. Precautions shall be taken to preclude damaging generator components during test.

3.6.4.3 Engine-Generator Connection Coupling Test

When the generator provided is a two-bearing machine, the engine-generator connection coupling shall be inspected and checked by dial indicator to prove that no misalignment has occurred. The dial indicator shall measure variation in radial positioning and axial clearance between the coupling halves. Readings shall be taken at four points, spaced 90 degrees apart. Solid couplings and pin-type flexible couplings shall be aligned within a total indicator reading of 0.012 to 0.025 mm for both parallel and angular misalignment. For gear-type or grid-type couplings, 0.05 mm will be acceptable.

3.6.5 Safety Run Test

For the following tests, if any parts are changed, or adjustments made to the generator set, its controls, or auxiliaries, the associated safety tests shall be repeated.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections.

b. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

c. Activate the manual emergency stop switch and verify that the engine stops.

d. Remove the high and pre-high lubricating oil temperature sensing elements from the engine and temporarily install a temperature gauge in their normal locations on the engine (required for safety, not for recorded data). Where necessary provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.

e. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period. Operate the engine-generator set at no load until the output voltage and frequency stabilize. Monitor the temporarily installed temperature gauges. If either temperature reading exceeds the value required for an alarm condition, activate the manual emergency stop switch.

f. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on the engine.

g. Remove the high and pre-high coolant temperature sensing elements from the engine and temporarily install a temperature gauge in their normal locations on the engine (required for safety, not for recorded data). Where necessary provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.

h. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period. Operate the engine generator-set at no load until the output voltage and frequency stabilize.

i. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on the engine.

j. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

k. Operate the engine generator-set for at least 2 hours at 75 percent of Service Load.

l. Verify proper operation and setpoints of gauges and instruments.

m. Verify proper operation of ancillary equipment.

n. Manually adjust the governor to increase engine speed past the overspeed limit. Record the RPM at which the engine shuts down.

o. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75 percent of Service Load.

p. Manually adjust the governor to increase engine speed to within 2 percent of the overspeed trip speed previously determined and operate at that point for 5 minutes. Manually adjust the governor to the rated frequency.

q. Manually fill the day tank to a level above the overfill limit. Record the level at which the overfill alarm sounds. Verify shutdown of the fuel transfer pump. Drain the day tank down below the overfill limit.

r. Shut down the engine. Remove the time-delay low lube oil pressure alarm bypass and try to start the engine.

s. Attach a manifold to the engine oil system (at the oil pressure sensor port) that contains a shutoff valve in series with a connection for the engine's oil pressure sensor followed by an oil pressure gauge ending with a bleed valve. The engine's oil pressure sensor shall be moved from the engine to the manifold. The manifold shutoff valve shall be open and bleed valve closed.

t. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75 percent of Service Load.

u. Close the manifold shutoff valve. Slowly allow the pressure in the manifold to bleed off through the bleed valve while watching the pressure gauge. Record the pressure at which the engine shuts down. Catch oil spillage from the bleed valve in a container. Add the oil from the container back to the engine, remove the manifold, and reinstall the engine's oil pressure sensor on the engine.

v. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 100 percent of Service Load. Record the maximum sound level in each frequency band at a distance of 22.9 m from the end of the exhaust and air intake piping directly along the path of intake and discharge for horizontal piping; or at a radius of 10.7 m from the engine at 45 degrees apart in all directions for vertical piping. If a sound limiting enclosure is provided, the enclosure, the muffler, and intake silencer shall be modified or replaced as required to meet the sound requirements contained within this specification.

w. Manually drain off fuel slowly from the day tank to empty it to below the low fuel level limit and record the level at which the audible alarm sounds. Add fuel back to the day tank to fill it above low level alarm limits.

3.6.6 Performance Tests

In the following tests, where measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.), stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. For the following tests, if any parts are changed, or adjustments made to the generator set, its controls, or auxiliaries, the associated tests shall be repeated.

3.6.6.1 Continuous Engine Load Run Test

Test the engine-generator set and ancillary systems at service load to demonstrate durability; verify that heat of extended operation does not adversely affect or cause failure in any part of the system; and check all parts of the system. If the engine load run test is interrupted for any reason, the entire test shall be repeated. The engine load run test shall be accomplished principally during daylight hours, with an average ambient temperature of 30 degrees C, during the month of July. After each change

in load in the following test, measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the allowable range. Data taken at 15 minute intervals shall include the following:

Electrical: Output amperes, voltage, real and reactive power, power factor, frequency.

Pressure: Lube-oil.

Temperature: Coolant, Lube-oil, Exhaust, Ambient.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections. Include as a minimum checking of coolant fluid, fuel, and lube-oil levels.

b. Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warmup period.

c. Operate the engine generator-set for 2 hours at 75 percent of Service Load.

d. Increase load to 100 percent of Service Load and operate the engine generator-set for 4 hours.

e. For prime rated units, increase load to 110 percent of Service Load and operate the engine generator-set for 2 hours.

f. Decrease load to 100 percent of Service Load and operate the engine generator-set for 2 hours or until all temperatures have stabilized.

g. Remove load from the engine-generator set.

3.6.6.2 Voltage and Frequency Droop Test

For the following steps, verify that the output voltage and frequency return to and stabilize within the specified bandwidth values following each load change. Record the generator output frequency and line-line and line-neutral voltages following each load change.

a. With the generator operating at no load, adjust voltage and frequency to rated voltage and frequency.

b. Increase load to 100 percent of Rated Output Capacity. Record the generator output frequency and line-line and line-neutral voltages.

c. Calculate the percent droop for voltage and frequency with the following equations.

$$\text{Voltage droop percent} = \frac{\text{No-load volts} - \text{rated output capacity volts}}{\text{Rated output capacity volts}} \times 100$$

$$\text{Frequency droop percent} = \frac{\text{No load hertz} - \text{rated output capacity hertz}}{\text{Rated output capacity volts}} \times 100$$

d. Repeat steps a. through c. two additional times without making any adjustments.

3.6.6.3 Voltage Regulator Range Test

a. While operating at no load, verify that the voltage regulator adjusts from 90 to 110 percent of rated voltage.

b. Increase load to 100 percent of Rated Output Capacity. Verify that the voltage regulator adjusts from 90 to 110 percent of rated voltage.

3.6.6.4 Governor Adjustment Range Test

a. While operating at no load, verify that the governor adjusts from 90 to 110 percent of rated frequency.

b. Increase load to 100 percent of Rated Output Capacity. Verify that the governor adjusts from 90 to 110 percent of rated frequency.

3.6.6.5 Frequency and Voltage Stability and Transient Response

Verify that the engine-generator set responds to addition and dropping of blocks of load in accordance with the transient response requirements. Document maximum voltage and frequency variation from bandwidth and verify that voltage and frequency return to and stabilize within the specified bandwidth, within the specified response time period. Document results in tabular form and with high resolution, high speed strip chart recorders or comparable digital recorders, as approved by the Contracting Officer. Tabular data shall include the following:

(1.) Ambient temperature (at 15 minute intervals).

(2.) Generator output current (before and after load changes).

(3.) Generator output voltage (before and after load changes).

(4.) Frequency (before and after load changes).

(5.) Generator output power (before and after load changes.

(6.) Graphic representations shall include the actual instrument trace of voltage and frequency showing:

Charts marked at start of test; observed steady-state band; mean of observed band; momentary overshoot and undershoot (generator terminal voltage and frequency) and recovery time for each load change together with the voltage and frequency maximum and minimum trace excursions for each steady state load condition prior to and immediately following each load change. Generator terminal voltage and frequency transient recovery time for each step load increase and decrease.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections.

b. Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period and no load. Verify stabilization of voltage and frequency within specified bandwidths.

c. With the unit at no load, apply the Maximum Step Load Increase.

d. Apply load in steps equal to the Maximum Step Load Increase until the addition of one more step increase will exceed the Service Load.

e. Decrease load to the unit such that addition of the Maximum Step Load Increase will load the unit to 100 percent of Service Load.

f. Apply the Maximum Step Load Increase.

g. Decrease load to zero percent in steps equal to the Maximum Step Load Decrease.

h. Repeat steps c. through g.

3.6.7 Parallel Operation Test

Test the capability of each engine-generator set to parallel and share load with other generator sets, individually and in all combinations. This test must be performed with the voltage regulator and governor adjustment settings used for the Frequency and Voltage Stability and Transient Response test. If settings are changed during the performance of this test, a voltage and frequency stability and transient response test must be performed for each engine generator set using the setting utilized in this test. During operations record load-sharing characteristics of each set in parallel operation. Data taken shall include the following:

(1.) Ambient temperature (at 15 minute intervals).

(2.) Generator output current (before and after load changes).

(3.) Generator output voltage (before and after load changes).

(4.) Power division and exchange between generator sets.

(5.) Real power (watts) and reactive power (vars) on each set.

3.6.7.1 Combinations

Connect each set, while operating at no load, parallel with one other set in the system, operating at service load, until all possible two-unit-in-parallel combinations have been achieved. Verify stabilization of voltage and frequency within specified bandwidths and proportional sharing of real and reactive loads. Document stabilization of voltage and frequency within specified bandwidth, the active power division, active power exchange, reactive power division, and voltage and frequency stability and transient response in the following steps for each combination.

a. Divide the load proportionally between the sets and operate in parallel for 15 minutes.

b. Increase the load, in steps equal to the Maximum Step Increase, until each set is loaded to its service load.

c. Decrease the load, in steps equal to the Maximum Step Decrease, until each set is loaded to approximately 25 percent of its service load.

d. Increase the load, in steps equal to the Maximum Step Increase, until each set is loaded to approximately 50 percent of its service load Verify stabilization of voltage and frequency within specified bandwidths and proportional sharing of real and reactive load.

e. Reduce the sum of the loads on both sets to the output rating of the smaller set.

f. Transfer a load equal to the output rating of the smaller of the 2 sets to and from each set. Verify stabilization of voltage and frequency within specified bandwidths and proportional sharing of real and reactive load.

g. Document the active power division, active power exchange, reactive power division, and voltage and frequency stability and transient response.

3.6.7.2 Multiple Combinations

Connect each set, while operating at no load, parallel with all multiple combinations of all other set in the system, while operating at service load, until all multiple combinations of parallel operations have been achieved.

3.6.8 Parallel Operation Test (Commercial Source)

Connect each set parallel with the commercial power source. Operate in parallel for 15 minutes. Verify stabilization of voltage and frequency within specified bandwidths. Record the output voltage, frequency, and loading to demonstrate ability to synchronize with the commercial power source.

3.6.9 Automatic Operation Tests

Test the automatic operating system to demonstrate automatic starting, loading and unloading, the response to loss of operating engine-generator sets, and paralleling of each engine-generator set. The loads for this test shall utilize load banks at the indicated power factor and actual loads to be served, and the loading sequence shall be the indicated sequence. During all operations load-sharing characteristics shall be recorded. Perform this test for a minimum of two successive, successful tests. Data taken shall include the following:

(1.) Ambient temperature (at 15 minute intervals).

(2.) Generator output current (before and after load changes).

(3.) Generator output voltage (before and after load changes).

(4.) Generator output frequency (before and after load changes).

(5.) Power division and exchange between generator sets.

(6.) Real and reactive power on each set.

a. Initiate loss of the preferred power source and verify the specified sequence of operation.

b. Verify resetting of automatic starting and transfer logic.

3.6.10 Automatic Operation Tests for Stand-Alone Operation

Test the automatic loading system to demonstrate automatic starting, and loading and unloading of each engine-generator set. The loads for this test shall utilize the actual loads to be served, and the loading sequence shall be the indicated sequence. Perform this test for a minimum of two successive, successful tests. Data taken shall include the following:

(1.) Ambient temperature (at 15 minute intervals).

(2.) Generator output current (before and after load changes).

(3.) Generator output voltage (before and after load changes).

(4.) Generator output frequency (before and after load changes).

a. Initiate loss of the primary power source and verify automatic sequence of operation.

b. Restore the primary power source and verify sequence of operation.

c. Verify resetting of controls to normal.

3.6.11 Fuel Consumption Tests

Perform fuel consumption tests to confirm the manufacturer's certified rates on engine generator set and tabulate and average the results. Fuel consumption tests shall be conducted under the direct supervision of the engine manufacturer's representative. Fuel consumption readings shall be taken at 15 minute intervals, over a minimum period of 1 hour at 50 percent Service Load, 1 hour at 75 percent Service Load, and 4 hours at 100 percent Service Load. Fuel consumption data may be taken during the 75 percent load test and 100 percent load tests. Fuel consumption readings at site conditions shall be correlated to the guarantee-baseline conditions. Test report shall contain: readings of the output frequency, voltage, current, power factor, and power; barometric pressure; ambient temperature; intake-air temperature; fuel temperature; the site fuel consumption readings, adjustment calculations, factors, and source references for correlation of actual consumption rate of the guaranteed rate.

a. Start and operate the generator set and allow it to stabilize at rated load, rated voltage and rated frequency. During this period, readings of all instruments including thermal instrumentation shall be recorded at minimum intervals of 10 minutes. If necessary, adjustments to the load, voltage and frequency may be made to maintain rated load at rated voltage and rated frequency. However, adjustments to the voltage and frequency shall be limited to those adjustments available to the operator, specifically adjustments to the voltage or frequency adjust devices. On generator sets utilizing a droop-type speed control system as the prime speed control, the speed and droop portions of the control may be adjusted. No other adjustments to the voltage and frequency control systems shall be made unless permitted by the procurement document. Adjustments to the load, voltage or frequency controls shall be recorded on the data sheet. Unless otherwise specified in the procurement document, stabilization will be consideration to have occurred when four consecutive voltage and current recorded readings of the generator (or exciter) field either remain unchanged or have only minor variations about an equilibrium

condition with no evident continued increase or decrease in value after the last adjustment to the load, voltage or frequency has been made.

b. Perform one of the following procedures:

BALANCE SCALE PROCEDURE.

(1.) Supply fuel from auxiliary container mounted on a balance scale.

(2.) After stabilization has occurred, set the balance weights at any convenient value slightly less than the total weight of the fuel and container.

(3.) Start the stopwatch when the balance weights fall and record the total weight.

(4.) Reduce the balance weight a convenient amount and record the amount of the weights removed.

(5.) Stop the stopwatch when the balance weights fall and record the total weight and the elapsed time.

(6.) Repeat steps (1) thru (2) above until the timed portion of the test exceeds the 2 hours.

(7.) From the total elapsed time and total of the weights removed calculate the fuel consumption in terms of pounds per hour.

(8.) Using the value obtained in step (7) above, compute the rate of fuel consumption per kilowatt hour, as follows:

$$\text{Pounds per kWH} = \frac{\text{Fuel Consumption in Pounds per Hour}}{\text{kW Load}}$$

(9.) Repeat the test for each load condition specified.

(10.) Determine the capacity of the generator set fuel tank in pounds of fuel.

(11.) For each specified load, compute the number of continuous hours the generator set will operate on a full tank of fuel. The following formula shall be used.

$$\text{Operating hours} = \frac{\text{Fuel Tank Capacity (Pounds)}}{\text{Fuel Consumption (Pounds per hour)}}$$

ALTERNATE PROCEDURE FOR WEIGHING FUEL

(1.) Supply fuel from the auxiliary fuel container, mounted on a platform balance, or other weighing device.

(2.) After stabilization has occurred, record weight readings every one-half hour for a period of 2 hours.

(3.) Calculate the average hourly fuel consumption rate in pounds per hour.

(4.) Using the average hourly fuel consumption rate obtained

above, compute the rate of fuel consumption per kilowatt hour, as follows:

$$\text{Pounds per kWH} = \frac{\text{Fuel Consumption}}{\text{kW Load}}$$

(5.) Repeat test for each load condition specified.

(6.) Determine the capacity of the generator set fuel tank in pounds of fuel.

(7.) for each specified load test, compute the number of continuous ours the generator set will operate on a full tank of fuel. The following formula shall be used:

$$\text{Operating Hours} = \frac{\text{Fuel Tank Capacity (Pounds)}}{\text{Fuel Consumption (Pounds per Hour)}}$$

ALTERNATE PROCEDURE USING FLOWMETER.

Flowmeters may be used to determine the fuel rate. They usually are calibrated in either gallons per hour, or pounds per hour, for a fuel of a definite specific gravity and temperature.

(1.) After stabilization has occurred record the fuel consumption rate, and continue to record the fuel consumption rate at one-half hour intervals for 2 hours.

(2.) Determine the average of the readings (correct for fuel specific gravity and temperature). This is the fuel consumption rate and should be converted, if necessary, to pounds per hour.

(3.) Using the average value obtained above, calculate the rate of fuel consumption per kilowatt hour.

(4.) Repeat the test for each load condition specified.

(5.) Determine the capacity of the generator set fuel tank in pounds of fuel.

(6.) For each specified load test, compute the number of continuous hours the generator set will operate on a full tank of fuel. The following formula shall be used:

$$\text{Operating Hours} = \frac{\text{Fuel Tank Capacity (Pounds)}}{\text{Fuel Consumption (Pounds per Hour)}}$$

c. Results. Compare the operating hours or the fuel consumption rate per kWH.

3.7 ONSITE TRAINING

Conduct training course for operating staff as designated by the Contracting Officer. The training period shall consist of a total 8 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance. All operation and maintenance manuals shall bee approved and made available for the training course. All posted instructions shall be approved and posted prior to the beginning date of the training course. The training course schedule shall be

coordinated with the Using Service's work schedule, and submitted for approval 14 days prior to beginning date of proposed beginning date of training. The course instructions shall cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as major elements of the operation and maintenance manuals. Additionally, the course instructions shall demonstrate routine maintenance procedures as described in the operation and maintenance manuals. Two copies of a video tape of the manufacturers operating and maintenance training course shall be submitted.

3.8 FINAL TESTING AND INSPECTION

a. Start the engine, record the starting time, make and record all engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

b. Increase the load in steps no greater than the Maximum Step Load Increase to 100 percent of Service Load, and operate the engine-generator set for at least 30 minutes. Measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the same range as previous measurements and is within the required range.

c. Remove load and shut down the engine-generator set after the recommended cool down period.

d. Remove the lube oil filter and have the oil and filter examined by the engine manufacturer for excessive metal, abrasive foreign particles, etc. Any corrective action shall be verified for effectiveness by running the engine for 8 hours at Service Load, then re-examining the oil and filter.

e. Remove the fuel filter and examine the filter for trash, abrasive foreign particles, etc.

f. Visually inspect and check engine and generator mounting bolts for tightness and visible damage.

g. Replace air, oil, and fuel filters with new filters.

3.9 POSTED DATA AND INSTRUCTIONS

Posted Data and Instructions shall be posted prior to field acceptance testing of the engine generator set. Two sets of instructions/data shall be typed and framed under weatherproof laminated plastic, and posted side-by-side where directed. First set shall include a one-line diagram, wiring and control diagrams and a complete layout of the system. Second set of shall include the condensed operating instructions describing manufacturer's pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions. Instructions shall include procedures for interrelated equipment (such as heat recovery systems, co-generation, load-shedding, and automatic transfer switches).

3.10 ACCEPTANCE

Final acceptance of the engine-generator set will not be given until the

Contractor has successfully completed all tests and all defects in installation material or operation have been corrected.

-- End of Section --

SECTION 26 51 00.00 40

INTERIOR LIGHTING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

CALIFORNIA ENERGY COMMISSION (CEC)

CEC Title 24	(1978; R 2005) California's Energy Efficiency Standards for Residential and Nonresidential Buildings

ILLUMINATING ENGINEERING SOCIETY OF NORTH AMERICA (IESNA)

IESNA HB-9	(2000; Errata 2004; Errata 2005; Errata 2006) IES Lighting Handbook

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2007; TIA 2007-1; TIA 2007-2; TIA 2007-3; TIA 2007-4; TIA 2007-5) National Electrical Safety Code
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C78.1381	(1998) American National Standard for Electric Lamps - 250-Watt, 70 Watt, M85 Metal-Halide Lamps
ANSI C82.11	(Consolidated 2002) American National Standard for High-Frequency Fluorescent Lamp Ballasts--Supplements
ANSI C82.4	(2002) American National Standard for Ballasts for High-Intensity-Discharge and Low-Pressure Sodium (LPS) Lamps (Multiple-Supply Type)
ANSI/ANSLG C78.43	(2007) American National Standard for Electric Lamps - Single-Ended Metal-Halide

	Lamps
ANSI/IEC C78.81	(2005) American National Standard for Electric Lamps--Double-Capped Fluorescent Lamps--Dimensional and Electrical Characteristics
ANSI/IEC C78.901	(2005) American National Standard for Electric Lamps - Single Base Fluorescent Lamps--Dimensional and Electrical Characteristics
ANSI/NEMA C78.LL 1256	(2003) Procedures for Fluorescent Lamp Sample Preparation and the Toxicity Characteristic Leaching Procedure (TCLP)
NEMA 250	(2008) Enclosures for Electrical Equipment (1000 Volts Maximum)
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)	
NFPA 70	(2008; AMD 1 2008) National Electrical Code
NFPA 90A	(2009; Errata 09-1) Standard for the Installation of Air Conditioning and Ventilating Systems
U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)	
Energy Star	(1992; R 2006) Energy Star Energy Efficiency Labeling System
UNDERWRITERS LABORATORIES (UL)	
UL 1029	(1994; R 2001 thru 2009) Standard for High-Intensity-Discharge Lamp Ballasts
UL 1598	(2008; R 2006 thru 2010) Luminaires
UL 844	(2006; R 2006 thru 2008) Standard for Luminaires for Use in Hazardous (Classified) Locations
UL 935	(2001; R 2006 thru 2009) Standard for Fluorescent-Lamp Ballasts

1.2 RELATED REQUIREMENTS

Materials not considered to be lighting equipment or lighting fixture accessories are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Lighting fixtures and accessories mounted on exterior surfaces of buildings are specified in this section.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE 100.

b. Average life is the time after which 50 percent has failed and 50 percent has survived under normal conditions.

c. Total harmonic distortion (THD) is the root mean square (RMS) of all the harmonic components divided by the total fundamental current.

1.4 SUBMITTALS

Contractor shall submit the following using submittal procedures as specified in the Contract Documents.

Employ the terminology, classifications, and methods prescribed by the IESNA HB-9, as applicable, for the lighting system specified in data, drawings, and reports.

SD-02 Shop Drawings

Submit Fabrication Drawings for the following items consisting of fabrication and assembly details to be performed in the factory.

Commercial Incandescent Lighting Fixtures

Industrial Incandescent Lighting Fixtures

Enclosed and Gasketed Vapor-Tight Fixtures

Incandescent Lamps

Lowering Devices

Submit Installation Drawings for the incandescent lighting fixtures in accordance with the paragraph entitled, "Installation," of this section.

SD-03 Product Data

Fluorescent lighting fixtures

Fluorescent electronic ballasts

Fluorescent electromagnetic ballasts

Fluorescent lamps

High-intensity-discharge (HID) lighting fixtures

HID ballasts

High-pressure sodium (HPS) lamps

Low-pressure sodium lamps

Metal-halide lamps

Incandescent lighting fixtures

Incandescent lamps

Power hook fixture hangers

Electronic dimming ballast

Dimming ballast controls

Light Level Sensor

Environmental Data

Energy Efficiency

Submit Equipment and Performance Data for incandescent lighting fixtures in accordance with paragraph entitled, "Related Requirements," of this section.

Submit Manufacturer's catalog data for the following items:

Commercial Incandescent Lighting Fixtures

Industrial Incandescent Lighting Fixtures

Enclosed and Gasketed Vapor-Tight Fixtures

Incandescent Lamps

Lowering Devices

SD-04 Samples

Lighting fixtures, complete with lamps and ballasts

SD-06 Test Reports

Operating test

Submit test results as stated in paragraph entitled "Field Quality Control."

Submit Test reports for Operational Tests on incandescent lighting fixtures in accordance with the paragraph entitled, "Field Testing," of this section.

SD-10 Operation and Maintenance Data

Lighting Control System

Submit operation and maintenance data in accordance with the Contract Documents and as specified herein, showing all light fixtures, control modules, control zones, occupancy sensors, light level sensors, power packs, dimming ballasts, schematic diagrams and all interconnecting control wire, conduit, and associated hardware.

Operational Service

Submit documentation that includes contact information, summary of procedures, and the limitations and conditions applicable to the project. Indicate manufacturer's commitment to reclaim materials for recycling and/or reuse.

1.5 QUALITY ASSURANCE

1.5.1 Fluorescent Electronic Ballasts

Submit ballast catalog data as required in the paragraph entitled "Fluorescent Lamp Electronic Ballasts" contained herein. As an option, submit the fluorescent fixture manufacturer's electronic ballast specification information in lieu of the actual ballast manufacturer's catalog data. Include published specifications and sketches, which cover the information required by the paragraph entitled "Fluorescent Lamp Electronic Ballasts" herein. This information may be supplemented by catalog data if required, containing a list of vendors with vendor part numbers.

1.5.2 Lighting Fixtures, Complete With Lamps and Ballasts

Submit one sample of each fixture type for inspection, review, and approval. Retain the sample for comparison against the remainder of the fixtures. The sample may be used in the final fixture installation.

1.5.3 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the USAID Implementing Partner. Provide equipment, materials, installation, and workmanship in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.5.4 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship,which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period includes applications of equipment and materials under similar circumstances and of similar size, on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.4.1 Alternative Qualifications

Products having less than a 2-year field service record are acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.4.2 Material and Equipment Manufacturing Date

Do not use products manufactured more than 3 years prior to date of delivery to site, unless specified otherwise.

1.5.4.3 Energy Efficiency

Comply with National Energy Policy Act and Energy Star requirements for lighting products. Submit data indicating lumens per watt efficiency and color rendition index of light source.

1.6 WARRANTY

Support the equipment items with service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.6.1 Electronic Ballast Warranty

Furnish the electronic ballast manufacturer's warranty, for not less than 5 years from the date of manufacture of the electronic ballast. Ballast assembly in the lighting fixture, transportation, and on-site storage is not to exceed 12 months, thereby permitting 4 years of the ballast 5 year warranty to be in service and energized. State in the warranty that the manufacturer agrees to exchange a malfunctioning ballast and promptly ship the replacement to the using Government facility,said replacement ballast being identical to, or an improvement upon, the original design of the malfunctioning ballast.

1.7 OPERATIONAL SERVICE

Coordinate with manufacturer for take-back program for services which reclaim materials for recycling and/or reuse. Collect information from the manufacturer about green lease options, and submit to USAID Implementing Partner. Placement into landfills or burning of reclaimed materials is not allowed. Indicate procedures for compliance with regulations governing disposal of mercury. When such a service is not available, seek out local recyclers to reclaim the materials.

PART 2 PRODUCTS

2.1 PRODUCT STANDARDS

Provide incandescent lighting fixtures conforming to UL 1598. Provide fixtures in hazardous areas conforming to UL 844.

Furnish lighting fixtures completely assembled with wiring and mounting devices and ready for installation at the locations noted. Design and equip recessed fixtures in suspended ceilings for installation in the type of ceiling in which the fixture is to be installed. Design fixtures to be supported independent of the ceiling. Equip fixtures with the lamps required.

2.2 FLUORESCENT LIGHTING FIXTURES

Provide fluorescent fixtures, conforming to UL 1598 with electronic ballasts unless specifically indicated otherwise.

2.2.1 Fluorescent Lamp Electronic Ballasts

Provide electronic ballasts, meeting as a minimum, the following characteristics:

a. Provide ballasts complying with UL 935, ANSI C82.11, NFPA 70, and CEC Title 24 unless specified otherwise. Provide 100 percent electronic high frequency type ballasts with no magnetic core and coil components, which provide transient immunity as recommended by IEEE C62.41.1 and IEEE C62.41.2. Design ballast for the wattage of the lamps used in the indicated application. Design ballasts to operate on the voltage system to which they are connected.

b. A power factor of 0.95 (minimum).

c. Operates at a frequency of 20,000 Hertz (minimum), and is compatible with and not cause interference with the operation of occupancy sensors or other infrared control systems. Provide ballasts operating at or above 40,000 Hertz where available.

d. Light regulation of plus or minus 10 percent lumen output with a plus or minus 10 percent input voltage regulation. Ensure ballasts have 10 percent flicker (maximum) using any compatible lamp.

e. A ballast factor between 0.85 (minimum) and 1.00 (maximum). Current crest factor - 1.7 (maximum).

f. UL listed Class P with a sound rating of "A."

g. Include circuit diagrams and lamp connections displayed on the ballast.

h. Provide instant start ballasts unless otherwise indicated, with programmed start where indicated. Provide instant start ballasts which operate lamps in a parallel circuit configuration that permits the operation of remaining lamps if one or more lamps fail or are removed.

i. Provide programmed start ballasts for compact fluorescent fixtures.

j. Provide ballasts for T-5 and smaller lamps with end-of-life protection circuits as required by ANSI/IEC C78.81 and ANSI/IEC C78.901 as applicable.

k. Provide ballasts capable of starting and maintaining operation at a minimum of -17 degrees C unless otherwise indicated.

l. Provide electronic ballasts with a full replacement warranty of 5 years from date of manufacture as specified in paragraph entitled "Electronic Ballast Warranty" herein.

2.2.1.1 T-8 Lamp Ballast

a. Total harmonic distortion (THD): 20 percent (maximum).

b. Input wattage.

1. 32 watts (maximum) when operating one F32T8 lamp

2. 62 watts (maximum) when operating two F32T8 lamps

3. 92 watts (maximum) when operating three F32T8 lamps

4. 114 watts (maximum) when operating four F32T8 lamps

c. Ballast efficacy factor.

1. 2.54 (minimum) when operating one F32T8 lamp

2. 1.44 (minimum) when operating two F32T8 lamps

3. 0.93 (minimum) when operating three F32T8 lamps

4. 0.73 (minimum) when operating four F32T8 lamps

d. Provide three and four lamp fixtures with two ballasts per fixture where multilevel switching is indicated.

2.2.1.2 F17T8 Lamp Ballast

Provide F17T8 ballasts with:

a. Total harmonic distortion (THD): 25 percent (maximum).

b. Input wattage:

1. 34 watts (maximum) when operating two F17T8 lamps.

2.2.1.3 T-5 Long Twin Tube Lamp Ballast

a. Total harmonic distortion (THD): No greater than 25 percent when operating one lamp, 15 percent when operating two lamps, and 20 percent when operating three lamps.

b. Input wattage:

1. 45 watts (maximum) when operating one F40 T-5 lamps

2. 74 watts (maximum) when operating two F40 T-5 lamps

3. 105 watts (maximum) when operating three F40 T-5 lamps

c. Provide three and four lamp fixtures with two ballasts per fixture where multilevel switching is indicated.2.2.1.4 F96T8 Lamp Ballast

a. Total harmonic distortion (THD): No greater than 30 percent when operating one lamp and 20 percent when operating two lamps.

b. Input wattage:

1. 56 watts (maximum) when operating one F96T8 lamps

2. 102 watts (maximum) when operating two F96T8 lamps

2.2.2 Fluorescent Lamp Electronic Dimming Ballast

Provide electronic ballasts meeting as a minimum, the following characteristics:

a. Compliance with ANSI C82.11, UL 935, and NFPA 70, unless specified otherwise. Provide transient immunity as recommended by IEEE C62.41.1 and IEEE C62.41.2. Ballast dimming capability range - from 100 to 5

percent (minimum range) of light output, flicker free, and starts lamp at any preset light output setting without first having to go to full light output. Design ballast for the wattage of the lamps used in the indicated application. Design ballasts to operate on the voltage system to which they are connected.

b. Power factor of 0.95 (minimum) at full light output, and 0.90 (minimum) over the entire dimming range.

c. Operates at a frequency of 20,000 Hertz (minimum), and is compatible with and not cause interference with the operation of occupancy sensors or other infrared control systems. Provide ballasts operating at or above 40,000 Hertz where available.

d. Ballast factor at full light output is between 0.85 (minimum) and 1.00 (maximum). Current crest factor is 1.7 (maximum).

e. UL listed Class P with a sound rating of "A".

f. includes circuit diagrams and lamp connections displayed on the ballast.

g. Provide programmed start ballasts. Ballast may operate lamps in a series circuit configuration. Provide series/parallel wiring for programmed start ballasts where available.

h. Provide programmed start ballasts for compact fluorescent fixtures.

i. Ballast is capable of starting and maintaining operation at a minimum of 17 degrees C unless otherwise indicated.

j. Total harmonic distortion (THD): 20 percent (maximum) over the entire dimming range.

k. Provide ballasts for T-5 and smaller lamps with end-of-life protection circuits as required by ANSI/IEC C78.81 and ANSI/IEC C78.901 as applicable.

2.2.2.1 T-8 Lamp Ballast

Input wattage, for indicated lamp quantity is:

a. 35 watts (maximum) when operating one F32T8 lamp.

b. 70 watts (maximum) when operating two F32T8 lamps.

c. 104 watts (maximum) when operating three F32T8 lamps.

2.2.3 Dimming Ballast Controls

Provide slide dimmer ballast controls with on/off control, compatible with the ballast, and capable of controlling the ballast light output over the full dimming range. Provide dimming ballast controls approved by the ballast manufacturer.

2.2.4 Light Level Sensor

UL listed. Provide light level sensor capable of detecting changes in ambient lighting levels, and providing a dimming range of 20 percent to 100 percent, minimum, designed for use with dimming ballast and voltage system

to which they are connected. Ensure sensor is capable of controlling 40 electronic dimming ballast, minimum. Provide adjustable light level sensor with a set level range from 100 to 1000 lux, minimum. Provide sensor with a bypass function to electrically override sensor control.

2.2.5 Fluorescent Lamps

a. Provide T-8 rapid start low mercury lamps rated 32 watts (maximum), 2800 initial lumens (minimum), CRI of 75 (minimum), color temperature of 3500 K, with an average rated life of 20,000 hours. Provide low mercury lamps which have passed the EPA Toxicity Characteristic Leachate Procedure (TCLP) for mercury by using the lamp sample preparation procedure described in ANSI/NEMA C78.LL 1256.

b. Provide T-8 rapid start lamp, 17 watt (maximum), nominal length of 610 mm, 1300 initial lumens, CRI of 75 (minimum), color temperature of 3500 K, and an average rated life of 20,000 hours.

c. Provide T-8 instant start lamp, 59 watts (maximum), nominal length of 2438 mm, minimum CRI of 75, 5700 initial lumens, color temperature of 3500 K, and average rated life of 15,000 hours.

d. Provide T-12 slim line lamps rated 60 watts (maximum), 5750 initial lumens (minimum), 12,000 hours average rated life.

e. Provide T-5, long twin tube fluorescent lamp, 40 watts (maximum), 3500 K, 574 mm maximum length, 20,000 hours average rated life, 3150 initial lumens, CRI of 80 (minimum), 2G11 Type base, 90 to 100 lumens/watt depending on wattage.

f. Provide T-8, U shaped fluorescent lamp, 31 watts maximum, 2600 initial lumens (minimum), 3500 K, 75 CRI (minimum), 20,000 hours average rated life, 41.29 mm leg spacing.

g. Provide compact fluorescent lamps: CRI 80, minimum, 3500 K, 10,000 hours average rated life, and as follows:

    1. T-4, twin tube, rated 5 watt, 250 initial lumens (minimum), 7 watts, 400 initial lumens (minimum), 9 watts, 600 initial lumens (minimum), and 13 watts, 825 initial lumens (minimum).

    2. T-4, double twin tube, rated 13 watts, 900 initial lumens (minimum), 18 watts, 1200 initial lumens (minimum), and 26 watts, 1800 initial lumens (minimum).

Average rated life is based on 3 hours operating per start.

2.2.6 Compact Fluorescent Fixtures

Provide compact fluorescent fixtures manufactured specifically for compact fluorescent lamps with ballasts integral to the fixture. Providing assemblies designed to retrofit incandescent fixtures is prohibited except when specifically indicated for renovation of existing fixtures. Provide fixtures using lamps as indicated, with a minimum CRI of 80.

2.2.6.1 Bare Bulb Retrofits

Replace 40-watt incandescent bulbs (495plus lumens) with 11- to 14-watt compact fluorescent bulbs (45 plus lumens per watt). Replace 60-watt

incandescent bulbs (900 plus lumens) with 15- to 19-watt compact fluorescent bulbs (60 plus lumens per watt). Replace 75-watt incandescent bulbs (1200 plus lumens) with 20- to 25-watt compact fluorescent bulbs (60 plus lumens per watt). Replace 100-watt incandescent bulbs (1750 plus lumens) with 29-watt or greater compact fluorescent bulbs (60 plus lumens per watt).

2.2.7 Open-Tube Fluorescent Fixtures

Provide with self-locking sockets, or lamp retainers (two per lamp). Provide a clear polycarbonate protective sleeve with end caps, over lamp, with 95 percent (minimum) light transmission. Rate the sleeve to withstand the thermal profile of the lamp and ballast.

2.2.8 Air Handling Fixtures

Provide fixtures used as air handling registers conforming to the requirements of NFPA 90A.

2.2.9 Electromagnetic Interference Filters

Provide in each fluorescent fixture mounted where indicated. Provide filters integral to the fixture assembly with one filter per ballast and suppress electromagnetic interference in the AM radio band from 500 to 1700 kHz.

2.3 HIGH-INTENSITY-DISCHARGE (HID) LIGHTING FIXTURES

UL 1598. Provide HID fixtures with tempered glass lenses when using metal-halide lamps.

2.3.1 HID Ballasts

Provide HID ballasts conforming to UL 1029 and ANSI C82.4, with constant wattage autotransformer (CWA) or regulator, high power factor type (minimum 90 percent). Provide single-lamp ballasts which have a minimum starting temperature of minus 30 degrees C. Provide ballasts:

a. Designed to operate on the voltage system to which they are connected.

b. Designed for installation in a normal ambient temperature of 40 degrees C.

c. Constructed so that open circuit operation will not reduce the average life.

Provide high-pressure sodium (HPS) ballasts with a solid-state igniter/starter with an average life in the pulsing mode of 3500 hours at the intended ambient temperature. Igniter case temperature is not to exceed 90 degrees C in any mode.

2.3.2 Metal-Halide Lamps

a. Double-ended, 70 watt, conforming to ANSI C78.1381

b. Single-ended, wattage as indicated, conforming to ANSI/ANSLG C78.43

2.3.2.1 Luminaire Efficiency Rating (LER)

a. Upward efficiency of 0 percent

1. 150-399 watts: Minimum 41 LER for closed fixture

2. 400-999 watts: Minimum 53 LER for closed fixture; minimum 59 for open fixture

3. 1000 plus watts: Minimum 77 LER for closed fixture

b. Upward efficiency of 1 percent-10 percent

1. 150-399 watts: Minimum 56 LER for closed fixture

2. 400-999 watts: Minimum 62 LER for closed fixture; minimum 64 for open fixture

3. 1000 plus watts: Minimum 88 LER for open fixture

c. Upward efficiency greater than 20 percent

1. 150-399 watts: Minimum 62 LER for closed fixture; minimum 77 for open fixture

2. 400-999 watts: Minimum 65 LER for closed fixture

2.4 RECESS- AND FLUSH-MOUNTED FIXTURES

Provide type that can be relamped from the bottom, with access to ballast from the bottom, with trim for the exposed surface of flush-mounted fixtures as indicated.

2.5 SUSPENDED FIXTURES

Provide hangers capable of supporting twice the combined weight of fixtures supported by hangers. Provide with swivel hangers to ensure a plumb installation, cadmium-plated steel with a swivel-ball tapped for the conduit size indicated. Provide shock-absorbing type hangers where indicated. Provide hangers which allow fixtures to swing within an angle of 0.79 rad. Brace pendants 1219 mm or longer provided in shops or hangers to limit swinging. Provide single-unit suspended fluorescent fixtures with twin-stem hangers. Provide multiple-unit or continuous row fluorescent fixtures with tubing or stem for wiring at one point and a tubing or rod suspension provided for each unit length of chassis, including one at each end. Provide rods with a minimum 4.57 mm diameter.

2.6 POWER HOOK FIXTURE HANGERS

Provide UL listed assembly including through-wired power hook housing, interlocking plug and receptacle, power cord, and fixture support loop. Provide power hook housing of cast aluminum having two 19 mm threaded hubs, including support hook with safety screw. Provide fixture support loop of cast aluminum with provisions for accepting 19 mm threaded fixture stems. Include with power cord 410 mm (16 inches) of 3 conductor No. 16 Type SO cord.

2.7 EQUIPMENT IDENTIFICATION

2.7.1 Manufacturer's Nameplate

Provide each item of equipment with a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.7.2 Labels

Provide labeled luminaires in accordance with UL 1598 requirements. Clearly mark all for operation of specific lamps and ballasts according to proper lamp type.

a. Lamp diameter code (T-4, T-5, T-8, T-12), tube configuration (twin, quad, triple), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.

b. Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.

c. Start type (preheat, rapid start, instant start) for fluorescent and compact fluorescent luminaires.

d. ANSI ballast type (M98, M57, etc.) for HID luminaires.

e. Correlated color temperature (CCT) and color rendering index (CRI) for all luminaires.

Provide all markings related to lamp type clear and located to be readily visible to service personnel, but unseen from normal viewing angles when lamps are in place. Provide ballasts with clear markings indicating multi-level outputs and indicate proper terminals for the various outputs.

2.8 FACTORY APPLIED FINISH

Provide electrical equipment with factory-applied painting systems which , as a minimum, meet the requirements of NEMA 250 corrosion-resistance test.

2.9 COMMERCIAL INCANDESCENT LIGHTING FIXTURES

Commercial incandescent lighting fixtures include recessed, surface mounted, and pendant-mounted luminaires.

Provide corrosion-resistant nonferrous metal parts of fixtures. Do not use solder or self-threading sheet metal screws in the construction of the fixture enclosure.

Equip fixtures rated up to and including 300 watts with medium screw-base lampholders. Equip fixtures rated in excess of 300 watts but not more than 1,500 watts with mogul screw-base lampholders. Provide screw shells of lampholders which are electrically connected to the metal part of lighting fixtures or equipment grounding-circuit conductor.

2.9.1 Surface-Mounted Fixtures

Design the surface-mounted fixtures to be fastened to wall or ceiling flush-mounted outlet boxes. Do not subject combustible ceiling materials

to temperatures in excess of 90 degrees C.

2.9.2 Recessed Fixtures

Design recessed fixtures in suspended ceilings for the type of ceiling construction in which the fixture is to be installed. Do not subject combustible ceiling materials to temperatures in excess of 90 degrees C. Where recessed fixtures are supported on suspended ceilings, provide a minimum of four support rods per fixture with no support further than 150 millimeter from the edge of the fixture. Do not support fixtures by acoustic panels.

2.9.3 Pendant-Mounted Fixtures

Equip pendant-mounted fixtures with stems, swivel ball-and-socket self-aligning hangers that allow a minimum of a 20 -degree angle swing, ceiling canopies, and fixture-hanging devices, made of seamless brass, aluminum, steel, corrosion-resistant steel tubing, or steel conduit not less than 15 millimeter in diameter. Stem length, material, and finish are as noted.

2.10 INDUSTRIAL INCANDESCENT LIGHTING FIXTURES

Provide industrial incandescent lighting fixtures with industrial porcelain-enameled seamless dome reflectors with ventilated necks and hoods tapped for 15 millimeter conduit for swivel suspension pendant mounting. Provide lampholders with medium or mogul bases as applicable, furnished with incandescent lamps having the wattage rating indicated, meeting the requirements of UL 1598. Provide easily detachable reflectors and sockets as a unit, without the use of tools, but arranged so that they cannot inadvertently come loose.

2.11 ENCLOSED AND GASKETED VAPOR-TIGHT FIXTURES

Provide enclosed and gasketed vapor-tight fixtures suitable for wet or damp locations consisting of a cast-aluminum body, cap or matching outlet box, porcelain lampholder, glass enclosing globe, cork gaskets, and cast-aluminum guards for wall, ceiling, or pendant mounting in accordance with UL 1598 and NFPA 70.

Furnish exposed cast aluminum outlet boxes for wall- and ceiling-mounted fixtures with four tapped hubs 90 degrees apart circumferentially, with three cast-aluminum threaded pipe plugs to fit the tapped holes. Provide boxes with ears or lugs for surface mounting to wall or ceiling. Provide body with mounting screws and gasket to ensure a vapor-tight joint between the body and outlet box.

Concealed outlet boxes for wall- and ceiling-mounted fixtures may be standard sheet metal boxes. Provide fixture body with mounting screws and gasket to ensure a vapor-tight joint between the body and outlet box.

Seal body and cap for pendant-mounted fixtures with a gasket at the joint. Provide cast aluminum cap with top hub tapped for 15 millimeter tapered iron pipe threads.

Furnish cast aluminum exposed outlet boxes for pendant-mounted fixtures with the fixtures with four tapped hubs 90 degrees apart circumferentially, with three cast-aluminum threaded pipe plugs to fit the tapped holes. Supply boxes with ears or lugs for surface mounting to the ceiling.

Provide cast aluminum outlet-box covers for concealed and exposed outlet boxes with the center hub tapped for 15 millimeter tapered iron pipe threads. Provide cover and outlet box with mounting screws and gasket to ensure a vapor-tight joint between the cover and outlet box. Also provide 15 millimeter galvanized rigid steel conduit stem.

Provide clear nondiffusing heat-resistant glass enclosing globe molded in one piece into a cylindrical shape with a closed bowl-shaped bottom and an open molded top bead or thread. Make edges of the open end either ground or molded to a smooth, true surface that will ensure a vapor-tight joint when the globe is fastened to the gasketed body.

Provide a cast-aluminum guard of the same shape as the glass enclosing globe which is affixed to the fixture body with threads or setscrews.

2.12 INCANDESCENT LAMPS

Provide general-purpose lamps, frosted inside. Provide lamps with wattage ratings up to and including 300 watts with medium brass screw bases. Provide lamps with wattage ratings in excess of 300 watts with mogul brass screw bases.

Special-purpose lamps include PAR and R lamps. Provide PAR lamps with clear, molded, heat-resistant, hard-glass bulbs with parabolic, aluminized, inner-bulb wall reflector for spot- or flood-lighting applications. Provide R lamps with clear, soft, blown-glass bulbs with silver-deposited, inner-bulb wall reflector for spot or floodlighting applications. Design lamps for operation on 120 volts.

PART 3 EXECUTION

3.1 INSTALLATION

Ensure all electrical installations conform to IEEE C2, NFPA 70, and to the requirements specified herein.

3.1.1 Lamps

Deliver lamps of the type, wattage, and voltage rating indicated to the project in the original cartons and installed just prior to project completion. Replace lamps installed and used for working light during construction prior to turnover to the USAID Implementing Partner if more than 15 percent of their rated life has been used. Test the lamps for proper operation prior to turn-over and replace if necessary with new lamps from the original manufacturer. Provide 10 percent spare lamps of each type from the original manufacturer.

3.1.2 Lighting Fixtures

Set lighting fixtures plumb, square, and level with ceiling and walls, in alignment with adjacent lighting fixtures, and secure in accordance with manufacturers' directions and approved drawings, in conformance with the requirements of NFPA 70. Mounting heights specified or indicated are to the bottom of fixture for ceiling-mounted fixtures and to center of fixture for wall-mounted fixtures. Obtain approval of the exact mounting for lighting fixtures on the job before commencing installation and, where applicable, after coordinating with the type, style, and pattern of the ceiling being installed. Indepently support recessed and semi-recessed fixtures from the building structure by a minimum of four wires or rods per

fixture and located near each corner of each fixture. Ceiling grid clips are not allowed as an alternative to independently supported light fixtures. Independently support round fixtures smaller in size than the ceiling grid from the building structure by a minimum of four wires or rods per fixture spaced approximately equidistant around the fixture. Do not support fixtures by ceiling acoustical panels. Where fixtures of sizes less than the ceiling grid are indicated to be centered in the acoustical panel, support such fixtures independently and provide at least two 19 mm metal channels spanning, and secured to, the ceiling tees for centering and aligning the fixture. Provide wires or rods for lighting fixture support in this section.

3.1.3 Suspended Fixtures

Provide suspended fixtures with 0.79 rad swivel hangers so that they hang plumb and locate with no obstructions within the 0.79 rad range in all directions. Provide the stem, canopy and fixture capable of a 0.79 rad swing. Brace pendants, rods, or chains 1.2 meters or longer excluding fixture, to prevent swaying, using three cables at 2.09 rad separation. Provide suspended fixtures in continuous rows with internal wireway systems for end to end wiring and properly aligned to provide a straight and continuous row without bends, gaps, light leaks or filler pieces. Use aligning splines on extruded aluminum fixtures to assure hairline joints. Support steel fixtures to prevent "oil-canning" effects. Provide fixture finishes free of scratches, nicks, dents, and warps, and matching the color and gloss specified. Provide pendants finished to match Provide stainless steel air craft cable. Provide canopies finished to match the ceiling and low profile unless otherwise shown. Ensure maximum distance between suspension points is 3.1 meters or as recommended by the manufacturer, whichever is less.

3.1.4 Ballasts

3.1.4.1 Remote Ballasts

Mount remote type ballasts or transformers, where indicated, in a well ventilated, easily accessible location, within the maximum operating distance from the lamp, as designated by the manufacturer.

3.1.4.2 Electronic Dimming Ballasts

Provide all electronic dimming ballasts, controlled by the same controller, from the same manufacturer. Season or burn all fluorescent lamps on electronic dimming ballast control in at full light output for 100 hours before dimming.

3.2 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Specify painting in Section 09 90 00 PAINTS AND COATINGS.

3.3 FIELD QUALITY CONTROL

Upon completion of installation, verify that equipment is properly installed, connected, and adjusted. Conduct an operating test to show that equipment operates in accordance with requirements of this section.

3.3.1 Electronic Dimming Ballast

Test for full range of dimming capability. Observe for visually detectable flicker over full dimming range.

3.4 FIELD TESTING

Demonstrate that all incandescent lighting fixtures and their accessories, including lowering devices, operate satisfactorily in the presence of the Contracting Officer.

Perform operational tests in accordance with referenced standards in this section.

-- End of Section --

SECTION 26 52 00.00 40

EMERGENCY LIGHTING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101	(2009; Amd 09-1 & 09-2) Life Safety Code
NFPA 70	(2008; AMD 1 2008) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 924	(2006; R 1995 thru 2009) Standard for Emergency Lighting and Power Equipment

1.2 GENERAL REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS applies to work specified in this section.

Submit Material, Equipment, and Fixture Lists showing manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site.

1.3 SUBMITTALS

Contractor shall submit the following using submittal procedures as specified in the Contract Documents.

SD-01 Preconstruction Submittals

Submit Material, Equipment, and Fixture Lists in accordance with paragraph entitled, "General Requirements," of this section.

SD-02 Shop Drawings

Submit installation drawings for the Central Emergency Lighting Systems indicating location of installed fixture.

SD-03 Product Data

Submit the manufacturer's catalog data for the following items:

Emergency Lighting Egress Units
Emergency Fluorescent Lighting
Central Emergency Lighting Systems
Accessories

SD-06 Test Reports

Submit test reports showing results of System Operational Tests for emergency lighting systems.

SD-07 Certificates

Submit certificates for the following showing conformance with the referenced standards contained in this section.

Emergency Lighting Egress Units
Emergency Fluorescent Lighting
Central Emergency Lighting Systems
Accessories

PART 2 PRODUCTS

2.1 PRODUCT STANDARDS

Provide emergency lighting units conforming to UL 924 and NFPA 101.

Furnish emergency lighting units completely assembled with wiring and mounting devices, ready for installation at the locations indicated. Equip fixtures with lamps.

2.2 EMERGENCY LIGHTING EGRESS UNITS

Provide complete self-contained emergency lighting units with batteries, battery charger, one or more local or remote lamp heads with lamps, under-voltage relay, indicator lights, on/off switch, and test switch, in accordance with UL 924 for Type I (emergency light set), Class I (rechargeable storage-battery-powered unit), Style D (nonrefillable nickel-cadmium battery), as indicated.

Provide batteries rated not less than 6-12 volts.

Include in battery charger a dry-type full-wave rectifier with two charging rates, one to automatically maintain the battery in a fully charged state under normal conditions and the other to automatically recharge the battery to a fully charged state within 12 hours after continuous discharge of 1-1/2 hours through the connected lampload.

Provide batteries with the capacity and rating to supply the lamp load with maintained 87.5-percent power, minimum, for 1.5 hours, or the battery-lamp combination maintaining 60-percent, minimum, illumination. Provide maintenance-free lead acid type batteries, with a minimum normal life of 10 years.

Fabricate the unit enclosure from sheet steel not less than 1.3 millimeter. Design of cover is to provide access to the battery and battery-charger compartments and have a full-length piano hinge and a latching device. Protect component parts within the enclosure from dust, moisture, and oxidizing fumes from the battery. Coat interior and exterior surfaces of enclosure with a corrosion-resistant gray baked-enamel finish.

Mount the lampheads on the top of the unit enclosure, or wall mount, except where otherwise indicated and fully adjustable in the horizontal and vertical planes. Provide steel lamp head assembly with nickel plating. Form the exterior housing of the lamp from nickel-plated sheet steel.

Provide sealed-beam type lamps, halogen, rated not less than 12 watts at the specified dc voltage.

Mount an amber "ready-for-use on alternating current" indicating light, a red "recharging on alternating current" indicating light, and a momentary-contact pushbutton test switch on the cover of the unit enclosure. The amber light indicates, when illuminated, that the unit is electrically connected to the normal ac supply source and that the battery is fully charged. The red light indicates, when illuminated, that the battery is being recharged. The momentary-contact pushbutton test switch transfers the unit from normal supply to battery supply and tests operation of equipment under simulated ac source power failure.

Provide an under-voltage relay of the self-clearing type which automatically connects the lampload to the battery supply upon failure of the alternating current supply. Mount an on-off toggle switch inside the unit enclosure to disconnect the battery from the lampload when the unit is taken out of service for maintenance purposes. The relay energizes when the ac supply falls to 70 percent of normal voltage.

Provide emergency lighting units with angle iron mounting shelves and with a protective screen designed by the equipment manufacturer for this purpose. Coat the mounting shelf and screen with a corrosion-resistant finish in accordance with manufacturer's standard practice.

Provide emergency lighting units suitable for operation on the ac supply circuit to which they are to be electrically connected.

2.3 EMERGENCY FLUORESCENT LIGHTING

Provide each unit with an automatic power failure device, test switch, pilot light, and fully automatic high/low trickle charger in a self-contained solid-state, temperature-compensated power-pack. Provide gelled-electrolyte type battery with capacity as required to supply power to provide a minimum of 6500 lumens per square meter 600 lumens using a 40 -watt rapid start lamp. Provide a sealed and maintenance-free battery, with an active life of not less than 10 years under normal operating conditions.

2.4 SELF-TESTING MODULE

Provide self-testing module for exit signs and emergency lighting equipment which performs the following functions:

a. Continuous monitoring of charger operation and battery voltage with visual indication of normal operation and of malfunction.

b. Monthly discharge cycling of battery with monitoring of transfer circuit function, battery capacity and emergency lamp operation with visual indication of malfunction. Conduct the battery capacity test using a synthetic load.

c. Manual test switch to simulate a discharge test cycle.

d. Provide module with low voltage battery disconnect (LVD) and brown-out protection circuit.

PART 3 EXECUTION

3.1 INSTALLATION

Permanently fix in place the emergency lighting unit and install wiring for each unit in accordance with NFPA 70. Use the same panel bus or branch circuit as that serving the normal lighting in the area for the branch circuit feeding the unit equipment, and connect ahead of area switches. Keep remotely connected emergency lighting circuit wiring independent of all other wiring and equipment and do not enter the same conduit, cable, box, or cabinet with other wiring unless the fixture is supplied from two sources.

Mount emergency lighting units and remote lamps at a minimum of 2100 millimeter above the finished floor.

3.2 FIELD TESTING

Demonstrate emergency lighting units to operate satisfactorily in the presence of the USAID Implementing Partner.

Perform System Operational Tests in accordance with referenced standards in this section.

-- End of Section --

SECTION 26 53 00.00 40

EXIT SIGNS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101	(2009; Amd 09-1 & 09-2) Life Safety Code

U.S. DEPARTMENT OF ENERGY (DOE)

DOE LT-4	(2000) How to Buy Energy-Efficient Exit Signs

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910	Occupational Safety and Health Standards

UNDERWRITERS LABORATORIES (UL)

UL 924	(2006; R 1995 thru 2009) Standard for Emergency Lighting and Power Equipment

1.2 GENERAL REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS applies to work specified in this section.

Material, Equipment, and Fixture Lists shall be submitted for the following showing manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site.

1.3 SUBMITTALS

Contractor shall submit the following using submittal procedures as specified in the Contract Documents.

SD-01 Preconstruction Submittals

Material, Equipment, and Fixture Lists shall be submitted for the following in accordance with paragraph entitled, "General Requirements," of this section.

Exit Lighting Units
Contemporary Fixtures
Accessories

SD-02 Shop Drawings

Installation drawings shall be submitted for Exit Lighting Units

in accordance with the paragraph entitled, "Installation," of this section.

Outline drawings shall be submitted for Exit Lighting Units indicating overall physical features, dimensions, ratings, service requirements, and weights of equipment.

SD-03 Product Data

Manufacturer's catalog data shall be submitted for the following items:

Exit Lighting Units
Contemporary Fixtures
Accessories

SD-06 Test Reports

Test reports shall be submitted showing results of Operational Tests of exit lighting systems.

SD-07 Certificates

Certificates shall be submitted showing compliance with the following requirements.

Efficiencies

PART 2 PRODUCTS

2.1 PRODUCT STANDARDS

Emergency exit lighting fixtures shall conform to UL 924, NFPA 101, and as specified.

Exit lighting fixtures shall be furnished completely assembled with wiring and mounting devices and ready for installation at the locations indicated. Ceiling-mounted fixtures shall be designed to be supported independent of the ceiling. Fixtures shall be equipped with lamps.

2.1.1 Efficiencies

Exit lighting fixtures shall have efficiencies in accordance with the recommended levels specified in DOE LT-4.

2.2 CONTEMPORARY FIXTURES

Contemporary exit lighting fixture shall have a fixture body with edge-lighted plastic exit-sign panels, face trims, lamps, lampholders, and mounting brackets for top, back, and end mounting to walls and ceilings in accordance with NFPA 101, as indicated.

Fixtures shall be single face with thin wedge-shaped vertical cross sections. Top edge of double-face fixtures shall be not more than 70 millimeter thick. Top edge of single-face fixtures shall be not more than 50 millimeter thick. Bottom edge of double-face fixtures shall be not more than 45 millimeter thick. Bottom edge of single-face fixtures shall be not more than 32 millimeter thick.

Plastic sign panels shall be acrylic with green translucent letters and directional arrows, as required. Letters shall be 150 millimeter high with stroke not less than 30 millimeter wide.

Wireway cover and plastic sign backup plate shall be anodized sheet aluminum with a matte finish. Face trims shall be formed from sheet aluminum and shall have a brushed-satin finish. Fixture bodies formed from sheet steel shall be not less than1 millimeter 20 gage and painted.

Plastic sign panels shall be edge-lighted from the top with at least two low-voltage miniature incandescent lamps that will illuminate the plastic sign panels and floor. Exit signs shall be wired for two-circuit service at 230 volts and shall include a diode circuit that will provide a minimum of 50,000 hours of lamp life.

Mounting plates and brackets formed from sheet aluminum or plate shall have a brushed-satin finish. Mounting plates shall be not less than 115 millimeter square and designed to secure the fixture to a 100 millimeter square outlet box.

2.3 EMERGENCY POWER LOSS EXIT LIGHTING UNITS

Each self-contained unit shall have an automatic power failure device, test switch, pilot light, and fully automatic high/low solid-state trickle charger in a self-contained power pack. Battery shall be the gelled-electrolyte type and shall be maintenance-free for a period of not less than 10-years under normal operating conditions. Normal operation shall be with 230-volts.

2.4 LIGHT EMITTING DIODES (LEDs) EXIT LIGHTING FIXTURES

Exit lighting fixtures shall include sheetmetal enclosures with frames, battery charger, batteries, green light emitting diodes (LEDs) and mounting brackets. Fixtures shall be single faced. Mounting plates shall be suitable for securing the fixture to a 100 millimeteroutlet box. Fixture features shall include continuous charging, automatic switching to standby batteries upon loss of power, overload protection, short circuit protection, test switch, low voltage disconnect, switch controlled left and right LED directional arrows, and shall be field connectable to operate from 230 volts. Minimum operating time of the battery system shall be three (3) hours for double faced fixtures and seven (7) hours for single faced fixtures. Brightness shall not be less than ten (10) candela. All components shall have a five year warranty.

2.5 SELF LUMINOUS EXIT SIGNS

All units shall be internally illuminated non-electric (light source is independent of electrical power and is generated by the action of tritium gas on a phosphorescent material).

All self luminous signs shall be in accordance with UL 924, 29 CFR 1910, Section 37, Part (G), Subparts (6) and (7), and NFPA 101, Section 5-10.3.3. All signs shall be licensed by the United States Nuclear Regulatory Commission. Integrity and performance shall be guaranteed for 20 years of normal use.

2.5.1 Enclosure

The assembled tamperproof enclosure shall be of 3 millimeter high impact

ABS plastic, framed with 1.3 millimeter thick extruded aluminum.

Each sign shall bear a permanently attached metal nameplate bearing the Manufacturer's Name and Address and Date of Manufacture (in addition to information required by listed authorities.

2.5.2 Face

Each face of the sign shall be a non-colored translucent panel covered by an opaque 3 millimeter red ABS plastic stencil bearing the word "EXIT" in 150 by 20 millimeter letters and including a universal directional arrow which indicates the direction of the exit (left, right or both ways).

2.5.3 Illumination

Illumination of the sign shall be by means of sealed glass tubes, internally phosphor coated and filled with tritium gas. Tubes shall be securely bonded to the enclosure and cushioned against mechanical shock. Luminous areas shall have a minimum initial brightness of 0.51 candela per square meter and a guaranteed minimum brightness after ten years of 0.27 candela per square meter.

2.5.4 Mounting Accessories

Each sign shall be supplied with tamperproof hardware for wall mounting. Edge on for double face, flat for single face or double face for ceiling mount.

PART 3 EXECUTION

3.1 INSTALLATION

Fixtures shall be connected to the main panel bus through overcurrent protection. Emergency lighting panel shall be used where available.

3.2 FIELD TESTING

Exit lighting shall be demonstrated to operate satisfactorily in the presence of the USAID Implementing Partner.

Operational Tests shall be performed in accordance with referenced standards in this section.

-- End of Section --

WO-LT-0005

Ghazi Boys High School
Kabul, Afghanistan

Technical Specifications
(Vol. 2 of 2)

100% Design Review Submittal
July 10, 2010

This project was made possible by the United States Agency for International Development and the generous support of the American People through USAID Global Architecture and Engineering IQC Contracts

Note to Reviewer

This Technical Specification document is submitted in accordance with the requirements of the Work Order.

This submittal of the Technical Specifications represents the 100% Design Review Submission to be used for the site work and electrical, water, and wastewater utilities only.

FINAL DESIGN

GHAZI BOYS HIGH SCHOOL
KABUL, AFGHANISTAN

TABLE OF CONTENTS

DATE

VOLUME 1 OF 2

DIVISION 02 – EXISTING CONDITIONS

02 41 00	DEMOLITION	06/30/10

DIVISION 03 – CONCRETE

03 11 13.00 10	STRUCTURAL CONCRETE FORMWORK	06/30/10
03 15 13.00 10	EXPANSION JOINTS, CONTRACTION JOINTS, AND WATERSTOPS	06/30/10
03 15 14.00 10	EXPANSION, CONTRACTION AND CONSTRUCTION JOINTS IN CONCRETE FOR CIVIL WORKS	06/30/10
03 20 01.00 10	CONCRETE REINFORCEMENT	06/30/10
03 31 00.00 10	CAST-IN-PLACE STRUCTURAL CONCRETE	06/30/10

DIVISION 04 – MASONRY

04 20 00	MASONRY	06/30/10

DIVISION 05 – METALS

05 12 00	STRUCTURAL STEEL	06/30/10
05 50 13	MISCELLANEOUS METAL FABRICATIONS	06/30/10

DIVISION 07 – THERMAL AND MOISTURE PROTECTION

07 21 13	BOARD AND BLOCK INSULATION	06/30/10
07 21 16	MINERAL FIBER BLANKET INSULATION	06/30/10
07 41 13	METAL ROOF PANELS	06/30/10
07 60 00	FLASHING AND SHEET METAL	06/30/10
07 92 00	JOINT SEALANTS	06/30/10

DIVISION 08 – OPENINGS

08 11 13	STEEL DOORS AND FRAMES	06/30/10
08 34 19.10 20	ROLLING SERVICE DOORS	06/30/10
08 71 00	DOOR HARDWARE	06/30/10
08 91 00	METAL WALL LOUVERS	06/30/10

DIVISION 09 – FINISHES

09 22 00	SUPPORTS FOR PLASTER AND GYPSUM BOARD	06/30/10
09 24 23	STUCCO	06/30/10
09 29 00	GYPSUM BOARD	06/30/10
09 90 00	PAINTS AND COATINGS	06/30/10

DIVISION 13 – SPECIAL CONSTRUCTION

13 48 00	SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT	06/30/10
13 48 00.00 10	SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT	06/30/10

DIVISION 23 – HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

23 00 00	AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS	06/30/10
23 82 46	ELECTRIC UNIT HEATERS	06/30/10

DIVISION 26 – ELECTRICAL

26 00 00.00 20	BASIC ELECTRICAL MATERIALS AND METHODS	06/30/10
26 05 00.00 40	COMMON WORK RESULTS FOR ELECTRICAL	06/30/10
26 05 19.00 10	INSULATED WIRE AND CABLE	06/30/10
26 05 48.00 10	SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT	06/30/10
26 05 71.00 40	LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES	06/30/10
26 11 16	SECONDARY UNIT SUBSTATIONS	06/30/10
26 20 00	INTERIOR DISTRIBUTION SYSTEM	06/30/10
26 23 00	SWITCHBOARDS	06/30/10
26 28 01.00 10	COORDINATED POWER SYSTEM PROTECTION	06/30/10

26 32 15.00 10	DIESEL-GENERATOR SET STATIONARY 100-2500 KW, WITH AUXILIARIES	06/30/10
26 51 00.00 40	INTERIOR LIGHTING	06/30/10
26 52 00.00 40	EMERGENCY LIGHTING	06/30/10
26 53 00.00 40	EXIT SIGNS	06/30/10

VOLUME 2 OF 2

DIVISION 31 – EARTHWORK

31 00 00	EARTHWORK	06/30/10
31 05 19	GEOTEXTILE	06/30/10

DIVISION 32 – EXTERIOR IMPROVEMENTS

32 01 19	FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS	06/30/10
32 11 23	AGGREGATE BASE COURSE	06/30/10
32 13 13.06	PORTLAND CEMENT CONCRETE PAVEMENT FOR ROADS AND SITE FACILITIES	06/30/10
32 15 00	AGGREGATE SURFACE COURSE	06/30/10
32 16 13	CONCRETE SIDEWALKS AND CURBS AND GUTTERS	06/30/10
32 17 23.00 20	PAVEMENT MARKINGS	06/30/10
32 31 13	CHAIN LINK FENCES AND GATES	06/30/10

DIVISION 33 – UTILITIES

33 11 00	WATER DISTRIBUTION	07/08/10
33 20 00	WATER WELLS	06/30/10
33 30 00	SANITARY SEWERS	07/08/10
33 32 13.14	PACKAGED SEWAGE LIFT STATIONS, GRINDER PUMP TYPE	06/30/10
33 56 10	FACTORY-FABRICATED FUEL STORAGE TANKS	07/08/10
33 71 02.00 20	UNDERGROUND ELECTRICAL DISTRIBUTION	06/30/10
33 77 36.00 40	MEDIUM-VOLTAGE UTILITY FUSES	06/30/10

DIVISION 43 – PROCESS GAS AND LIQUID HANDLING, PURIFICATION, AND STORAGE EQUIPMENT

43 21 13	DOMESTIC DISTRIBUTION PUMPS	06/30/10
43 21 39	WELL PUMPS	06/30/10
43 32 76	CHLORINE FEEDING MACHINES (AUTOMATIC,	07/10/10

SEMIAUTOMATIC, AND MANUAL)

DIVISION 44 – POLUTION CONTROL EQUIPMENT

44 41 12 PACKAGED WASTEWATER TREATMENT PLANT 06/30/10

End of Table of Contents

SECTION 31 00 00

EARTHWORK

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C 136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D 1140	(2000; R 2006) Amount of Material in Soils Finer than the No. 200 (75-micrometer) Sieve
ASTM D 1556	(2007) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	(2007) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D 2487	(2006) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 2937	(2004) Density of Soil in Place by the Drive-Cylinder Method
ASTM D 422	(1963; R 2007) Particle-Size Analysis of Soils
ASTM D 4318	(2005) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D 6938	(2007a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

1.2 DEFINITIONS

1.2.1 Satisfactory Materials

Satisfactory materials comprise any materials classified by ASTM D 2487 as:

a. GW: Well graded gravel with or without sand
b. GP: Poorly garded gravel with or without sand
c. GM: Silty gravel with or without sand
d. GP-GM: Well graded gravel with or without silt or sand

e. GW-GM: Poorly graded gravel with or without silt and sand
f. GC: Clayey gravel with or without sand
g. GP-GC: Poorly graded gravel with or without clay and sand (or silty clay and sand)
h. GM-GC: Silty, clayey gravel with or without sand
i. SW: Well graded sand with or without gravel
j. SM: Silty sand with or without gravel
k. SW-SM: Well graded sand with or without silt and gravel
l. SC: Clayey sand with or without gravel
m. SW-SC: Well graded sand with or without clay and gravel (or silty clay and gravel).

Satisfactory materials for grading comprise stones less than 75 mm in any dimension. The liquid limit shall not exceed 35 and the plasticity index shall not exceed 12 when tested in accordance with ASTM D 4318.

1.2.2 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Unsatisfactory materials also include man-made fills; trash; refuse; and material classified as satisfactory that is too wet or too dry, does not meet the specified density, or contains root and other organic matter or frozen material. Notify the USAID Implementing Partner when encountering any contaminated materials.

1.2.3 Cohesionless and Cohesive Materials

Cohesionless materials include materials classified as GW, GP, SW, and SP. Materials classified as GM and SM will be identified as cohesionless only when the fines are non-plastic. Perform testing, required for classifying materials, in accordance with ASTM D 4318, ASTM C 136, ASTM D 422, and ASTM D 1140.

1.2.4 Degree of Compaction

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D 1557 as a percent of laboratory maximum density. Minimum degree of compaction shall be 90%, as determined by a Modified Proctor Test.

1.2.5 Hard/Unyielding Materials

Hard/Unyielding materials comprise weathered rock, dense consolidated deposits, or conglomerate materials which are not included in the definition of "rock" with stones greater than 25 mm in any dimension or as defined by the pipe manufacturer, whichever is smaller. These materials usually require the use of heavy excavation equipment, ripper teeth, or jack hammers for removal.

1.2.6 Rock

Solid material with firmly cemented masses or conglomerate deposits, neither of which can be removed without drilling and blasting, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, and buried masonry. Removal of hard material will not be considered rock excavation because of intermittent drilling and blasting that is performed merely to increase production.

1.2.7 Unstable Material

Unstable material is too wet to properly support the utility pipe, conduit, or appurtenant structure.

1.2.8 Select Granular Material

1.2.8.1 General Requirements

Select granular material consists of materials classified as GW, GP, SW, or SP where indicated. The liquid limit of such material must not exceed 35 percent when tested in accordance with ASTM D 4318. The plasticity index must not be greater than 12 percent when tested in accordance with ASTM D 4318, and not more than 25 percent by weight may be finer than 75 micrometers sieve when tested in accordance with ASTM D 1140.

1.2.9 Initial Backfill Material

Initial backfill consists of select granular material or satisfactory materials free from rocks 25 mm or larger in any dimension or free from rocks of such size as recommended by the pipe manufacturer, whichever is smaller.

1.2.10 Expansive Soils

Expansive soils are defined as soils that have a plasticity index equal to or greater than 12 when tested in accordance with ASTM D 4318.

1.2.11 Nonfrost Susceptible (NFS) Material

Nonfrost susceptible material are a uniformly graded washed sand with a maximum particle size of 4.75 mm (no. 4 sieve) and less than 5 percent passing the 0.075 mm size sieve, and with not more than 3 percent by weight finer than 0.02 mm grain size.

1.3 CLASSIFICATION OF EXCAVATION

No consideration will be given to the nature of the materials, and all excavation will be designated as unclassified excavation.

1.3.1 Dewatering Work Plan

Submit procedures for accomplishing dewatering work using submittal procedures as specified in the the contract documents.

1.4 SUBMITTALS

Contractor shall submit the following using submittal procedures as specified in the Contract Documents.

SD-01 Preconstruction Submittals

Dewatering Work Plan

Quality Control Plan

Submit 15 days prior to starting work.

SD-03 Product Data

Utilization of Excavated Materials
Opening of any Excavation or Borrow Pit

Procedure and location for disposal of unused satisfactory material. Proposed source of borrow material. Notification of encountering rock in the project. Advance notice on the opening of excavation or borrow areas.

SD-06 Test Reports

Testing
Borrow Site Testing

Within 24 hours of conclusion of physical tests, 6 copies of test results, including calibration curves and results of calibration tests. Results of testing at the borrow site.

SD-07 Certificates

Testing

Qualifications of the commercial testing laboratory or the Contractor's testing facilities.

PART 2 PRODUCTS

2.1 REQUIREMENTS FOR OFFSITE SOILS

Test offsite soils brought in for use as backfill for Total Petroleum Hydrocarbons (TPH) and total metals (lead, chromium, arsenic, cadmium, nickel, zinc, copper, mercury, silver and selenium). Backfill shall contain a maximum of 100 parts per million (ppm) of total petroleum hydrocarbons (TPH). Provide Borrow Site Testing for TPH from a composite sample of material from the borrow site, with at least one test from each borrow site. Do not bring material onsite until tests have been approved by the USAID Implementing Partner.

2.2 MATERIAL FOR RIP-RAP

2.2.1 Bedding Material

Provide bedding material consisting of sand, gravel, or crushed rock, with a maximum particle size of 50 mm. Compose material of tough, durable particles. Allow fines passing the 75 micrometers standard sieve with a plasticity index less than six.

2.2.2 Erosion Control Rock

Provide rock fragments sufficiently durable to ensure permanence in the structure and the environment in which it is to be used. Provide fragments sized so that no individual fragment exceeds a weight of 68 kg or as approved by USAID Implementing Partner.

PART 3 EXECUTION

3.1 GENERAL EXCAVATION

Perform excavation of every type of material encountered within the limits

of the project to the lines, grades, and elevations indicated and as specified. Perform the grading in accordance with the typical sections shown and the tolerances specified in paragraph FINISHING. Transport satisfactory excavated materials and place in fill or embankment within the limits of the work. Excavate unsatisfactory materials encountered within the limits of the work below grade and replace with satisfactory materials. Include such excavated material and the satisfactory material ordered as replacement in excavation. Dispose surplus satisfactory excavated material not required for fill or embankment in areas approved for surplus material storage or designated waste areas. Dispose unsatisfactory excavated material in designated waste or spoil areas. During construction, perform excavation and fill in a manner and sequence that will provide proper drainage at all times. Excavate material required for fill or embankment in excess of that produced by excavation within the grading limits from the borrow areas indicated on the contract documents or from other approved areas by the USAID Implementing Partner.

3.1.1 Ditches, Gutters, and Channel Changes

Finish excavation of ditches, gutters, and channel changes by cutting accurately to the cross sections, grades, and elevations shown on the Contract Drawings. Do not excavate ditches and gutters below grades shown.

3.1.2 Drainage Structures

Make excavations to the lines, grades, and elevations shown on contract documents, or as directed. Remove loose disintegrated rock and thin strata. Do not disturb the bottom of the excavation when concrete or masonry is to be placed in an excavated area. Do not excavate to the final grade level until just before the concrete or masonry is to be placed.

3.1.3 Drainage

Provide for the collection and disposal of surface and subsurface water encountered during construction. Completely drain construction site during periods of construction to keep soil materials sufficiently dry. Grade the construction area to provide positive surface water runoff away from the construction activity and provide temporary ditches, swales, and other drainage features and equipment as required to maintain dry soils. It is the responsibility of the Contractor to assess the soil and ground water conditions presented by the plans and specifications and to employ necessary measures to permit construction to proceed.

3.1.4 Dewatering

Control groundwater flowing toward or into excavations to prevent sloughing of excavation slopes and heave in the excavation. While the excavation is open, maintain the water level continuously, at least 2 m below the working level. Operate dewatering system continuously until construction work below existing water levels is complete. Submit performance records weekly. Measure and record performance of dewatering system at same time each day by use of observation wells or piezometers installed in conjunction with the dewatering system.

3.1.5 Trench Excavation Requirements

Excavate the trench as shown on the plan details. Shore trench walls more than 1.5 meters high, cut back to a stable slope, or provide with equivalent means of protection for employees who may be exposed to moving

ground or cave in. Excavate trench walls which are cut back to at least the angle of repose of the soil. Give special attention to slopes which may be adversely affected by weather or moisture content. Do not exceed the trench width below the pipe top of 600 mm plus pipe outside diameter (O.D.) for pipes of less than 600 mm inside diameter. Where recommended trench widths are exceeded, provide redesign, stronger pipe, or special installation procedures by the Contractor. The Contractor is responsible for the cost of redesign, stronger pipe, or special installation procedures without any additional compensation.

3.1.5.1 Bottom Preparation

Grade the bottoms of trenches accurately to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Excavate bell holes to the necessary size at each joint or coupling to eliminate point bearing. Remove stones of 75 mm or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, to avoid point bearing.

3.1.5.2 Removal of Unyielding Material

Where overdepth is not indicated and unyielding material is encountered in the bottom of the trench, remove such material 150 mm below the required grade and replace with suitable materials as provided in paragraph BACKFILLING AND COMPACTION.

3.1.5.3 Removal of Unstable Material

Where unstable material is encountered in the bottom of the trench, remove such material to the depth directed and replace it to the proper grade with select granular material as provided in paragraph BACKFILLING AND COMPACTION. When removal of unstable material is required due to the Contractor's fault or neglect in performing the work, the Contractor is responsible for excavating the resulting material and replacing it without additional compensation.

3.1.5.4 Excavation for Appurtenances

Provide excavation for manholes, catch-basins, inlets, or similar structures of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown. Clean rock of loose debris and cut to a firm surface as shown or as directed. Remove unstable material, loose disintegrated rock and thin strata. When concrete or masonry is to be placed in an excavated area, take special care not to disturb the bottom of the excavation. Do not excavate to the final grade level until just before the concrete or masonry is to be placed.

3.1.6 Structural Excavation

Test pits will be performed at all locations as required by Geotechnical Engineer.

Ensure that footing subgrades have been inspected and approved by the USAID Implementing Partner prior to concrete placement.

3.2 SELECTION OF BORROW MATERIAL

Select borrow material to meet the requirements and conditions of the

particular fill or embankment for which it is to be used. Unless otherwise provided in the contract, the Contractor is responsible for obtaining the right to procure material, pay royalties and other charges involved, and bear the expense of developing the sources, including rights-of-way for hauling from the owners. Unless specifically provided, do not obtain borrow within the limits of the project site without prior written approval.

3.3 GRADING AREAS

Where indicated, divide work into grading areas within which satisfactory excavated material will be placed in embankments, fills, and required backfills. Place and grade in separate stockpiles of satisfactory, unsatisfactory, and wasted materials as specified. Protect stockpiles of satisfactory materials from contamination which may destroy the quality and fitness of the stockpiled material.

3.4 FINAL GRADE OF SURFACES TO SUPPORT CONCRETE

Do not excavate to final grade until just before concrete is to be placed. Roughen the level surfaces, and cut the sloped surfaces, as indicated, into rough steps or benches to provide a satisfactory bond.

3.5 GROUND SURFACE PREPARATION

3.5.1 General Requirements

Remove and replace unsatisfactory material with satisfactory materials in surfaces to receive fill or in excavated areas. Scarify the surface to a depth of 150 mm before the fill is started. Plow, step, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so that the fill material will bond with the existing material.

3.5.2 Frozen Material

Do not place material on surfaces that are muddy, frozen, or contain frost. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Moisten material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used.

3.6 UTILIZATION OF EXCAVATED MATERIALS

The Contractor shall dispose unsatisfactory materials removed from excavations outside the construction limits. Use satisfactory material removed from excavations in the construction of fills, embankments, subgrades, shoulders, bedding (as backfill), and for similar purposes.

3.7 BACKFILLING AND COMPACTION

Backfill adjacent to any and all types of structures shall be compacted to at least 90 percent of maximum density as determined by Modified Protor Test within minus 1 percent to plus 2 percent of optimum moisture content for cohesive or for cohesionless materials to prevent wedging action or eccentric loading upon or against the structure. Fill material must be placed in lifts up to a maximum of 200 mm uncompacted thickness. If hand-held compaction equipment is used, the lift thickness shall be no more than 150 mm.

3.7.1 Trench Backfill

The Contractor shall place backfill to an adequate level to ensure stability of the line when performing the required pressure test.

3.7.1.1 Replacement of Unyielding Material

Replace unyielding material removed from the bottom of the trench with select granular material or initial backfill material.

3.7.1.2 Replacement of Unstable Material

Replace unstable material removed from the bottom of the trench or excavation with select granular material placed in layers not exceeding 150 mm loose thickness. Each layer shall be compacted to 95 percent of laboratory maximum density.

3.7.1.3 Bedding and Initial Backfill

Place initial backfill material 150 mm under utility line and to a height of at least 300 mm above the utility pipe or conduit and compact it with approved tampers. Bring up the backfill evenly on both sides of the pipe for the full length of the pipe. Take care to ensure thorough compaction of the fill under the haunches of the pipe. Compact backfill to 150 mm above the top of pipe to 95 percent of ASTM D 1557 maximum density. Provide plastic piping with bedding to spring line of pipe. Provide materials as follows:

a. Class I: Angular, 6 to 40 mm, graded stone, or as recommended by the pipe manufacturer, whichever is smaller.

b. Clean, coarse-grained sand classified as SP.

3.7.1.4 Final Backfill

Fill the remainder of the trench with satisfactory material. Place backfill material and compact to 95 percent of maximum density.

3.7.2 Backfill for Appurtenances

After the manhole, catchbasin, inlet, or similar structure has been constructed and the concrete has been allowed to cure for 7 days, place backfill in such a manner that the structure is not damaged by the shock of falling earth. Deposit the backfill material, compact it as specified for final backfill, and bring up the backfill evenly on all sides of the structure to prevent eccentric loading and excessive stress.

3.8 SPECIAL REQUIREMENTS

Special requirements for both excavation and backfill relating to the specific utilities are as follows:

3.8.1 Water Lines

Excavate trenches to a depth that provides a minimum cover as shown on the construction drawings from the indicated finished grade to the top of the pipe.

3.8.2 Electrical Distribution System

Provide a minimum cover as shown in the contract documents from the finished grade to direct burial cable and conduit or duct line, unless otherwise indicated.

3.9 EMBANKMENTS

3.9.1 Earth Embankments

Construct earth embankments from satisfactory materials free of organic or frozen material and rocks with any dimension greater than 75 mm. Place the material in successive horizontal layers of loose material not more than 200 mm in depth. Spread each layer uniformly on a soil surface that has been moistened or aerated as necessary, and scarified or otherwise broken up so that the fill will bond with the surface on which it is placed.

3.10 SUBGRADE PREPARATION

3.10.1 Proof Rolling

Finish proof rolling on an exposed subgrade free of surface water which would promote degradation of an otherwise acceptable subgrade. After stripping, proof roll the existing subgrade with six passes of a dump truck loaded with 6 cubic meters of soil or 13.6 metric tons, pneumatic-tired roller. Operate the roller or the truck in a systematic manner to ensure the number of passes over all areas, and at speeds between 4 to 5.5 km/hour. When proof rolling, provide one-half of the passes made with the roller in a direction perpendicular to the other passes. Notify the USAID Implementing Partner a minimum of 3 days prior to proof rolling. Perform proof rolling in the presence of the USAID Implementing Partner. Remove the rutting or pumping material as directed by the USAID Implementing Partner and replace with satisfactory material.

3.10.2 Construction

Shape subgrade to line, grade, and cross section, and compact as specified. Include plowing, and any moistening or aerating required to obtain specified compaction for this operation. Remove soft or otherwise unsatisfactory material and replace with satisfactory excavated material or other approved material as directed. Excavate rock encountered in the cut section to a depth of 150 mm below finished grade for the subgrade. Bring up low areas resulting from removal of unsatisfactory material or excavation of rock to required grade with satisfactory materials, and shape the entire subgrade to line, grade, and cross section and compact as specified.

3.10.3 Compaction

Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Compact each layer of the embankment to at least 90 percent of laboratory maximum density.

3.10.3.1 Subgrade for Pavements

Compact subgrade for pavements to at least 90 percentage laboratory maximum density for the depth below the surface of the pavement shown. When more than one soil classification is present in the subgrade, thoroughly blend,

reshape, and compact the top 300 mm of subgrade.

3.11 FINISHING

Finish the surface of excavations, embankments, and subgrades to a smooth and compact surface in accordance with the lines, grades, and cross sections or elevations shown in the contract documents. Provide the degree of finish for graded areas within 30 mm of the grades and elevations indicated except that the degree of finish for subgrades specified in paragraph SUBGRADE PREPARATION. Finish gutters and ditches in a manner that will result in effective drainage. Finish the surface of areas to be turfed from settlement or washing to a smoothness suitable for the application of turfing materials. Repair graded, topsoiled, or backfilled areas prior to acceptance of the work, and re-established grades to the required elevations and slopes.

3.11.1 Subgrade and Embankments

During construction, keep embankments and excavations shaped and drained. Maintain ditches and drains along subgrade to drain effectively at all times. Do not disturb the finished subgrade by traffic or other operation. The Contractor is responsible for protecting and maintaining the finished subgrade in a satisfactory condition until gravel is placed. Do not permit the storage or stockpiling of materials on the finished subgrade. Do not lay gravel until the subgrade has been checked and approved, and in no case place gravel on a muddy, spongy, or frozen subgrade.

3.11.2 Capillary Water Barrier

Place a capillary water barrier under concrete floors and slabs directly on subgrade and compact with a minimum of two passes of a hand-operated plate-type vibratory compactor.

3.11.3 Grading Around Structures

Construct areas within 1.5 m outside of each building and structure line true-to-grade, shape to drain, and maintain free of trash and debris until final inspection has been completed and the work has been accepted.

3.12 TESTING

Perform testing according to Contractor's Quality Control Plan. Determine field in-place density in accordance with ASTM D 1556 or ASTM D 6938. When ASTM D 6938 is used, check the calibration curves and adjust using only the sand cone method as described in ASTM D 1556. ASTM D 6938 results in a wet unit weight of soil in determining the moisture content of the soil when using this method. Check the calibration curves furnished with the moisture gauges along with density calibration checks as described in ASTM D 6938; check the calibration of both the density and moisture gauges at the beginning of a job on each different type of material encountered and one (1) sand cone density for each ten (10) densities performed in accordance with ASTM D 6938. ASTM D 2937, use the Drive Cylinder Method only for soft, fine-grained, cohesive soils. When test results indicate, as determined by the USAID Implementing Partner, that compaction is not as specified, remove the material, replace and recompact to meet specification requirements. Perform tests on recompacted areas to determine conformance with specification requirements. Appoint a registered professional civil engineer to certify inspections and test results. These certifications

shall state that the tests and observations were performed by or under the direct supervision of the engineer and that the results are representative of the materials or conditions being certified by the tests. The following number of tests, if performed at the appropriate time, will be the minimum acceptable for each type operation.

3.12.1 Fill and Backfill Material Gradation

One test per 100 cubic meters stockpiled or in-place source material. Determine gradation of fill and backfill material in accordance with ASTM C 136, ASTM D 422, and ASTM D 1140 when the material is granular and ASTM D 422 and ASTM D 1140 when the material is not granular.

3.12.2 In-Place Densities

a. Structural Fill Areas: One test per 230 square meters, or fraction thereof, of each lift. If more than 20% of the field density measurements yield unsatisfactory results, the testing frequency shall be subdivided and tested at a frequency of 120 square meters.

b. Non-Structural Fill Areas: One test per 460 square meters, or fraction thereof, of each lift. In every area where field density measurements yield unsatisfactory results, testing frequency shall be reduced to one test per 230 square meters.

3.12.3 Moisture Contents

In the stockpile, excavation, or borrow areas, perform a minimum of two tests per day per type of material or source of material being placed during stable weather conditions. During unstable weather, perform tests as dictated by local conditions and approved by the USAID Implementing Partner.

3.12.4 Optimum Moisture and Laboratory Maximum Density

Perform tests for each type material or source of material including borrow material to determine the optimum moisture and laboratory maximum density values. One representative test per 500 cubic meters of fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum density.

3.12.5 Tolerance Tests for Subgrades

Perform continuous checks on the degree of finish specified in paragraph SUBGRADE PREPARATION during construction of the subgrades.

3.12.6 Displacement of Sewers

After other required tests have been performed and the trench backfill compacted, inspect the pipe to determine whether significant displacement has occurred. Conduct this inspection in the presence of the USAID Implementing Partner. Inspect pipes by shining a light (lamping) between manholes or manhole locations. If, in the judgment of the USAID Implementing Partner, the interior of the pipe shows poor alignment or any other defects that would cause improper functioning of the system, replace or repair the defects as directed without additional compensation.

3.13 DISPOSITION OF SURPLUS MATERIAL

Provide surplus material or other soil material not required or suitable for filling or backfilling, and brush, refuse, stumps, roots, and timber as removed from the project site as directed by the USAID Implementing Partner.

-- End of Section --

SECTION 31 05 19

GEOTEXTILE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D 4354	(1999; R 2009) Sampling of Geosynthetics for Testing
ASTM D 4355	(2007) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D 4491	(1999a; R 2004e1) Water Permeability of Geotextiles by Permittivity
ASTM D 4533	(2004; R 2009) Trapezoid Tearing Strength of Geotextiles
ASTM D 4632	(2008) Grab Breaking Load and Elongation of Geotextiles
ASTM D 4751	(2004) Determining Apparent Opening Size of a Geotextile
ASTM D 4759	(2002; R 2007) Determining the Specification Conformance of Geosynthetics
ASTM D 4833	(2007) Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
ASTM D 4873	(2002; R 2009) Identification, Storage, and Handling of Geosynthetic Rolls and Samples

1.2 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.

SD-03 Product Data

Thread

A minimum of 7 days prior to scheduled use, proposed thread type for sewn seams along with data sheets showing the physical properties of the thread.

Manufacturing Quality Control Sampling and Testing

A minimum of 7 days prior to scheduled use, manufacturer's quality control manual.

Securing Pins

SD-04 Samples

Quality Assurance Samples and Tests

Samples for quality assurance testing; assign 7 days in the schedule to allow for testing.

SD-07 Certificates

Geotextile

A minimum of 7 days prior to scheduled use, manufacturer's certificate of compliance stating that the geotextile meets the requirements of this section. For needle punched geotextiles, the manufacturer shall also certify that the geotextile has been continuously inspected using permanent on-line full-width metal detectors and does not contain any needles which could damage other geosynthetic layers. The certificate of compliance shall be attested to by a person having legal authority to bind the geotextile manufacturer.

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver, store, and handle geotextile in accordance with ASTM D 4873.

1.3.1 Delivery

Notify the USAID Implementing Partner a minimum of 24 hours prior to delivery and unloading of geotextile rolls packaged in an opaque, waterproof, protective plastic wrapping. The plastic wrapping shall not be removed until deployment. If quality assurance samples are collected, immediately rewrap rolls with the plastic wrapping. Geotextile or plastic wrapping damaged during storage or handling shall be repaired or replaced, as directed. Label each roll with the manufacturer's name, geotextile type, roll number, roll dimensions (length, width, gross weight), and date manufactured.

1.3.2 Storage

Protect rolls of geotextile from construction equipment, chemicals, sparks and flames, temperatures in excess of 71 degrees C, or any other environmental condition that may damage the physical properties of the geotextile. To protect geotextile from becoming saturated, either elevate rolls off the ground or place them on a sacrificial sheet of plastic in an area where water will not accumulate.

1.3.3 Handling

Handle and unload geotextile rolls with load carrying straps, a fork lift with a stinger bar, or an axial bar assembly. Rolls shall not be dragged along the ground, lifted by one end, or dropped to the ground.

PART 2 PRODUCTS

2.1 RAW MATERIALS

2.1.1 Geotextile

Provide geotextile that is a woven pervious sheet of polymeric material consisting of long-chain synthetic polymers composed of at least 95 percent by weight polyolefins, polyesters, or polyamides. The use of woven slit film geotextiles (i.e. geotextiles made from yarns of a flat, tape-like character) will not be allowed. Add stabilizers and/or inhibitors to the base polymer, as needed, to make the filaments resistant to deterioration by ultraviolet light, oxidation, and heat exposure. Regrind material, which consists of edge trimmings and other scraps that have never reached the consumer, may be used to produce the geotextile. Post-consumer recycled material may also be used. Geotextile shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including the edges. Geotextiles shall meet the requirements specified in Table 1. Where applicable, Table 1 property values represent minimum average roll values (MARV) in the weakest principal direction. Values for AOS represent maximum average roll values.

TABLE 1
MINIMUM PHYSICAL REQUIREMENTS FOR DRAINAGE GEOTEXTILE

PROPERTY	UNITS	ACCEPTABLE VALUES	TEST METHOD
GRAB STRENGTH	N	900	ASTM D 4632
PUNCTURE	N	400	ASTM D 4833
TRAPEZOID TEAR	N	330	ASTM D 4533
APPARENT OPENING SIZE	U.S. SIEVE	50	ASTM D 4751
PERMITTIVITY	SEC -1	0.05	ASTM D 4491
ULTRAVIOLET DEGRADATION	PERCENT	70 AT 500 HRS	ASTM D 4355

2.1.2 Thread

Construct sewn seams with high-strength polyester, nylon, or other approved thread type. Thread shall have ultraviolet light stability equivalent to the geotextile and the color shall contrast with the geotextile.

2.2 MANUFACTURING QUALITY CONTROL SAMPLING AND TESTING

The Manufacturer is responsible for establishing and maintaining a quality control program to assure compliance with the requirements of the specification. Documentation describing the quality control program shall be made available upon request. Perform manufacturing quality control sampling and testing in accordance with the manufacturer's approved quality control manual. As a minimum, geotextiles shall be randomly sampled for testing in accordance with ASTM D 4354, Procedure A. Acceptance of geotextile shall be in accordance with ASTM D 4759. Tests not meeting the

specified requirements will result in the rejection of applicable rolls.

2.3 SECURING PINS

Securing pins shall be 0.5 cm diameter stainless steel type 304 pins, pointed at one end and fabricated with a head to retain a stainless steel type 304 washer having an outside diameter of not less than 4 cm. The securing pin shall not be less than 45 cm in length. U-shaped pins will be permitted.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Surface Preparation

Prepare surface, on which the geotextile will be placed, to a relatively smooth surface condition in accordance with the applicable portion of these specifications and shall be free from obstruction, debris, depressions, ruts, protrusions, erosion features, or vegetation which could damage the geotextile. Remove any irregularities so as to ensure continuous, intimate contact of the geotextile with all the surface. Any loose material, soft or low density pockets of material, shall be removed. Subgrade materials and compaction requirements shall be in accordance with Section 31 00 00 EARTHWORK.

3.1.2 Placement

Geotextile rolls which are damaged or contain imperfections shall be repaired or replaced as directed. The geotextile shall be laid flat and smooth so that it is in direct contact with exposed faces of the excavation and material surfaces. The geotextile shall also be free of tensile stresses, folds, and wrinkles. No horizontal overlapped seams shall occur on the face of excavations, only vertical overlapped seams will be permitted.

3.2 SEAMS

3.2.1 Overlap Seams

Continuously overlap geotextile panels a minimum of 300 mm at all longitudinal and transverse joints. Where seams must be oriented across the slope, lap the upper panel over the lower panel. If approved, sewn seams may be used instead of overlapped seams.

3.3 PROTECTION

Protect the geotextile during installation from clogging, tears, and other damage. Damaged geotextile shall be repaired or replaced as directed. Use adequate ballast (e.g. sand bags) to prevent uplift by wind. The geotextile shall not be left uncovered for more than 14 days after installation.

3.4 SECURING PIN INSTALLATION

Secure the geotextile by pins to prevent movement prior to placement of materials. Remove securing pins as placement of materials proceeds to prevent tearing of geotextile or enlarging holes. Insert securing pins through both strips of overlapped geotextile along the line passing through

midpoints of the overlap. Maximum spacing between securing pins shall be 0.6 m. When windy conditions prevail at the construction site, increase the number of pins upon the demand of the USAID Implementing Partner.

3.5 REPAIRS

Repair torn or damaged geotextile. Clogged areas of geotextile shall be removed. Perform repairs by placing a patch of the same type of geotextile over the damaged area. The patch shall extend a minimum of 300 mm beyond the edge of the damaged area. Patches shall be continuously fastened using approved methods. The machine direction of the patch shall be aligned with the machine direction of the geotextile being repaired. Remove and replace geotextile rolls which cannot be repaired. Repairs shall be performed at the expense of the Contractor without additional compensation.

3.6 PENETRATIONS

Construct engineered penetrations of the geotextile by methods recommended by the geotextile manufacturer.

3.7 COVERING

Do not cover geotextile prior to inspection and approval by the USAID Implementing Partner. Place cover soil in a manner that prevents soil from entering the geotextile overlap zone, prevents tensile stress from being mobilized in the geotextile, and prevents wrinkles from folding over onto themselves. On side slopes, soil backfill shall be placed from the bottom of the slope upward. Cover soil shall not be dropped onto the geotextile from a height greater than 1 m. No equipment shall be operated directly on top of the geotextile without approval of the USAID Implementing Partner. Use equipment with ground pressures less than 50 kPa to place the first lift over the geotextile. A minimum of 300 mm of soil shall be maintained between full-scale construction equipment and the geotextile. Cover soil material type, compaction, and testing requirements are described in Section 31 00 00 EARTHWORK. Equipment placing cover soil shall not stop abruptly, make sharp turns, spin their wheels, or travel at speeds exceeding 2.2 m/s.

-- End of Section --

SECTION 32 01 19

FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C 509	(2006) Elastomeric Cellular Preformed Gasket and Sealing Material
ASTM D 5893	(2004) Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements
ASTM D 6690	(2007) Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements
ASTM D 789	(2007) Determination of Relative Viscosity and Moisture Content of Polyamide (PA)

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 525	(1989) Test Method for Evaluation of Hot-Applied Joint Sealants for Bubbling Due to Heating

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS SS-S-200	(Rev E; Am 2) Sealant, Joint, Two-Component, Jet-Blast-Resistant, Cold-Applied, for Portland Cement Concrete Pavement

1.2 SYSTEM DESCRIPTION

Machines, tools, and equipment used in the performance of the work required by this section shall be approved before the work is started and maintained in satisfactory condition at all times.

1.2.1 Joint Cleaning Equipment

1.2.1.1 Concrete Saw

Provide a self-propelled power saw, with water-cooled diamond or abrasive saw blades, for cutting joints to the depths and widths specified or for refacing joints or cleaning sawed joints where sandblasting does not provide a clean joint.

1.2.1.2 Hand Tools

Hand tools may be used, when approved, for removing defective sealant from a crack and repairing or cleaning the crack faces.

1.2.2 Sealing Equipment

1.2.2.1 Hot-Poured Sealing Equipment

The unit applicators used for heating and installing ASTM D 6690 joint sealant materials shall be mobile and shall be equipped with a double-boiler, agitator-type kettle with an oil medium in the outer space for heat transfer; a direct-connected pressure-type extruding device with a nozzle shaped for inserting in the joint to be filled; positive temperature devices for controlling the temperature of the transfer oil and sealant; and a recording type thermometer for indicating the temperature of the sealant. The applicator unit shall be designed so that the sealant will circulate through the delivery hose and return to the inner kettle when not in use.

1.2.2.2 Two-Component, Cold-Applied, Machine Mix Sealing Equipment

Provide equipment used for proportioning, mixing, and installing FS SS-S-200 Type M joint sealants designed to deliver two semifluid components through hoses to a portable mixer at a preset ratio of 1 to 1 by volume using pumps with an accuracy of plus or minus 5 percent for the quantity of each component. The reservoir for each component shall be equipped with mechanical agitation devices that will maintain the components in a uniform condition without entrapping air. Incorporate provisions to permit thermostatically controlled indirect heating of the components, when required. However, immediately prior to proportioning and mixing, the temperature of either component shall not exceed 32.2 degrees C. Provide screens near the top of each reservoir to remove any foreign particles or partially polymerized material that could clog fluid lines or otherwise cause misproportioning or improper mixing of the two components. Provide equipment capable of thoroughly mixing the two components through a range of application rates of 37.8 to 189 L per hour and through a range of application pressures from 345 kPa to 10.3 MPa as required by material, climatic, or operating conditions. Design the mixer for the easy removal of the supply lines for cleaning and proportioning of the components. The mixing head shall accommodate nozzles of different types and sizes as may be required by various operations. The dimensions of the nozzle shall be such that the nozzle tip will extend into the joint to allow sealing from the bottom of the joint to the top. Maintain the initially approved equipment in good working condition, serviced in accordance with the supplier's instructions, and unaltered in any way without obtaining prior approval.

1.2.2.3 Two-Component, Cold-Applied, Hand-Mix Sealing Equipment

Mixing equipment for FS SS-S-200 Type H sealants shall consist of a slow-speed electric drill or air-driven mixer with a stirrer in accordance with the manufacturer's recommendations.

1.2.2.4 Cold-Applied, Single-Component Sealing Equipment

The equipment for installing ASTM D 5893 single component joint sealants shall consist of an extrusion pump, air compressor, following plate, hoses, and nozzle for transferring the sealant from the storage container into the

joint opening. The dimension of the nozzle shall be such that the tip of the nozzle will extend into the joint to allow sealing from the bottom of the joint to the top. Maintain the initially approved equipment in good working condition, serviced in accordance with the supplier's instructions, and unaltered in any way without obtaining prior approval. Small hand-held air-powered equipment (i.e., caulking guns) may be used for small applications.

1.3 SUBMITTALS

Contractor shall submit the following using submittal procedures as specified in the Contract Documents.

SD-03 Product Data

Manufacturer's Recommendations

Printed copies of manufacturer's recommendations, prior to use on the project, where installation procedures, or any part thereof, are required to be in accordance with those recommendations. Installation of the material will not be allowed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

Equipment

List of proposed equipment to be used in performance of construction work including descriptive data, 15 days prior to use on the project.

SD-04 Samples

Materials

Samples of the materials (sealant, primer if required, and backup material), in sufficient quantity for testing and approval 15 days prior to the beginning of work. No material will be allowed to be used until it has been approved.

1.4 QUALITY ASSURANCE

1.4.1 Safety

Do not place joint sealant within 8 m of any liquid oxygen (LOX) equipment, LOX storage, or LOX piping. Thoroughly clean joints in this area and leave them unsealed.

1.4.2 Test Requirements

Test the joint sealant and backup or separating material for conformance with the referenced applicable material specification. Perform testing of the materials in an approved independent laboratory and submit certified copies of the test reports for approval 15 days prior to the use of the materials at the job site. Samples will be retained by the USAID Implementing Partner for possible future testing should the materials appear defective during or after application. Conformance with the requirements of the laboratory tests specified will not constitute final acceptance of the materials. Final acceptance will be based on the performance of the in-place materials.

1.4.3 Trial Joint Sealant Installation

Prior to the cleaning and sealing of the joints for the entire project, prepare a test section at least 60 m long using the specified materials and approved equipment, so as to demonstrate the proposed joint preparation and sealing of all types of joints in the project. Following the completion of the test section and before any other joint is sealed, inspect the test section to determine that the materials and installation meet the requirements specified. If it is determined that the materials or installation do not meet the requirements, remove the materials, and reclean and reseal the joints without additional compensation. When the test section meets the requirements, it may be incorporated into the permanent work. Prepare and seal all other joints in the manner approved for sealing the test section.

1.5 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the job site for defects, unload, and store them with a minimum of handling to avoid damage. Provide storage facilities at the job site for maintaining materials at the temperatures and conditions recommended by the manufacturer.

1.6 ENVIRONMENTAL REQUIREMENTS

The ambient air temperature and the pavement temperature within the joint wall shall be a minimum of 10 degrees C and rising at the time of application of the materials. Do not apply sealant if moisture is observed in the joint.

PART 2 PRODUCTS

2.1 SEALANTS

Materials for sealing cracks in the various paved areas are as indicated on the drawings.

Sealing Material

ASTM D 6690, Type II and COE CRD-C 525

ASTM D 5893

FS SS-S-200 Type H

2.2 PRIMERS

When primers are recommended by the manufacturer of the sealant, use them in accordance with the recommendation of the manufacturer.

2.3 BACKUP MATERIALS

Provide backup material that is a compressible, nonshrinking, nonstaining, nonabsorbing material, nonreactive with the joint sealant. The material shall have a melting point at least 3 degrees C greater than the pouring temperature of the sealant being used when tested in accordance with ASTM D 789. The material shall have a water absorption of not more than 5 percent of the sample weight when tested in accordance with ASTM C 509. The backup material shall be 25 plus or minus 5 percent larger in diameter

than the nominal width of the crack.

2.4 BOND BREAKING TAPES

Provide a bond breaking tape or separating material that is a flexible, nonshrinkable, nonabsorbing, nonstaining, and nonreacting adhesive-backed tape. The material shall have a melting point at least 3 degrees C greater than the pouring temperature of the sealant being used when tested in accordance with ASTM D 789. The bond breaker tape shall be approximately 3 mm wider than the nominal width of the joint and shall not bond to the joint sealant.

PART 3 EXECUTION

3.1 PREPARATION OF JOINTS

Immediately before the installation of the sealant, thoroughly clean the joints to remove all laitance, curing compound, filler, protrusions of hardened concrete, and old sealant from the sides and upper edges of the joint space to be sealed.

3.1.1 Existing Sealant Removal

Cut loose the in-place sealant from both joint faces and to the depth shown on the drawings. Depth shall be sufficient to accommodate any separating or backup material that is required to maintain the depth of new sealant to be installed. Prior to further cleaning operations, remove all loose old sealant remaining in the joint opening by blowing with compressed air. Hand tools may be required to remove sealant from random cracks. Chipping, spalling, or otherwise damaging the concrete will not be allowed.

3.1.2 Sawing

3.1.2.1 Refacing of Joints

Accomplish refacing of joints using a concrete saw to remove all residual old sealant and a minimum of concrete from the joint face to provide exposure of newly cleaned concrete, and, if required, to enlarge the joint opening to the width and depth shown on the drawings. Stiffen the blade with a sufficient number of suitable dummy (used) blades or washers. Thoroughly clean, immediately following the sawing operation, the joint opening using a water jet to remove all saw cuttings and debris.

3.1.2.2 Refacing of Random Cracks

Accomplish sawing of the cracks using a power-driven concrete saw. The saw blade shall be 152 mm or less in diameter to enable the saw to follow the trace of the crack. Stiffen the blade, as necessary, with suitable dummy (or used) blades or washers. Immediately following the sawing operation, thoroughly clean the crack opening using a water jet to remove all saw cuttings and debris.

3.1.3 Water Blasting

The newly exposed concrete joint faces and the pavement surfaces extending a minimum of 13 mm from the joint edges shall be waterblasted clean. Use a multiple-pass technique until the surfaces are free of dust, dirt, curing compound, filler, old sealant residue, or any foreign debris that might prevent the bonding of the sealant to the concrete. After final cleaning

and immediately prior to sealing, blow out the joints with compressed air and leave them completely free of debris and water.

3.1.4 Back-Up Material

When the joint opening is of a greater depth than indicated for the sealant depth, plug or seal off the lower portion of the joint opening using a back-up material to prevent the entrance of the sealant below the specified depth. Take care to ensure that the backup material is placed at the specified depth and is not stretched or twisted during installation.

3.1.5 Bond Breaking Tape

Where inserts or filler materials contain bitumen, or the depth of the joint opening does not allow for the use of a backup material, insert a bond breaker separating tape to prevent incompatibility with the filler materials and three-sided adhesion of the sealant. Securely bond the tape to the bottom of the joint opening so it will not float up into the new sealant.

3.1.6 Rate of Progress of Joint Preparation

Limit the stages of joint preparation, which include sandblasting, air pressure cleaning and placing of the back-up material to only that lineal distance that can be sealed during the same day.

3.2 PREPARATION OF SEALANT

3.2.1 Hot-Poured Sealants

Sealants conforming to ASTM D 6690 shall not be heated in excess of the safe heating temperature recommended by the manufacturer as shown on the sealant containers. Withdraw and waste sealant that has been overheated or subjected to application temperatures for over 4 hours or that has remained in the applicator at the end of the day's operation.

3.2.2 Type H Sealants

Mix the FS SS-S-200 Type H sealant components either in the container furnished by the manufacturer or a cylindrical metal container of volume approximately 50 percent greater than the package volume. Thoroughly mix the base material in accordance with the manufacturer's instructions. The cure component shall then be slowly added during continued mixing until a uniform consistency is obtained.

3.2.3 Single-Component, Cold-Applied Sealants

Inspect the ASTM D 5893 sealant and containers prior to use. Reject any materials that contain water, hard caking of any separated constituents, nonreversible jell, or materials that are otherwise unsatisfactory. Settlement of constituents in a soft mass that can be readily and uniformly remixed in the field with simple tools will not be cause for rejection.

3.3 INSTALLATION OF SEALANT

3.3.1 Time of Application

Seal joints immediately following final cleaning of the joint walls and following the placement of the separating or backup material. Open joints

that cannot be sealed under the conditions specified, or when rain interrupts sealing operations, shall be recleaned and allowed to dry prior to installing the sealant.

3.3.2 Sealing Joints

Immediately preceding, but not more than 15 m ahead of the joint sealing operations, perform a final cleaning with compressed air. Fill the joints from the bottom up to 3 mm plus or minus 1.5 mm below the pavement surface. Remove and discard excess or spilled sealant from the pavement by approved methods. Install the sealant in such a manner as to prevent the formation of voids and entrapped air. In no case shall gravity methods or pouring pots be used to install the sealant material. Traffic shall not be permitted over newly sealed pavement until authorized by the USAID Implementing Partner. When a primer is recommended by the manufacturer, apply it evenly to the joint faces in accordance with the manufacturer's instructions. Check the joints frequently to ensure that the newly installed sealant is cured to a tack-free condition within the time specified.

3.4 INSPECTION

3.4.1 Joint Cleaning

Inspect joints during the cleaning process to correct improper equipment and cleaning techniques that damage the concrete pavement in any manner. Cleaned joints will be approved prior to installation of the separating or back-up material and joint sealant.

3.4.2 Joint Sealant Application Equipment

Inspect the application equipment to ensure conformance to temperature requirements, proper proportioning and mixing (if two-component sealant) and proper installation. Evidences of bubbling, improper installation, failure to cure or set will be cause to suspend operations until causes of the deficiencies are determined and corrected.

3.4.3 Joint Sealant

Inspect the joint sealant for proper rate of cure and set, bonding to the joint walls, cohesive separation within the sealant, reversion to liquid, entrapped air and voids. Sealants exhibiting any of these deficiencies at any time prior to the final acceptance of the project shall be removed from the joint, wasted, and replaced as specified herein, without additional compensation.

3.5 CLEAN-UP

Upon completion of the project, remove all unused materials from the site and leave the pavement in a clean condition.

-- End of Section --

SECTION 32 11 23

AGGREGATE BASE COURSE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C 117	(2004) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 127	(2007) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C 128	(2007a) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C 131	(2006)Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C 29/C 29M	(2007) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM D 1556	(2007) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	(2007) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D 2167	(1994; R 2001) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D 2487	(2006) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 422	(1963; R 2007) Particle-Size Analysis of Soils
ASTM D 4318	(2005) Liquid Limit, Plastic Limit, and

	Plasticity Index of Soils
ASTM D 6938	(2007a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D 75	(2003) Standard Practice for Sampling Aggregates
ASTM E 11	(2004) Wire Cloth and Sieves for Testing Purposes

1.2 DEFINITIONS

For the purposes of this specification, the following definitions apply.

1.2.1 Aggregate Base Course

Aggregate base course (ABC) is well graded, durable aggregate uniformly moistened and mechanically stabilized by compaction.

1.2.2 Degree of Compaction

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum laboratory dry density obtained by the test procedure presented in ASTM D 1557 abbreviated as a percent of laboratory maximum dry density. Since ASTM D 1557 applies only to soils that have 30 percent or less by weight of their particles retained on the 19.0 mm sieve, the degree of compaction for material having more than 30 percent by weight of their particles retained on the 19.0 mm sieve are expressed as a percentage of the laboratory maximum dry density.

1.3 SYSTEM DESCRIPTION

All plant, equipment, and tools used in the performance of the work will be subject to approval before the work is started and shall be maintained in satisfactory working condition at all times. Provide adequate equipment having the capability of producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

1.4 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.

SD-03 Product Data

Plant, Equipment, and Tools

List of proposed equipment to be used in performance of construction work, including descriptive data.

SD-06 Test Reports

Sampling and Testing
Field Density Tests

Certified copies of test results for approval not less than 30 days before material is required for the work.

Calibration curves and related test results prior to using the device or equipment being calibrated.

Copies of field test results within 24 hours after the tests are performed.

1.5 QUALITY ASSURANCE

Sampling and testing are the responsibility of the Contractor and performed by a testing laboratory approved by the USAID Implementing Partner. Work requiring testing will not be permitted until the testing laboratory has been approved. Test the materials to establish compliance with the specified requirements; perform testing at the specified frequency. The USAID Implementing Partner may specify the time and location of the tests. Furnish copies of test results to the USAID Implementing Partner within 24 hours of completion of the tests.

1.5.1 Sampling

Take samples for laboratory testing in conformance with ASTM D 75. When deemed necessary, the sampling will be observed by the USAID Implementing Partner.

1.5.2 Tests

Perform the following tests in conformance with the applicable standards listed.

1.5.2.1 Sieve Analysis

Make sieve analysis in conformance with ASTM C 117 and ASTM C 136. Sieves shall conform to ASTM E 11. Particle-size analysis of the soils shall also be completed in conformance with ASTM D 422.

1.5.2.2 Liquid Limit and Plasticity Index

Determine liquid limit and plasticity index in accordance with ASTM D 4318.

1.5.2.3 Moisture-Density Determinations

Determine the laboratory maximum dry density and optimum moisture content in accordance with ASTM D 1557.

1.5.2.4 Field Density Tests

Measure field density in accordance with ASTM D 1556, ASTM D 2167 or ASTM D 6938. For the method presented in ASTM D 1556 use the base plate as shown in the drawing. For the method presented in ASTM D 6938 check the calibration curves and adjust them, if necessary, using only the sand cone method as described in paragraph Calibration, of the ASTM publication. Tests performed in accordance with ASTM D 6938 result in a wet unit weight of soil, and ASTM D 6938 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall also be checked along with density calibration checks as described in ASTM D 6938. The calibration checks of both the density and moisture gauges shall be made by the prepared containers of material method, as

described in paragraph Calibration of ASTM D 6938, on each different type of material being tested at the beginning of a job and at intervals as directed.

1.5.2.5 Wear Test

Perform wear tests on ABC coarse material in conformance with ASTM C 131.

1.5.3 Testing Frequency

1.5.3.1 Initial Tests

Perform one of each of the following tests, on the proposed material prior to commencing construction, to demonstrate that the proposed material meets all specified requirements when furnished. If materials from more than one source are going to be utilized, this testing shall be completed for each source.

a. Sieve Analysis including the 0.02 mm sieve.

b. Liquid limit and plasticity index.

c. Moisture-density relationship.

d. Wear.

e. Weight per cubic meter of Slag.

1.5.3.2 In-Place Tests

Perform each of the following tests on samples taken from the placed and compacted. Samples shall be taken and tested at the rates indicated.

a. Perform density tests on every lift of material placed and at a frequency of one set of tests for every 250 square meters, or portion thereof, of completed area.

b. Perform sieve analysis including the 0.02 mm sieve on every lift of material placed and at a frequency of one sieve analysis for every 500 square meters, or portion thereof, of material placed.

c. Perform liquid limit and plasticity index tests at the same frequency as the sieve analysis.

d. Measure the total thickness of the base course at intervals, in such a manner as to ensure one measurement for each 500 square meters of base course. Measurements shall be made in 75 mm diameter test holes penetrating the base course.

1.5.4 Approval of Material

Select the source of the material 30 days prior to the time the material will be required in the work. Approval of material will be based on initial test results. Final approval of the materials will be based on sieve analysis, liquid limit, and plasticity index tests performed on samples taken from the completed and fully compacted course(s).

1.6 ENVIRONMENTAL REQUIREMENTS

Perform construction when the atmospheric temperature is above 2 degrees C. When the temperature falls below 2 degrees C, protect all completed areas by approved methods against detrimental effects of freezing. Correct completed areas damaged by freezing, rainfall, or other weather conditions to meet specified requirements.

PART 2 PRODUCTS

2.1 AGGREGATES

Provide ABC consisting of clean, sound, durable particles of crushed stone, crushed slag, crushed gravel, angular sand, or other approved material. ABC shall be free of lumps of clay, organic matter, and other objectionable materials or coatings. The portion retained on the 4.75 mm sieve is known as coarse aggregate; that portion passing the 4.75 mm sieve is known as fine aggregate.

2.1.1 Coarse Aggregate

Provide coarse aggregates with angular particles of uniform density. When the coarse aggregate is supplied from more than one source, aggregate from each source shall meet the specified requirements and shall be stockpiled separately.

a. Crushed Gravel: Crushed gravel shall be manufactured by crushing gravels, and shall meet all the requirements specified below.

b. Crushed Stone: Provide crushed stone consisting of freshly mined quarry rock, meeting all the requirements specified below.

c. Crushed Slag: Crushed slag shall be an air-cooled blast-furnace product having an air dry unit weight of not less than 1120 kg/cubic meter as determined by ASTM C 29/C 29M, and shall meet all the requirements specified below.

2.1.1.1 Aggregate Base Course (ABC)

ABC coarse aggregate shall be hard durible crushed rock. The amount of flat and elongated particles shall not exceed 30 percent. A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. In the portion retained on each sieve specified, the crushed aggregates shall contain at least 50 percent by weight of crushed pieces having two or more freshly fractured faces with the area of each face being at least equal to 75 percent of the smallest midsectional area of the piece. When two fractures are contiguous, the angle between planes of the fractures must be at least 30 degrees in order to count as two fractured faces. Crushed gravel shall be manufactured from gravel particles 50 percent of which, by weight, are retained on the maximum size sieve listed in TABLE 1.

2.1.2 Fine Aggregate

Fine aggregates shall be angular particles of uniform density. When the fine aggregate is supplied from more than one source, aggregate from each source shall meet the specified requirements.

2.1.2.1 Aggregate Base Course

ABC fine aggregate shall consist of screenings, angular sand, crushed recycled concrete fines, or other finely divided mineral matter processed or naturally combined with the coarse aggregate.

2.1.3 Gradation Requirements

Apply the specified gradation requirements to the completed base course. The aggregates shall be continuously well graded within the limits specified in TABLE 1. Sieves shall conform to ASTM E 11.

TABLE 1. GRADATION OF AGGREGATES

Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	No. 1
50.0 mm	100
37.5 mm	70-100
25.0 mm	45-80
12.5 mm	30-60
4.75 mm	20-50
2.00 mm	15-40
0.425 mm	5-25
0.075 mm	0-8

NOTE 1: Particles having diameters less than 0.02 mm shall not be in excess of 3 percent by weight of the total sample tested.

NOTE 2: The values are based on aggregates of uniform specific gravity. If materials from different sources are used for the coarse and fine aggregates, they shall be tested in accordance with ASTM C 127 and ASTM C 128 to determine their specific gravities. If the specific gravities vary by more than 10 percent, the percentages passing the various sieves shall be corrected as directed by the USAID Implementing Partner.

2.2 LIQUID LIMIT AND PLASTICITY INDEX

Apply liquid limit and plasticity index requirements to the completed course and to any component that is blended to meet the required gradation. The portion of any component or of the completed course passing the 0.425 mm sieve shall be either nonplastic or have a liquid limit not greater than 25 and a plasticity index not greater than 5.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

When the ABC is constructed in more than one layer, clean the previously constructed layer of loose and foreign matter by sweeping. Provide adequate drainage during the entire period of construction to prevent water from collecting or standing on the working area. Provide line and grade stakes as necessary for control. Grade stakes shall be in lines parallel to the centerline of the area under construction and suitably spaced for

string lining.

3.2 OPERATION OF AGGREGATE SOURCES

Clearing, stripping, and excavating are the responsibility of the Contractor. Operate the aggregate sources to produce the quantity and quality of materials meeting the specified requirements in the specified time limit.

3.3 STOCKPILING MATERIAL

Clear and level storage sites prior to stockpiling of material. Stockpile all materials, including approved material available from excavation and grading, in the manner and at the locations designated. Aggregates shall be stockpiled on the cleared and leveled areas designated by the USAID Implementing Partner to prevent segregation. Materials obtained from different sources shall be stockpiled separately.

3.4 PREPARATION OF UNDERLYING COURSE

Prior to constructing the base course(s), the underlying course or subgrade shall be cleaned of all foreign substances. At the time of construction of the base course(s), the underlying course shall contain no frozen material. The surface of the underlying course or subgrade shall meet specified compaction and surface tolerances. The underlying course shall conform to Section 31 00 00 EARTHWORK. Ruts or soft yielding spots in the underlying courses, areas having inadequate compaction, and deviations of the surface from the requirements set forth herein shall be corrected by loosening and removing soft or unsatisfactory material and by adding approved material, reshaping to line and grade, and recompacting to specified density requirements. For cohesionless underlying courses containing sands or gravels, as defined in ASTM D 2487, the surface shall be stabilized prior to placement of the base course(s). Stabilization shall be accomplished by mixing ABC into the underlying course and compacting by approved methods. The stabilized material shall be considered as part of the underlying course and shall meet all requirements of the underlying course. The finished underlying course shall not be disturbed by traffic or other operations and shall be maintained in a satisfactory condition until the base course is placed.

3.5 INSTALLATION

3.5.1 Mixing the Materials

Mix the coarse and fine aggregates in a stationary plant, or in a traveling plant or bucket loader on an approved paved working area. Make adjustments in mixing procedures or in equipment, as directed, to obtain true grades, to minimize segregation or degradation, to obtain the required water content, and to insure a satisfactory base course meeting all requirements of this specification.

3.5.2 Placing

Place the mixed material on the prepared subgrade or subbase in layers of uniform thickness with an approved spreader. When a compacted layer 150 mm or less in thickness is required, place the material in a single layer. When a compacted layer in excess of 150 mm is required, place the material in layers of equal thickness. No layer shall be thicker than 150 mm or thinner than 75 mm when compacted. The layers shall be so placed that when

compacted they will be true to the grades or levels required with the least possible surface disturbance. Where the base course is placed in more than one layer, the previously constructed layers shall be cleaned of loose and foreign matter by sweeping with power sweepers, power brooms, or hand brooms, as directed. Such adjustments in placing procedures or equipment shall be made as may be directed to obtain true grades, to minimize segregation and degradation, to adjust the water content, and to insure an acceptable base course.

3.5.3 Grade Control

The finished and completed base course shall conform to the lines, grades, and cross sections shown. Underlying material(s) shall be excavated and prepared at sufficient depth for the required base course thickness so that the finished base course and the subsequent surface course will meet the designated grades.

3.5.4 Edges of Base Course

The base course(s) shall be placed so that the completed section will be a minimum of 600 mm wider, on all sides, than the next layer that will be placed above it. Additionally, place approved fill material along the outer edges of the base course in sufficient quantities to compact to the thickness of the course being constructed, or to the thickness of each layer in a multiple layer course, allowing in each operation at least a 600 mm width of this material to be rolled and compacted simultaneously with rolling and compacting of each layer of base course. If this base course material is to be placed adjacent to another pavement section, then the layers for both of these sections shall be placed and compacted along this edge at the same time.

3.5.5 Compaction

Compact each layer of the base course, as specified, with approved compaction equipment. Maintain water content during the compaction procedure to within plus or minus 2 percent of the optimum water content determined from laboratory tests as specified in paragraph QUALITY ASSURANCE. Begin rolling at the outside edge of the surface and proceed to the center, overlapping on successive trips at least one-half the width of the roller. Alternate trips of the roller shall be slightly different lengths. Speed of the roller shall be such that displacement of the aggregate does not occur. In all places not accessible to the rollers, the mixture shall be compacted with hand-operated power tampers. Continue compaction until each layer has a degree of compaction that is at least 95 percent of laboratory maximum density through the full depth of the layer. Make such adjustments in compacting or finishing procedures as may be directed to obtain true grades, to minimize segregation and degradation, to reduce or increase water content, and to ensure a satisfactory base course. Any materials that are found to be unsatisfactory shall be removed and replaced with satisfactory material or reworked, as directed, to meet the requirements of this specification.

3.5.6 Thickness

Construct the compacted thickness of the base course as indicated. No individual layer shall be thicker than 150 mm nor be thinner than 75 mm in compacted thickness. The total compacted thickness of the base course(s) shall be within 13 mm of the thickness indicated. Where the measured thickness is more than 13 mm deficient, correct such areas by scarifying,

adding new material of proper gradation, reblading, and recompacting as directed. Where the measured thickness is more than 13 mm thicker than indicated, the course shall be considered as conforming to the specified thickness requirements. Average job thickness shall be the average of all thickness measurements taken for the job, but shall be within 6 mm of the thickness indicated. The total thickness of the base course shall be measured at intervals in such a manner as to ensure one measurement for each 500 square meters of base course. Measurements shall be made in 75 mm diameter test holes penetrating the base course.

3.5.7 Finishing

The surface of the top layer of base course shall be finished after final compaction by cutting any overbuild to grade and rolling with a steel-wheeled roller. Thin layers of material shall not be added to the top layer of base course to meet grade. If the elevation of the top layer of base course is 13 mm or more below grade, then the top layer should be scarified to a depth of at least 75 mm and new material shall be blended in and compacted to bring to grade. Adjustments to rolling and finishing procedures shall be made as directed to minimize segregation and degradation, obtain grades, maintain moisture content, and insure an acceptable base course. Should the surface become rough, corrugated, uneven in texture, or traffic marked prior to completion, the unsatisfactory portion shall be scarified, reworked and recompacted or it shall be replaced as directed.

3.5.8 Smoothness

The surface of the top layer shall show no deviations in excess of 10 mm when tested with a 3.66 meter straightedge. Take measurements in successive positions parallel to the centerline of the area to be paved. Measurements shall also be taken perpendicular to the centerline at 15 meter intervals. Deviations exceeding this amount shall be corrected by removing material and replacing with new material, or by reworking existing material and compacting it to meet these specifications.

3.6 TRAFFIC

Completed portions of the base course may be opened to limited traffic, provided there is no marring or distorting of the surface by the traffic. Heavy equipment shall not be permitted except when necessary to construction, and then the area shall be protected against marring or damage to the completed work.

3.7 MAINTENANCE

Maintain the base course in a satisfactory condition until the full pavement section is completed and accepted. Maintenance shall include immediate repairs to any defects and shall be repeated as often as necessary to keep the area intact. Any base course that is not paved over prior to the onset of winter, shall be retested to verify that it still complies with the requirements of this specification. Any area of base course that is damaged shall be reworked or replaced as necessary to comply with this specification.

3.8 DISPOSAL OF UNSATISFACTORY MATERIALS

Refer to Section 31 00 00 EARTHWORK.

-- End of Section --

SECTION 32 13 13.06

PORTLAND CEMENT CONCRETE PAVEMENT FOR ROADS AND SITE FACILITIES

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACI INTERNATIONAL (ACI)

ACI 211.1	(1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 301	(2005; Errata 2008) Specifications for Structural Concrete
ACI 305R	(1999; Errata 2006) Hot Weather Concreting
ACI 306.1	(1990; R 2002) Standard Specification for Cold Weather Concreting

ASTM INTERNATIONAL (ASTM)

ASTM A 184/A 184M	(2006) Standard Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A 615/A 615M	(2009b) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A 966/A 966M	(2008) Standard Test Method for Magnetic Particle Examination of Steel Forgings Using Alternating Current
ASTM C 1077	(2009b) Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C 1260	(2007) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C 143/C 143M	(2009) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C 150/C 150M	(2009) Standard Specification for Portland Cement
ASTM C 171	(2007) Standard Specification for Sheet Materials for Curing Concrete

ASTM C 172	(2008) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C 231	(2009a) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 260	(2006) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C 309	(2007) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 31/C 31M	(2009) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C 33/C 33M	(2008) Standard Specification for Concrete Aggregates
ASTM C 494/C 494M	(2008a) Standard Specification for Chemical Admixtures for Concrete
ASTM C 78	(2009) Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C 94/C 94M	(2009a) Standard Specification for Ready-Mixed Concrete

1.2 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.

SD-03 Product Data

Curing materials

Admixtures

Dowel

Reinforcement

Submit a complete list of materials including type, brand and applicable reference specifications.

Cementitious Materials

SD-04 Samples

Field-Constructed Mockup

SD-05 Design Data

Concrete mix design

Thirty days minimum prior to concrete placement, submit a mix design, with applicable tests, for each strength and type of concrete for approval. Submit a complete list of materials including type; brand; source and amount of cement, fly ash, slag, and admixtures; and applicable reference specifications. Provide mix proportion data using at least three different water-cement ratios for each type of mixture, which will produce a range of strength encompassing those required for each class and type of concrete required. Submittal shall clearly indicate where each mix design will be used when more than one mix design is submitted. Obtain acknowledgement of approvals prior to concrete placement. Submit a new mix design for each material source change.

SD-06 Test Reports

Aggregate tests

Concrete slump tests

Air content tests

Flexural strength tests

Cementitious materials

SD-07 Certificates

Batch tickets

Cementitious materials

SD-11 Closeout Submittals

1.3 DELIVERY, STORAGE, AND HANDLING

ASTM C 94/C 94M.

1.4 QUALITY ASSURANCE

1.4.1 Required Information

Submit copies of laboratory test reports showing that the mix has been successfully tested to produce concrete with the properties specified and that mix will be suitable for the job conditions. The laboratory test reports shall include mill test and all other test for cementitious materials, aggregates, and admixtures. Provide maximum nominal aggregate size, gradation analysis, percentage retained and passing sieve, and a graph of percentage retained verses sieve size. Test reports shall be submitted along with the concrete mix design. Sampling and testing of materials, concrete mix design, sampling and testing in the field shall be performed by a commercial testing laboratory which conforms to ASTM C 1077. The laboratory shall be approved in writing by the USAID Implementing Partner.

1.4.2 Batch Tickets

ASTM C 94/C 94M. Submit mandatory batch ticket information for each load of ready-mixed concrete.

1.4.3 Field-Constructed Mockup

Install minimum 21 square meters to demonstrate typical joints, surface finish, texture, color, permeability, and standard of workmanship. When USAID Implementing Partner determines that mockup does not meet requirements, demolish and remove it from the site and install another until the mockup is accepted. Keep accepted mockup undisturbed during construction as a standard for judging completed paving. Accepted mockup may be incorporated into final work when approved by USAID Implementing Partner.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cementitious Materials

Cementitious materials in concrete mix shall be 50 percent non-portland cement pozzolanic materials by weight.

2.1.1.1 Cement

ASTM C 150/C 150M, Type I or II with maximum alkali content of 0.60%. Cement certificate shall include test results in accordance with ASTM C 150/C 150M, including equivalent alkalies indicated in the Supplementary Optional Chemical Requirements.

2.1.2 Water

Fresh, clean, and potable.

2.1.3 Aggregate

2.1.3.1 2.1.3.1 Alkali Reactivity Test

Aggregates to be used in all concrete shall be evaluated and tested by the Contractor for alkali-aggregate reactivity in accordance with ASTM C 1260. The types of aggregates shall be evaluated in a combination which matches the contractors' proposed mix design (including Class F fly ash or GGBF slag), utilizing the modified version of ASTM C 1260. Test results of the combination shall have a measured expansion of less than 0.08 percent at 16 days. Should the test data indicate an expansion of greater than 0.08%, the aggregate(s) shall be rejected and the contractor shall submit new aggregate sources for retesting or may submit additional test results incorporating Lithium Nitrate for consideration.

2.1.3.2 Fine Aggregates

ASTM C 33/C 33M.

2.1.3.3 Coarse Aggregates

ASTM C 33/C 33M.

2.1.4 Admixtures

ASTM C 494/C 494M: Type A, water reducing; Type B, retarding; Type C,

accelerating; Type D, water-reducing and retarding; and Type E, water-reducing and accelerating admixture. Do not use calcium chloride admixtures. Where not shown or specified, the use of admixtures is subject to written approval of the USAID Implementing Partner.

ASTM C 260: Air-entraining.

2.1.5 Reinforcement

2.1.5.1 Dowel Bars

Bars shall conform to ASTM A 615/A 615M, Grade 420 for plain billet-steel bars of the size and length indicated. Remove all burrs and projections from the bars.

2.1.5.2 Tie Bars

Bars shall be billet or axle steel deformed bars and conform to ASTM A 615/A 615M or ASTM A 966/A 966M Grade 420.

2.1.5.3 Reinforcement

Deformed steel bar mats shall conform to ASTM A 184/A 184M. Bar reinforcement shall conform to ASTM A 615/A 615M, Grade 300.

2.1.6 Curing Materials

2.1.6.1 White-Burlap-Polyethylene Sheet

ASTM C 171, 0.10 mm thick white opaque polyethylene bonded to 0.31 kg per meter (1.0 meter) wide burlap.

2.1.6.2 Liquid Membrane-Forming Compound

ASTM C 309, white pigmented, Type 2, Class B, free of paraffin or petroleum.

2.1.6.3 Liquid Chemical Sealer-Hardener Compound

Compound shall be magnesium fluosilicate which when mixed with water seals and hardens the surface of the concrete. Do not use on exterior slabs exposed to freezing conditions. Compound shall not reduce the adhesion of resilient flooring, tile, paint, roofing, waterproofing, or other material applied to concrete.

2.1.7 Joint Fillers and Sealants

Provide as specified in Section 32 01 19 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS. New joints shall match existing alignment.

2.2 CONTRACTOR-FURNISHED MIX DESIGN

Contractor-furnished mix design concrete shall be designed in accordance with ACI 211.1 except as modified herein, and the mix design shall be as specified herein under paragraph entitled "Submittals." The concrete shall have a minimum flexural strength of 4.48 MPa at 90 days. The concrete may be air entrained. If air entrainment is used the air content shall be 5.0 plus or minus 1.5 percent. Maximum size aggregate for slip forming shall be 38 mm. The minimum cementitious factor is 335 kg per cubic meter and slump shall be 25 mm to 75 mm (or less when slip form is used.

If the cementitious material is not sufficient to produce concrete of the flexural strength required it shall be increased as necessary, without additional compensation under the contract. The cementitious factor shall be calculated using cement, Class F fly ash, and or GGBF slag. The mix shall use a cement replacement (by weight) of 25%-35% Class F fly ash, or 40%-50% GGBF slag, or a combination of the two. In the combination, each 5% of Class F fly ash shall be replaced by 8% GGBF slag.

PART 3 EXECUTION

3.1 FORMS

3.1.1 Construction

Construct forms to be removeable without damaging the concrete.

3.1.2 Coating

Before placing the concrete, coat the contact surfaces of forms except existing pavement sections where bonding is required, with a non-staining mineral oil, non-staining form coating compound, or two coats of nitro-cellulose lacquer. When using existing pavement as a form, clean existing concrete and then coat with asphalt emulsion bondbreaker before concrete is placed.

3.1.3 Grade and Alignment

Check and correct grade elevations and alignment of the forms immediately before placing the concrete.

3.2 REINFORCEMENT

3.2.1 Dowel Bars

Install bars accurately aligned, vertically and horizontally, at indicated locations and to the dimensions and tolerances indicated. Before installation thoroughly grease the sliding portion of each dowel. Dowels must remain in position during concrete placement and curing.

3.2.2 Tie Bars

Install bars, accurately aligned horizontally and vertically, at indicated locations. For slipform construction, insert bent tie bars by hand or other approved means.

3.2.3 Setting Slab Reinforcement

Reinforcement shall be positioned on suitable chairs prior to concrete placement. At expansion, contraction and construction joints, place the reinforcement as indicated. Reinforcement, when placed in concrete, shall be free of mud, oil, scale or other foreign materials. Place reinforcement accurately and wire securely. The laps at splices shall be 300 mm minimum and the distances from ends and sides of slabs and joints shall be as indicated.

3.3 MEASURING, MIXING, CONVEYING, AND PLACING CONCRETE

3.3.1 Measuring

ASTM C 94/C 94M.

3.3.2 Mixing

Begin mixing within 30 minutes after cement has been added to aggregates. When the air temperature is greater than 29.4 degrees C, reduce mixing time and place concrete within 60 minutes. Additional water may be added to bring slump within required limits as specified in Section 11.7 of ASTM C 94/C 94M, provided that the specified water-cement ratio is not exceeded.

3.3.3 Placing

Follow guidance of ACI 301, except as modified herein. Do not exceed a free vertical drop of 0.90 m from the point of discharge. Place concrete continuosly at a uniform rate, with minimum amount of segregation, without damage to the grade and without unscheduled stops except for equipment failure or other emegencies. If this occurs within 3 m of a previously placed expansion joint, remove concrete back to joint, repair any damage to grade, install a construction joint and continue placing concrete only after cause of the stop has been corrected.

3.3.4 Vibration

Immediately after spreading concrete, consolidate concrete with internal type vibrating equipment along the boundaries of all slabs regardless of slab thickness, and interior of all concrete slabs 150 mm or more in thickness. Limit duration of vibration to that necessary to produce consolidation of concrete. Excessive vibration will not be permitted. Vibrators shall not be operated in concrete at one location for more than 15 seconds. At the option of the Contractor, vibrating equipment of a type approved by the USAID Implementing Partner may be used to consolidate concrete in unreinforced pavement slabs less than 150 mm thick.

3.3.4.1 Vibrating Equipment

Operate equipment, except hand-manipulated equipment, ahead of the finishing machine. Select the number of vibrating units and power of each unit to properly consolidate the concrete. Mount units on a frame that is capable of vertical movement and, when necessary, radial movement, so vibrators may be operated at any desired depth within the slab or be completely withdrawn from the concrete. Clear distance between frame-mounted vibrating units that have spuds that extend into the slab at intervals across the paving lane shall not exceed 750 mm. Distance between end of vibrating tube and side form shall not exceed 50 mm. For pavements less than 250 mm thick, operate vibrators at mid-depth parallel with or at a slight angle to the subbase. For thicker pavements, angle vibrators toward the vertical, with vibrator tip preferably about 50 mm from subbase, and top of vibrator a few mm below pavement surface. Vibrators may be pneumatic, gas driven, or electric, and shall be operated at frequencies within the concrete of not less than 8,000 vibrations per minute. Amplitude of vibration shall be such that noticeable vibrations occur at 450 mm radius when the vibrator is inserted in the concrete to the depth specified.

3.3.5 Cold Weather

Except with authorization, do not place concrete when ambient temperature is below 5 degrees C or when concrete is likely to be subjected to freezing temperatures within 24 hours. When authorized, when concrete is likely to be subjected to freezing within 24 hours after placing, heat concrete materials so that temperature of concrete when deposited is between 18 and 27 degrees C. Methods of heating materials are subject to approval of the USAID Implementing Partner. Do not heat mixing water above 74 degrees C. Remove lumps of frozen material and ice from aggregates before placing aggregates in mixer. Follow practices found in ACI 306.1.

3.3.6 Hot Weather

Maintain required concrete temperature in accordance with Figure 2.1.5 in ACI 305R to prevent evaporation rate from exceeding 0.98 kg of water per square meter of exposed concrete per hour. Cool ingredients before mixing or use other suitable means to control concrete temperature and prevent rapid drying of newly placed concrete. After placement, use fog spray, apply monomolecular film, or use other suitable means to reduce the evaporation rate. Start curing when surface of fresh concrete is sufficiently hard to permit curing without damage. Cool underlying material by sprinkling lightly with water before placing concrete. Follow practices found in ACI 305R.

3.4 PAVING

Pavement shall be constructed with paving and finishing equipment utilizing fixed forms.

3.4.1 Consolidation

The paver vibrators shall be inserted into the concrete not closer to the underlying material than 50 mm. The vibrators or any tamping units in front of the paver shall be automatically controlled so that they shall be stopped immediately as forward motion ceases. Excessive vibration shall not be permitted. Concrete in small, odd-shaped slabs or in locations inaccessible to the paver mounted vibration equipment shall be vibrated with a hand-operated immersion vibrator. Vibrators shall not be used to transport or spread the concrete.

3.4.2 Operation

When the paver is operated between or adjacent to previously constructed pavement (fill-in lanes), provisions shall be made to prevent damage to the previously constructed pavement, including keeping the existing pavement surface free of any debris, and placing rubber mats beneath the paver tracks. Transversely oscillating screeds and extrusion plates shall overlap the existing pavement the minimum possible, but in no case more than 200 mm.

3.4.3 Required Results

The paver-finisher shall be operated to produce a thoroughly consolidated slab throughout, true to line and grade within specified tolerances. The paver-finishing operation shall produce a surface finish free of irregularities, tears, voids of any kind, and any other discontinuities. It shall produce only a very minimum of paste at the surface. Multiple passes of the paver-finisher shall not be permitted. The equipment and its

operation shall produce a finished surface requiring no hand finishing, other than the use of cutting straightedges, except in very infrequent instances. No water, other than true fog sprays (mist), shall be applied to the concrete surface during paving and finishing.

3.4.4 Fixed Form Paving

Forms shall be steel, except that wood forms may be used for curves having a radius of 45 m or less, and for fillets. Forms may be built up with metal or wood, added only to the base, to provide an increase in depth of not more than 25 percent. The base width of the form shall be not less than eight-tenths of the vertical height of the form, except that forms 200 mm or less in vertical height shall have a base width not less than the vertical height of the form. Wood forms for curves and fillets shall be adequate in strength and rigidly braced. Forms shall be set on firm material cut true to grade so that each form section when placed will be firmly in contact with the underlying layer for its entire base. Forms shall not be set on blocks or on built-up spots of underlying material. Forms shall remain in place at least 12 hours after the concrete has been placed. Forms shall be removed without injuring the concrete.

3.4.5 Placing Reinforcing Steel

Reinforcement shall be positioned on suitable chairs securely fastened to the subgrade prior to concrete placement.

3.4.6 Placing Dowels and Tie Bars

Dowels shall be installed with alignment not greater than 1 mm per 100 mm. Except as otherwise specified below, location of dowels shall be within a horizontal tolerance of plus or minus 15 mm and a vertical tolerance of plus or minus 5 mm. The portion of each dowel intended to move within the concrete or expansion cap shall be painted with one coat of rust inhibiting primer paint, and then oiled just prior to placement. Dowels and tie bars in joints shall be omitted when the center of the dowel tie bar is located within a horizontal distance from an intersecting joint equal to or less than one-fourth of the slab thickness.

3.4.6.1 Contraction Joints

Dowels and tie bars in longitudinal and transverse contraction joints within the paving lane shall be held securely in place by means of rigid metal basket assemblies. The dowels and tie bars shall be welded to the assembly or held firmly by mechanical locking arrangements that will prevent them from becoming distorted during paving operations. The basket assemblies shall be held securely in the proper location by means of suitable anchors.

3.4.6.2 Construction Joints-Fixed Form Paving

Installation of dowels and tie bars shall be by the bonded-in-place method, supported by means of devices fastened to the forms. Installation by removing and replacing in preformed holes will not be permitted.

3.4.6.3 Dowels Installed in Hardened Concrete

Installation shall be by bonding the dowels into holes drilled into the hardened concrete. Holes approximately 3 mm greater in diameter than the dowels shall be drilled into the hardened concrete. Dowels shall be bonded

in the drilled holes using epoxy resin injected at the back of the hole before installing the dowel and extruded to the collar during insertion of the dowel so as to completely fill the void around the dowel. Application by buttering the dowel shall not be permitted. The dowels shall be held in alignment at the collar of the hole, after insertion and before the grout hardens, by means of a suitable metal or plastic collar fitted around the dowel. The vertical alignment of the dowels shall be checked by placing the straightedge on the surface of the pavement over the top of the dowel and measuring the vertical distance between the straightedge and the beginning and ending point of the exposed part of the dowel. Where tie bars are required in longitudinal construction joints of slipform pavement, bent tie bars shall be installed at the paver, in front of the transverse screed or extrusion plate. If tie bars are required, a standard keyway shall be constructed, and the bent tie bars shall be inserted into the plastic concrete through a 0.45 to 0.55 mm thick metal keyway liner. Tie bars shall not be installed in preformed holes. The keyway liner shall be protected and shall remain in place and become part of the joint. Before placement of the adjoining paving lane, the tie bars shall be straightened, without spalling the concrete around the bar.

3.4.6.4 Expansion Joints

Dowels in expansion joints shall be installed by the bonded-in-place method or by bonding into holes drilled in hardened concrete, using procedures specified above.

3.5 FINISHING CONCRETE

Start finishing operations immediately after placement of concrete. Use finishing machine, except hand finishing may be used in emergencies and for concrete slabs in inaccessible locations or of such shapes or sizes that machine finishing is impracticable. Finish pavement surface on both sides of a joint to the same grade. Finish formed joints from a securely supported transverse bridge. Provide hand finishing equipment for use at all times. Transverse and longitudinal surface tolerances shall be 6 mm in 3 m.

3.5.1 Side Form Finishing

Strike off and screed concrete to the required slope and cross-section by a power-driven transverse finishing machine. Transverse rotating tube or pipe shall not be permitted unless approved by the USAID Implementing Partner. Elevation of concrete shall be such that, when consolidated and finished, pavement surface will be adequately consolidated and at the required grade. Equip finishing machine with two screeds which are readily and accurately adjustable for changes in pavement slope and compensation for wear and other causes. Make as many passes over each area of pavement and at such intervals as necessary to give proper compaction, retention of coarse aggregate near the finished surface, and a surface of uniform texture, true to grade and slope. Do not permit excessive operation over an area, which will result in an excess of mortar and water being brought to the surface.

3.5.1.1 Equipment Operation

Maintain the travel of machine on the forms without lifting, wobbling, or other variation of the machine which tend to affect the precision of concrete finish. Keep the tops of the forms clean by a device attached to the machine. During the first pass of the finishing machine, maintain a

uniform ridge of concrete ahead of the front screed for its entire length.

3.5.1.2 Joint Finish

Before concrete is hardened, correct edge slump of pavement, exclusive of edge rounding, in excess of 6 mm. Finish concrete surface on each side of construction joints to the same plane, and correct deviations before newly placed concrete has hardened.

3.5.1.3 Hand Finishing

Strike-off and screed surface of concrete to elevations slightly above finish grade so that when concrete is consolidated and finished pavement surface is at the indicated elevation. Vibrate entire surface until required compaction and reduction of surface voids is secured with a strike-off template.

3.5.1.4 Longitudinal Floating

After initial finishing, further smooth and consolidate concrete by means of hand-operated longitudinal floats. Use floats that are not less than 3.65 m long and 150 mm wide and stiffened to prevent flexing and warping.

3.5.2 Texturing

Before the surface sheen has disappeared and before the concrete hardens, the surface of the pavement shall be given a texture as described herein. Following initial texturing on the first day of placement, the Placing Foreman, USAID Implementing Partner representative, and a representative of the facility owner shall inspect the texturing for compliance with design requirements. After curing is complete, all textured surfaces shall be thoroughly power broomed to remove all debris. Any type of transverse texturing shall produce grooves in straight lines across each lane within a tolerance of plus or minus 13 mm of a true line. The concrete in areas of recesses for tie-down anchors, lighting fixtures, and other outlets in the pavement shall be finished to provide a surface of the same texture as the surrounding area.

3.5.2.1 Burlap Drag Finish

Before concrete becomes non-plastic, finish the surface of the slab by dragging on the surface a strip of clean, wet burlap measuring from 0.91 to 3 m long and 600 mm wider than the width of the pavement. Select dimension of burlap drag so that at least 0.91 m of the material is in contact with the pavement. Drag the surface so as to produce a finished surface with a fine granular or sandy texture without leaving disfiguring marks.

3.5.2.2 Brooming

Finish the surface of the slab by brooming the surface with a new wire broom at least 450 mm wide. Gently pull the broom over the surface of the pavement from edge to edge just before the concrete becomes non-plastic. Slightly overlap adjacent strokes of the broom. Broom perpendicular to centerline of pavement so that corrugations produced will be uniform in character and width, and not more than 2 mm in depth. Broomed surface shall be free from porous spots, irregularities, depressions, and small pockets or rough spots such as may be caused by accidentally disturbing particles of coarse aggregate embedded near the surface.

3.5.2.3 Wire-Comb Texturing

Surface texture transverse to the pavement center line shall be applied using a mechanical wire comb drag. The comb shall be capable of traversing the full width of the pavement in a single pass at a uniform speed and with a uniform pressure. Successive passes of the comb shall be overlapped the minimum necessary to obtain a continuous and uniformly textured surface. The scores shall be 2 to 5 mm deep, 1.5 to 3 mm wide, and spaced 10 mm apart.

3.5.2.4 Surface Grooving

The areas indicated on the drawings shall be grooved with a spring tine drag producing individual grooves 6 mm deep and 6 mm wide at a spacing between groove centerlines of 50 mm. These grooves shall be cut perpendicular to the centerline. Before grooving begins, the concrete shall be allowed to stiffen sufficiently to prevent dislodging of aggregate. Grooves shall not be cut within 150 mm of a transverse joint or crack.

3.5.3 Edging

At the time the concrete has attained a degree of hardness suitable for edging, carefully finish slab edges, including edges at formed joints, with an edge having a maximum radius of 3 mm. When brooming is specified for the final surface finish, edge transverse joints before starting brooming, then operate broom to obliterate as much as possible the mark left by the edging tool without disturbing the rounded corner left by the edger. Clean by removing loose fragments and soupy mortar from corners or edges of slabs which have crumbled and areas which lack sufficient mortar for proper finishing. Refill voids solidly with a mixture of suitable proportions and consistency and refinish. Remove unnecessary tool marks and edges. Remaining edges shall be smooth and true to line.

3.5.4 Repair of Surface Defects

Follow guidance of ACI 301.

3.6 CURING AND PROTECTION

Protect concrete adequately from injurious action by sun, rain, flowing water, frost, mechanical injury, tire marks and oil stains, and do not allow it to dry out from the time it is placed until the expiration of the minimum curing periods specified herein. Use White-Burlap-Polyethylene Sheet or liquid membrane-forming compound, except as specified otherwise herein. Do not use membrane-forming compound on surfaces where its appearance would be objectionable, on surfaces to be painted, where coverings are to be bonded to concrete, or on concrete to which other concrete is to be bonded. Maintain temperature of air next to concrete above 5 degrees C for the full curing periods.

3.6.1 White-Burlap-Polyethylene Sheet

Wet entire exposed surface thoroughly with a fine spray of water, saturate burlap but do not have excessive water dripping off the burlap and then cover concrete with White-Burlap-Polyethylene Sheet, burlap side down. Lay sheets directly on concrete surface and overlap 300 mm. Make sheeting not less than 450 mm wider than concrete surface to be cured, and weight down on the edges and over the transverse laps to form closed joints. Repair or

replace sheets when damaged during curing. Check daily to assure burlap has not lost all moisture. If moisture evaporates, resaturate burlap and re-place on pavement (re-saturation and re-placing shall take no longer than 10 minutes per sheet). Leave sheeting on concrete surface to be cured for at least 7 days.

3.6.2 Liquid Membrane-Forming Compound Curing

Apply compound immediately after surface loses its water sheen and has a dull appearance and before joints are sawed. Agitate curing compound thoroughly by mechanical means during use and apply uniformly in a two-coat continuous operation by suitable power-spraying equipment. Total coverage for the two coats shall be at least 4 liters of undiluted compound per 20 square meters. Compound shall form a uniform, continuous, coherent film that will not check, crack, or peel and shall be free from pinholes or other imperfections. Apply an additional coat of compound immediately to areas where film is defective. Respray concrete surfaces that are subject to heavy rainfall within 3 hours after curing compound has been applied in the same manner.

3.6.2.1 Protection of Treated Surfaces

Keep concrete surfaces to which liquid membrane-forming compounds have been applied free from vehicular traffic and other sources of abrasion for not less than 72 hours. Foot traffic is allowed after 24 hours for inspection purposes. Maintain continuity of coating for entire curing period and repair damage to coating immediately.

3.6.3 Liquid Chemical Sealer-Hardener

Apply sealer-hardener to interior floors not receiving floor covering and floors located under access flooring. Apply the sealer-hardener in accordance with manufacturer's recommendations. Seal or cover joints and openings in which joint sealant is to be applied as required by the joint sealant manufacturer. The sealer-hardener shall not be applied until the concrete has been moist cured and has aged for a minimum of 30 days. Apply a minimum of two coats of sealer-hardener.

3.7 FIELD QUALITY CONTROL

3.7.1 Sampling

The Contractor's approved laboratory shall collect samples of fresh concrete in accordance with ASTM C 172 during each working day as required to perform tests specified herein. Make test specimens in accordance with ASTM C 31/C 31M.

3.7.2 Consistency Tests

The Contractor's approved laboratory shall perform concrete slump tests in accordance with ASTM C 143/C 143M. Take samples for slump determination from concrete during placement. Perform tests at the beginning of a concrete placement operation and and for each batch (minimum) or every 16 cubic meters (maximum) of concrete to ensure that specification requirements are met. In addition, perform tests each time test beams and cylinders are made.

3.7.3 Flexural Strength Tests

The Contractor's approved laboratory shall test for flexural strength in accordance with ASTM C 78. Make four test specimens for each set of tests. Test two specimens at 7 days, and the other two at 28 days. Concrete strength will be considered satisfactory when the minimum of the 28 -day test results equals or exceeds the specified 28-day flexural strength, and no individual strength test is less than 3.79 MPa. If the ratio of the 7-day strength test to the specified 28-day strength is less than 65 percent, make necessary adjustments for conformance. Frequency of flexural tests on concrete beams shall be not less than four test beams for each 38 cubic meters of concrete, or fraction thereof, placed. Concrete which is determined to be defective, based on the strength acceptance criteria therein, shall be removed and replaced with acceptable concrete.

3.7.4 Air Content Tests

Test air-entrained concrete for air content at the same frequency as specified for slump tests. Determine percentage of air in accordance with ASTM C 231 on samples taken during placement of concrete in forms.

3.7.5 Surface Testing

Surface testing for surface smoothness and plan grade shall be performed as indicated below by the Testing Laboratory. The measurements shall be properly referenced in accordance with paving lane identification and stationing, and a report given to the USAID Implementing Partner within 24 hours after measurement is made. A final report of surface testing, signed by a Registered Engineer, containing all surface measurements and a description of all actions taken to correct deficiencies, shall be provided to the USAID Implementing Partner upon conclusion of surface testing.

3.7.5.1 Surface Smoothness Requirements

The finished surfaces of the pavements shall have no abrupt change of 3 mm or more, and all pavements shall be within the tolerances specified when checked with a 4 meter straightedge: 5 mm longitudinal and 6.5 mm transverse directions for roads and streets and 6.5 mm for both directions for other concrete surfaces, such as parking areas.

3.7.5.2 Surface Smoothness Testing Method

The surface of the pavement shall be tested with the straightedge to identify all surface irregularities exceeding the tolerances specified above. The entire area of the pavement shall be tested in both a longitudinal and a transverse direction on parallel lines approximately 4.5 m apart. The straightedge shall be held in contact with the surface and moved ahead one-half the length of the straightedge for each successive measurement. The amount of surface irregularity shall be determined by placing the straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length and measuring the maximum gap between the straightedge and the pavement surface, in the area between these two high points.

3.7.6 Plan Grade Testing and Conformance

The surfaces shall vary not more than 18 mm above or below the plan grade line or elevation indicated. Each pavement category shall be checked by the Contractor for conformance with plan grade requirements by running

lines of levels at intervals to determine the elevation at each joint intersection.

3.7.7 Test for Pavement Thickness

Measure during concrete placement to determine in-place thickness of concrete pavement.

3.7.8 Reinforcement

Inspect reinforcement prior to installation to assure it is free of loose flaky rust, loose scale, oil, mud, or other objectionable material.

3.7.9 Dowels

Inspect dowel placement prior to placing concrete to assure that dowels are of the size indicated, and are spaced, aligned and painted and oiled as specified. Dowels shall not deviate from vertical or horizontal alignment after concrete has been placed by more than 3 mm per 300 mm.

-- End of Section --

SECTION 32 15 00

AGGREGATE SURFACE COURSE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C 117	(2004) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 131	(2006)Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D 1556	(2007) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	(2007) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D 2167	(1994; R 2001) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D 3740	(2008) Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
ASTM D 422	(1963; R 2007) Particle-Size Analysis of Soils
ASTM D 4318	(2005) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D 6938	(2007a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D 75	(2003) Standard Practice for Sampling Aggregates

ASTM E 11 (2004) Wire Cloth and Sieves for Testing Purposes

1.2 SUBMITTALS

Contractor shall submit the following using submittal procedures as specified in the Contract Documents.

SD-03 Product Data

Equipment

List of proposed equipment to be used in performance of construction work including descriptive data.

SD-06 Test Reports

Sampling and Testing
Density Tests

Calibration curves and related test results prior to using the device or equipment being calibrated. Copies of field test results within 24 hours after the tests are performed. Test results from samples, not less than 30 days before material is required for the work. Results of laboratory tests for quality control purposes, for approval, prior to using the material.

1.3 QUALITY ASSURANCE

Sampling and testing is the responsibility of the Contractor. Sampling and testing shall be performed by an approved commercial testing laboratory or by the Contractor, subject to approval. If the Contractor elects to establish its own testing facilities, approval of such facilities will be based on compliance with ASTM D 3740. No work requiring testing will be permitted until the Contractor's facilities have been inspected and approved.

1.3.1 Sampling

Take samples for material gradation, liquid limit, and plastic limit tests in conformance with ASTM D 75. When deemed necessary, the sampling will be observed by the USAID Implementing Partner.

1.3.2 Testing

1.3.2.1 Gradation

Make aggregate gradation in conformance with ASTM C 117, ASTM C 136, and ASTM D 422. Sieves shall conform to ASTM E 11.

1.3.2.2 Liquid Limit and Plasticity Index

Determine liquid limit and plasticity index in accordance with ASTM D 4318.

1.3.3 Approval of Materials

Select the source of the material to be used for producing aggregates 30 days prior to the time the material will be required in the work. Tentative approval of materials will be based on appropriate test results

on the aggregate source. Final approval of the materials will be based on tests for gradation, liquid limit, and plasticity index performed on samples taken from the completed and compacted surface course.

1.3.4 Equipment

All plant, equipment, and tools used in the performance of the work covered by this section will be subject to approval by the USAID Implementing Partner before the work is started and shall be maintained in satisfactory working condition at all times. The equipment shall be adequate and shall have the capability of producing the required compaction, and meeting the grade controls, thickness controls, and smoothness requirements set forth herein.

1.4 ENVIRONMENTAL REQUIREMENTS

Aggregate surface courses shall not be constructed when the ambient temperatures is below 2 degrees C and on subgrades that are frozen or contain frost. It is the responsibility of the Contractor to protect, by approved method or methods, all areas of surfacing that have not been accepted by the USAID Implementing Partner. Surfaces damaged by freeze, rainfall, or other weather conditions shall be brought to a satisfactory condition by the Contractor.

PART 2 PRODUCTS

2.1 AGGREGATES

Provide aggregates consisting of clean, sound, durable particles of natural gravel, crushed gravel, crushed stone, sand, soil, or other approved materials processed and blended or naturally combined. Provide aggregates free from lumps and balls of clay, organic matter, objectionable coatings, and other foreign materials. The Contractor is responsible for obtaining materials that meet the specification and can be used to meet the grade and smoothness requirements specified herein after all compaction and proof rolling operations have been completed.

2.1.1 Coarse Aggregates

The material retained on the 4.75 mm sieve shall be known as coarse aggregate. Coarse aggregates shall be reasonably uniform in density and quality. The coarse aggregate shall have a percentage of wear not to exceed 50 percent after 500 revolutions as determined by ASTM C 131. The amount of flat and/or elongated particles shall not exceed 20 percent. A flat particle is one having a ratio of width to thickness greater than three; an elongated particle is one having a ratio of length to width greater than three. When the coarse aggregate is supplied from more than one source, aggregate from each source shall meet the requirements set forth herein.

2.1.2 Fine Aggregates

The material passing the 4.75 mm sieve shall be known as fine aggregate. Fine aggregate shall consist of screenings, sand, soil, or other finely divided mineral matter that is processed or naturally combined with the coarse aggregate.

2.1.3 Gradation Requirements

Gradation requirements specified in TABLE I shall apply to the completed aggregate surface. It is the responsibility of the Contractor to obtain materials that will meet the gradation requirements after mixing, placing, compacting, and other operations. TABLE I shows permissible grading for granular material used in aggregate surface roads and airfields. Sieves shall conform to ASTM E 11.

TABLE I. GRADATION FOR AGGREGATE SURFACE COURSES

Sieve Designation	No. 1
25.0 mm	100
9.5 mm	50-85
4.7 mm	35-65
2.00 mm	25-50
0.425 mm	15-30
0.075 mm	8-15

2.2 LIQUID LIMIT AND PLASTICITY INDEX REQUIREMENTS

The portion of the completed aggregate surface course passing the 0.425 mm sieve shall have a maximum liquid limit of 35 and a plasticity index of 4 to 9.

PART 3 EXECUTION

3.1 OPERATION OF AGGREGATE SOURCES

Perform clearing, stripping, and excavating. Operate the aggregate sources to produce the quantity and quality of materials meeting these specification requirements in the specified time limit. Upon completion of the work, the aggregate sources on public or private property shall be finalized to drain readily and be left in a satisfactory condition. Finalize aggregate sources on private lands in agreement with local laws or authorities.

3.2 STOCKPILING MATERIALS

Prior to stockpiling the material, clear and level the storage sites. All materials, including approved material available from excavation and grading, shall be stockpiled in the manner and at the locations designated. Stockpile aggregates in such a manner that will prevent segregation. Aggregates and binders obtained from different sources shall be stockpiled separately.

3.3 COMPACTION

Degree of compaction is a percentage of the maximum density obtained by the test procedure presented in ASTM D 1557 abbreviated herein as present laboratory maximum density. Compact each layer of the aggregate surface course with approved compaction equipment, as required in the following paragraphs. The water content during the compaction procedure shall be maintained at optimum or at the percentage specified by the USAID Implementing Partner. In locations not accessible to the rollers, the mixture shall be compacted with mechanical tampers. Compaction shall

continue until each layer through the full depth is compacted to at least 90 percent of laboratory maximum density. Remove any materials that are found to be unsatisfactory and replace them with satisfactory material or rework them to produce a satisfactory material.

3.4 PREPARATION OF SUBGRADE

Clean the subgrade of all foreign substances, including shoulders. At the time of surface course construction, the subgrade shall contain no frozen material. Ruts or soft yielding spots in the subgrade areas having inadequate compaction and deviations of the surface from the requirements set forth herein shall be corrected by loosening and removing soft or unsatisfactory material and by adding approved material, reshaping to line and grade and recompacting to density requirements specified in Section 32 11 23 AGGREGATE BASE COURSE. The completed subgrade shall not be disturbed by traffic or other operations and shall be maintained by the Contractor in a satisfactory condition until the surface course is placed.

3.5 GRADE CONTROL

During construction, the lines and grades including crown and cross slope indicated for the aggregate surface course shall be maintained by means of line and grade stakes placed by the Contractor.

3.6 MIXING AND PLACING MATERIALS

The materials shall be mixed and placed to obtain uniformity of the material and a uniform optimum water content for compaction. Make adjustments in mixing, placing procedures, or in equipment to obtain the true grades, to minimize segregation and degradation, to obtain the desired water content, and to ensure a satisfactory surface course.

3.7 LAYER THICKNESS

Place the aggregate material on the subgrade in layers of uniform thickness. When a compacted layer of 150 mm or less is specified, the material may be placed in a single layer; when a compacted thickness of more than 150 mm is required, no layer shall exceed 150 mm nor be less than 75 mm when compacted.

3.8 EDGES OF AGGREGATE-SURFACED ROAD

Approved material shall be placed along the edges of the aggregate surface course in such quantity as to compact to the thickness of the course being constructed. When the course is being constructed in two or more layers, at least 300 mm of shoulder width shall be rolled and compacted simultaneously with the rolling and compacting of each layer of the surface course.

3.9 SMOOTHNESS TEST

The surface of each layer shall not show any deviations in excess of 10 mm when tested with a 3 m straightedge applied both parallel with and at right angles to the centerline of the area to be paved. Deviations exceeding this amount shall be corrected by removing material, replacing with new material, or reworking existing material and compacting, as directed.

3.10 THICKNESS CONTROL

The completed thickness of the aggregate surface course shall be within 13 mm, plus or minus, of the thickness indicated on plans. The thickness of the aggregate surface course shall be measured at intervals in such manner that there will be a thickness measurement for at least each 500 square meters of the aggregate surface course. The thickness measurement shall be made by test holes at least 75 mm in diameter through the aggregate surface course. When the measured thickness of the aggregate surface course is more than 13 mm deficient in thickness, correct such areas by scarifying, adding mixture of proper gradation, reblading, and recompacting, as directed, without additional compensation. Where the measured thickness of the aggregate surface course is more than 13 mm thicker than that indicated, it shall be considered as conforming with the specified thickness requirements plus 13 mm. The average job thickness shall be the average of the job measurements determined as specified above, but shall be within 6 mm of the thickness indicated. When the average job thickness fails to meet this criterion, make corrections by scarifying, adding or removing mixture of proper gradation, and reblading and recompacting, as directed, without additional compensation.

3.11 DENSITY TESTS

Measure density in the field in accordance with ASTM D 1556, ASTM D 2167 or ASTM D 6938. For the method presented in ASTM D 1556 use the base plate as shown in the drawing. For the method presented in ASTM D 6938 the calibration curves shall be checked and adjusted, if necessary, using only the sand cone method as described in paragraph Calibration of the ASTM publication. Tests performed in accordance with ASTM D 6938 result in a wet unit weight of soil and ASTM D 6938 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall also be checked along with density calibration checks as described in ASTM D 6938. The calibration checks of both the density and moisture gauges shall be made by the prepared containers of material method, as described in paragraph Calibration of ASTM D 6938, on each different type of material being tested at the beginning of a job and at intervals, as directed.

3.12 WEAR TEST

Perform wear tests in conformance with ASTM C 131.

3.13 MAINTENANCE

Maintain the aggregate surface course in a condition that will meet all specification requirements until accepted.

-- End of Section --

SECTION 32 16 13

CONCRETE SIDEWALKS AND CURBS AND GUTTERS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182	(2005) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

ASTM INTERNATIONAL (ASTM)

ASTM A 615/A 615M	(2008) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM C 143/C 143M	(2008) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C 171	(2007) Standard Specification for Sheet Materials for Curing Concrete
ASTM C 172	(2007a) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C 173/C 173M	(2008) Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C 231	(2008) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 31/C 31M	(2008) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C 920	(2005) Standard Specification for Elastomeric Joint Sealants
ASTM D 1751	(2004) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D 1752	(2004a) Standard Specification for Preformed Sponge Rubber Cork and Recycled

PVC Expansion

ASTM D 5893	(2004) Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements

1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

Provide plant, equipment, machines, and tools used in the work subject to approval and maintained in a satisfactory working condition at all times. The equipment shall have the capability of producing the required product, meeting grade controls, thickness control and smoothness requirements as specified. Use of the equipment shall be discontinued if it produces unsatisfactory results. The USAID Implementing Partner shall have access at all times to the plant and equipment to ensure proper operation and compliance with specifications.

1.2.2 Slip Form Equipment

Slip form paver or curb forming machine, will be approved based on trial use on the job.

1.3 SUBMITTALS

Contractor shall submit the following using submittal procedures as specified in the Contract Documents.

SD-03 Product Data

Concrete

Copies of certified delivery tickets for all concrete used in the construction.

SD-06 Test Reports

Field Quality Control

Copies of all test reports within 24 hours of completion of the test.

1.4 ENVIRONMENTAL REQUIREMENTS

1.4.1 Placing During Cold Weather

Do not place concrete when the air temperature reaches 5 degrees C and is falling, or is already below that point. Placement may begin when the air temperature reaches 2 degrees C and is rising, or is already above 5 degrees C. Make provisions to protect the concrete from freezing during the specified curing period. If necessary to place concrete when the temperature of the air, aggregates, or water is below 2 degrees C, placement and protection shall be approved in writing. Approval will be contingent upon full conformance with the following provisions. The underlying material shall be prepared and protected so that it is entirely free of frost when the concrete is deposited. Mixing water and aggregates shall be heated as necessary to result in the temperature of the in-place concrete being between 10 and 30 degrees C. Methods and equipment for

heating shall be approved. The aggregates shall be free of ice, snow, and frozen lumps before entering the mixer. Covering and other means shall be provided for maintaining the concrete at a temperature of at least 10 degrees C for not less than 72 hours after placing, and at a temperature above freezing for the remainder of the curing period.

1.4.2 Placing During Warm Weather

The temperature of the concrete as placed shall not exceed 30 degrees C except where an approved retarder is used. The mixing water and/or aggregates shall be cooled, if necessary, to maintain a satisfactory placing temperature. The placing temperature shall not exceed 35 degrees C at any time.

PART 2 PRODUCTS

2.1 CONCRETE

Provide concrete conforming to the applicable requirements of Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE except as otherwise specified. Concrete shall have a minimum compressive strength of 20.6 MPa at 28 days. Maximum size of aggregate shall be 37.5 mm.

2.1.1 Air Content

Mixtures shall have air content by volume of concrete of 5 to 7 percent, based on measurements made immediately after discharge from the mixer.

2.1.2 Slump

The concrete slump shall be 50 mm plus or minus 25 mm where determined in accordance with ASTM C 143/C 143M.

2.1.3 Reinforcement Steel

Reinforcement bars shall conform to ASTM A 615/A 615M..

2.2 CONCRETE CURING MATERIALS

2.2.1 Impervious Sheet Materials

Impervious sheet materials shall conform to ASTM C 171, type optional, except that polyethylene film, if used, shall be white opaque.

2.2.2 Burlap

Burlap shall conform to AASHTO M 182.

2.3 CONCRETE PROTECTION MATERIALS

Concrete protection materials shall be a linseed oil mixture of equal parts, by volume, of linseed oil and either mineral spirits, naphtha, or turpentine. At the option of the Contractor, commercially prepared linseed oil mixtures, formulated specifically for application to concrete to provide protection against the action of deicing chemicals may be used, except that emulsified mixtures are not acceptable.

2.4 JOINT FILLER STRIPS

2.4.1 Contraction Joint Filler for Curb and Gutter

Contraction joint filler for curb and gutter shall consist of hard-pressed fiberboard.

2.4.2 Expansion Joint Filler, Premolded

Expansion joint filler, premolded, shall conform to ASTM D 1751 or ASTM D 1752, 13 mm thick, unless otherwise indicated.

2.5 JOINT SEALANTS

Joint sealant, cold-applied shall conform to ASTM C 920 or ASTM D 5893.

2.6 FORM WORK

Design and construct form work to ensure that the finished concrete will conform accurately to the indicated dimensions, lines, and elevations, and within the tolerances specified. Forms shall be of wood or steel, straight, of sufficient strength to resist springing during depositing and consolidating concrete. Wood forms shall be surfaced plank, 50 mm nominal thickness, straight and free from warp, twist, loose knots, splits or other defects. Wood forms shall have a nominal length of 3 m. Radius bends may be formed with 19 mm boards, laminated to the required thickness. Steel forms shall be channel-formed sections with a flat top surface and with welded braces at each end and at not less than two intermediate points. Ends of steel forms shall be interlocking and self-aligning. Steel forms shall include flexible forms for radius forming, corner forms, form spreaders, and fillers. Steel forms shall have a nominal length of 3 m with a minimum of 3 welded stake pockets per form. Stake pins shall be solid steel rods with chamfered heads and pointed tips designed for use with steel forms.

2.6.1 Sidewalk Forms

Sidewalk forms shall be of a height equal to the full depth of the finished sidewalk.

2.6.2 Curb and Gutter Forms

Curb and gutter outside forms shall have a height equal to the full depth of the curb or gutter. The inside form of curb shall have batter as indicated and shall be securely fastened to and supported by the outside form. Rigid forms shall be provided for curb returns, except that benders or thin plank forms may be used for curb or curb returns with a radius of 3 m or more, where grade changes occur in the return, or where the central angle is such that a rigid form with a central angle of 90 degrees cannot be used. Back forms for curb returns may be made of 38 mm benders, for the full height of the curb, cleated together. In lieu of inside forms for curbs, a curb "mule" may be used for forming and finishing this surface, provided the results are approved.

PART 3 EXECUTION

3.1 SUBGRADE PREPARATION

The subgrade shall be constructed to the specified grade and cross section

prior to concrete placement. Subgrade shall be placed and compacted in conformance with Section 32 11 23 AGGREGATE BASE COURSE.

3.1.1 Sidewalk Subgrade

The subgrade shall be tested for grade and cross section with a template extending the full width of the sidewalk and supported between side forms.

3.1.2 Curb and Gutter Subgrade

The subgrade shall be tested for grade and cross section by means of a template extending the full width of the curb and gutter. The subgrade shall be of materials equal in bearing quality to the subgrade under the adjacent pavement.

3.1.3 Maintenance of Subgrade

The subgrade shall be maintained in a smooth, compacted condition in conformity with the required section and established grade until the concrete is placed. The subgrade shall be in a moist condition when concrete is placed. The subgrade shall be prepared and protected to produce a subgrade free from frost when the concrete is deposited.

3.2 FORM SETTING

Set forms to the indicated alignment, grade and dimensions. Hold forms rigidly in place by a minimum of 3 stakes per form placed at intervals not to exceed 1.2 m. Corners, deep sections, and radius bends shall have additional stakes and braces, as required. Clamps, spreaders, and braces shall be used where required to ensure rigidity in the forms. Forms shall be removed without injuring the concrete. Bars or heavy tools shall not be used against the concrete in removing the forms. Any concrete found defective after form removal shall be promptly and satisfactorily repaired. Forms shall be cleaned and coated with form oil each time before concrete is placed. Wood forms may, instead, be thoroughly wetted with water before concrete is placed, except that with probable freezing temperatures, oiling is mandatory.

3.2.1 Sidewalks

Set forms for sidewalks with the upper edge true to line and grade with an allowable tolerance of 3 mm in any 3 m long section. After forms are set, grade and alignment shall be checked with a 3 m straightedge. Forms shall have a transverse slope of 20 mm per meter with the low side adjacent to the roadway. Side forms shall not be removed for 12 hours after finishing has been completed.

3.2.2 Curbs and Gutters

The forms of the front of the curb shall be removed not less than 2 hours nor more than 6 hours after the concrete has been placed. Forms back of curb shall remain in place until the face and top of the curb have been finished, as specified for concrete finishing. Gutter forms shall not be removed while the concrete is sufficiently plastic to slump in any direction.

3.3 SIDEWALK CONCRETE PLACEMENT AND FINISHING

3.3.1 Formed Sidewalks

Place concrete in the forms in one layer. When consolidated and finished, the sidewalks shall be of the thickness indicated. After concrete has been placed in the forms, a strike-off guided by side forms shall be used to bring the surface to proper section to be compacted. The concrete shall be consolidated with an approved vibrator, and the surface shall be finished to grade with a strike off.

3.3.2 Concrete Finishing

After straightedging, when most of the water sheen has disappeared, and just before the concrete hardens, finish the surface with a wood float or darby to a smooth and uniformly fine granular or sandy texture free of waves, irregularities, or tool marks. A scored surface shall be produced by brooming with a fiber-bristle brush in a direction transverse to that of the traffic, followed by edging.

3.3.3 Edge and Joint Finishing

All slab edges, including those at formed joints, shall be finished with an edger having a radius of 3 mm. Transverse joint shall be edged before brooming, and the brooming shall eliminate the flat surface left by the surface face of the edger. Corners and edges which have crumbled and areas which lack sufficient mortar for proper finishing shall be cleaned and filled solidly with a properly proportioned mortar mixture and then finished.

3.3.4 Surface and Thickness Tolerances

Finished surfaces shall not vary more than 8 mm from the testing edge of a 3 m straightedge. Permissible deficiency in section thickness will be up to 6 mm.

3.4 CURB AND GUTTER CONCRETE PLACEMENT AND FINISHING

3.4.1 Formed Curb and Gutter

Concrete shall be placed to the section required in a single lift. Consolidation shall be achieved by using approved mechanical vibrators. Curve shaped gutters shall be finished with a standard curb "mule."

3.4.2 Curb and Gutter Finishing

Approved slipformed curb and gutter machines may be used in lieu of hand placement.

3.4.3 Concrete Finishing

Exposed surfaces shall be floated and finished with a smooth wood float until true to grade and section and uniform in texture. Floated surfaces shall then be brushed with a fine-hair brush with longitudinal strokes. The edges of the gutter and top of the curb shall be rounded with an edging tool to a radius of 13 mm. Immediately after removing the front curb form, the face of the curb shall be rubbed with a wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed. The front curb surface, while still wet, shall be brushed in the same

manner as the gutter and curb top. The top surface of gutter and entrance shall be finished to grade with a wood float.

3.4.4 Joint Finishing

Curb edges at formed joints shall be finished as indicated.

3.4.5 Surface and Thickness Tolerances

Finished surfaces shall not vary more than 6 mm from the testing edge of a 3 m straightedge. Permissible deficiency in section thickness will be up to 6 mm.

3.5 SIDEWALK JOINTS

Sidewalk joints shall be constructed to divide the surface into rectangular areas. Transverse contraction joints shall be spaced at a distance equal to the sidewalk width or 1.5 m on centers, whichever is less, and shall be continuous across the slab. Longitudinal contraction joints shall be constructed along the centerline of all sidewalks 3 m or more in width. Transverse expansion joints shall be installed at sidewalk returns and opposite expansion joints in adjoining curbs. Where the sidewalk is not in contact with the curb, transverse expansion joints shall be installed as indicated. Expansion joints shall be formed about structures and features which project through or into the sidewalk pavement, using joint filler of the type, thickness, and width indicated. Expansion joints are not required between sidewalks and curb that abut the sidewalk longitudinally.

3.5.1 Sidewalk Contraction Joints

The contraction joints shall be formed in the fresh concrete by cutting a groove in the top portion of the slab to a depth of at least one-fourth of the sidewalk slab thickness, using a jointer to cut the groove, or by sawing a groove in the hardened concrete with a power-driven saw, unless otherwise approved. Sawed joints shall be constructed by sawing a groove in the concrete with a 3 mm blade to the depth indicated. An ample supply of saw blades shall be available on the job before concrete placement is started, and at least one standby sawing unit in good working order shall be available at the jobsite at all times during the sawing operations.

3.5.2 Sidewalk Expansion Joints

Expansion joints shall be formed with 13 mm joint filler strips. Joint filler in expansion joints surrounding structures and features within the sidewalk may consist of preformed filler material conforming to ASTM D 1752 or building paper. Joint filler shall be held in place with steel pins or other devices to prevent warping of the filler during floating and finishing. Immediately after finishing operations are completed, joint edges shall be rounded with an edging tool having a radius of 3 mm, and concrete over the joint filler shall be removed. At the end of the curing period, expansion joints shall be cleaned and filled with cold-applied joint sealant. Joint sealant shall be gray or stone in color. Joints shall be sealed as specified in Section 32 01 19 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS. The joint opening shall be thoroughly cleaned before the sealing material is placed. Sealing material shall not be spilled on exposed surfaces of the concrete. Concrete at the joint shall be surface dry and atmospheric and concrete temperatures shall be above 10 degrees C at the time of application of joint sealing material. Excess material on exposed surfaces of the concrete shall be removed

immediately and concrete surfaces cleaned.

3.5.3 Reinforcement Steel Placement

Reinforcement steel shall be accurately and securely fastened in place with suitable supports and ties before the concrete is placed.

3.6 CURB AND GUTTER JOINTS

Curb and gutter joints shall be constructed at right angles to the line of curb and gutter.

3.6.1 Contraction Joints

Contraction joints shall be constructed directly opposite contraction joints in abutting portland cement concrete pavements and spaced so that monolithic sections between curb returns will not be less than 1.5 m nor greater than 4.5 m in length.

a. Contraction joints (except for slip forming) shall be constructed by means of 3 mm thick separators and of a section conforming to the cross section of the curb and gutter. Separators shall be removed as soon as practicable after concrete has set sufficiently to preserve the width and shape of the joint and prior to finishing.

b. When slip forming is used, the contraction joints shall be cut in the top portion of the gutter/curb hardened concrete in a continuous cut across the curb and gutter, using a power-driven saw. The depth of cut shall be at least one-fourth of the gutter/curb depth and 3 mm in width.

3.6.2 Expansion Joints

Expansion joints shall be formed by means of preformed expansion joint filler material cut and shaped to the cross section of curb and gutter. Expansion joints shall be provided in curb and gutter directly opposite expansion joints of abutting portland cement concrete pavement, and shall be of the same type and thickness as joints in the pavement. Where curb and gutter do not abut portland cement concrete pavement, expansion joints at least 13 mm in width shall be provided at intervals not less than 10 meters nor greater than 36 meters. Expansion joints shall be provided in nonreinforced concrete gutter at locations indicated. Expansion joints shall be sealed immediately following curing of the concrete or as soon thereafter as weather conditions permit. Joints shall be sealed as specified in Section 32 01 19 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS. Expansion joints and the top 25 mm depth of curb and gutter contraction-joints shall be sealed with joint sealant. The joint opening shall be thoroughly cleaned before the sealing material is placed. Sealing material shall not be spilled on exposed surfaces of the concrete. Concrete at the joint shall be surface dry and atmospheric and concrete temperatures shall be above 10 degrees C at the time of application of joint sealing material. Excess material on exposed surfaces of the concrete shall be removed immediately and concrete surfaces cleaned.

3.7 CURING AND PROTECTION

3.7.1 General Requirements

Protect concrete against loss of moisture and rapid temperature changes for

at least 7 days from the beginning of the curing operation. Protect unhardened concrete from rain and flowing water. All equipment needed for adequate curing and protection of the concrete shall be on hand and ready for use before actual concrete placement begins. Protection shall be provided as necessary to prevent cracking of the pavement due to temperature changes during the curing period.

3.7.1.1 Mat Method

The entire exposed surface shall be covered with 2 or more layers of burlap. Mats shall overlap each other at least 150 mm. The mat shall be thoroughly wetted with water prior to placing on concrete surface and shall be kept continuously in a saturated condition and in intimate contact with concrete for not less than 7 days.

3.7.1.2 Impervious Sheeting Method

The entire exposed surface shall be wetted with a fine spray of water and then covered with impervious sheeting material. Sheets shall be laid directly on the concrete surface with the light-colored side up and overlapped 300 mm when a continuous sheet is not used. The curing medium shall not be less than 450 mm wider than the concrete surface to be cured, and shall be securely weighted down by heavy wood planks, or a bank of moist earth placed along edges and laps in the sheets. Sheets shall be satisfactorily repaired or replaced if torn or otherwise damaged during curing. The curing medium shall remain on the concrete surface to be cured for not less than 7 days.

3.7.1.3 Membrane Curing Method

A uniform coating of white-pigmented membrane-curing compound shall be applied to the entire exposed surface of the concrete as soon after finishing as the free water has disappeared from the finished surface. Formed surfaces shall be coated immediately after the forms are removed and in no case longer than 1 hour after the removal of forms. Concrete shall not be allowed to dry before the application of the membrane. If any drying has occurred, the surface of the concrete shall be moistened with a fine spray of water and the curing compound applied as soon as the free water disappears. Curing compound shall be applied in two coats by hand-operated pressure sprayers at a coverage of approximately 5 square meters/L for the total of both coats. The second coat shall be applied in a direction approximately at right angles to the direction of application of the first coat. The compound shall form a uniform, continuous, coherent film that will not check, crack, or peel and shall be free from pinholes or other imperfections. If pinholes, abrasion, or other discontinuities exist, an additional coat shall be applied to the affected areas within 30 minutes. Concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied shall be resprayed by the method and at the coverage specified above. Areas where the curing compound is damaged by subsequent construction operations within the curing period shall be resprayed. Necessary precautions shall be taken to insure that the concrete is properly cured at sawed joints, and that no curing compound enters the joints. The top of the joint opening and the joint groove at exposed edges shall be tightly sealed before the concrete in the region of the joint is resprayed with curing compound. The method used for sealing the joint groove shall prevent loss of moisture from the joint during the entire specified curing period. Approved standby facilities for curing concrete pavement shall be provided at a location accessible to the jobsite for use in the event of mechanical failure of the spraying

equipment or other conditions that might prevent correct application of the membrane-curing compound at the proper time. Concrete surfaces to which membrane-curing compounds have been applied shall be adequately protected during the entire curing period from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from any other possible damage to the continuity of the membrane.

3.7.2 Backfilling

After curing, debris shall be removed and the area adjoining the concrete shall be backfilled, graded, and compacted to conform to the surrounding area in accordance with lines and grades indicated.

3.7.3 Protection

Completed concrete shall be protected from damage until accepted. Repair damaged concrete and clean concrete discolored during construction. Concrete that is damaged shall be removed and reconstructed for the entire length between regularly scheduled joints. Refinishing the damaged portion will not be acceptable. Removed damaged portions shall be disposed of as directed.

3.7.4 Protective Coating

Protective coating, of linseed oil mixture, shall be applied to the exposed-to-view concrete surface after the curing period, if concrete will be exposed to de-icing chemicals within 6 weeks after placement. Concrete to receive a protective coating shall be moist cured.

3.7.4.1 Application

Curing and backfilling operation shall be completed prior to applying two coats of protective coating. Concrete shall be surface dry and clean before each application. Coverage shall be by spray application at not more than 11 square meters/L for first application and not more than 15.5 square meters/L for second application, except that the number of applications and coverage for each application for commercially prepared mixture shall be in accordance with the manufacturer's instructions. Coated surfaces shall be protected from vehicular and pedestrian traffic until dry.

3.7.4.2 Precautions

Protective coating shall not be heated by direct application of flame or electrical heaters and shall be protected from exposure to open flame, sparks, and fire adjacent to open containers or applicators. Material shall not be applied at ambient or material temperatures lower than 10 degrees C.

3.8 FIELD QUALITY CONTROL

3.8.1 General Requirements

Perform the inspection and tests described and meet the specified requirements for inspection details and frequency of testing. Based upon the results of these inspections and tests, take the action and submit reports as required below, and any additional tests to insure that the requirements of these specifications are met.

3.8.2 Concrete Testing

3.8.2.1 Strength Testing

Provide molded concrete specimens for strength tests. Samples of concrete placed each day shall be taken not less than once a day nor less than once for every 190 cubic meters of concrete. The samples for strength tests shall be taken in accordance with ASTM C 172. Cylinders for acceptance shall be molded in conformance with ASTM C 31/C 31M by an approved testing laboratory. Each strength test result shall be the average of 2 test cylinders from the same concrete sample tested at 28 days, unless otherwise specified or approved. Concrete specified on the basis of compressive strength will be considered satisfactory if the averages of all sets of three consecutive strength test results equal or exceed the specified strength, and no individual strength test result falls below the specified strength by more than 4 MPa.

3.8.2.2 Air Content

Determine air content in accordance with ASTM C 173/C 173M or ASTM C 231. ASTM C 231 shall be used with concretes and mortars made with relatively dense natural aggregates. Two tests for air content shall be made on randomly selected batches of each class of concrete placed during each shift. Additional tests shall be made when excessive variation in concrete workability is reported by the placing foreman or the USAID Implementing Partner. If results are out of tolerance, the placing foreman shall be notified and he shall take appropriate action to have the air content corrected at the plant. Additional tests for air content will be performed on each truckload of material until such time as the air content is within the tolerance specified.

3.8.2.3 Slump Test

Two slump tests shall be made on randomly selected batches of each class of concrete for every 190 cubic meters, or fraction thereof, of concrete placed during each shift. Additional tests shall be performed when excessive variation in the workability of the concrete is noted or when excessive crumbling or slumping is noted along the edges of slip-formed concrete.

3.8.3 Thickness Evaluation

The anticipated thickness of the concrete shall be determined prior to placement by passing a template through the formed section or by measuring the depth of opening of the extrusion template of the curb forming machine. If a slip form paver is used for sidewalk placement, the subgrade shall be true to grade prior to concrete placement and the thickness will be determined by measuring each edge of the completed slab.

3.8.4 Surface Evaluation

The finished surface of each category of the completed work shall be uniform in color and free of blemishes and form or tool marks.

3.9 SURFACE DEFICIENCIES AND CORRECTIONS

3.9.1 Thickness Deficiency

When measurements indicate that the completed concrete section is deficient

in thickness by more than 6 mm the deficient section will be removed, between regularly scheduled joints, and replaced.

3.9.2 High Areas

In areas not meeting surface smoothness and plan grade requirements, high areas shall be reduced either by rubbing the freshly finished concrete with carborundum brick and water when the concrete is less than 36 hours old or by grinding the hardened concrete with an approved surface grinding machine after the concrete is 36 hours old or more. The area corrected by grinding the surface of the hardened concrete shall not exceed 5 percent of the area of any integral slab, and the depth of grinding shall not exceed 6 mm. Pavement areas requiring grade or surface smoothness corrections in excess of the limits specified above shall be removed and replaced.

3.9.3 Appearance

Exposed surfaces of the finished work will be inspected by the USAID Implementing Partner and any deficiencies in appearance will be identified. Areas which exhibit excessive cracking, discoloration, form marks, or tool marks or which are otherwise inconsistent with the overall appearances of the work shall be removed and replaced.

-- End of Section --

SECTION 32 17 23.00 20

PAVEMENT MARKINGS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS TT-P-1952	(Rev D) Paint, Traffic and Airfield Markings, Waterborne

1.2 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.

SD-03 Product Data

Paints for roads and streets

Equipment

SD-06 Test Reports

Paints for roads and streets

Certified reports from sampling and testing made in accordance with paragraph entitled "Sampling and Testing" prior to the use of the materials at the jobsite. Testing shall be performed in an approved independent laboratory.

SD-0 Paints for roads and streets

Construction equipment list

SD-08 Manufacturer's Instructions

Paints for roads and streets

Submit manufacturer's Material Safety Data Sheets.

SD-11 Closeout Submittals

Warranty

1.3 DELIVERY AND STORAGE

Deliver paints and paint materials in original sealed containers that plainly show the designated name, specification number, batch number, color, date of manufacture, manufacturer's directions, and name of manufacturer. Provide storage facilities at the job site, only in areas

approved by the USAID Implementing Partner, for maintaining materials at temperatures recommended by the manufacturer. Make available paint stored at the project site or segregated at the source for sampling not less than 30 days prior to date of required approval for use to allow sufficient time for testing. Notify the USAID Implementing Partner when paint is available for sampling.

1.4 WEATHER LIMITATIONS

Apply paint to clean, dry surfaces, and unless otherwise approved, only when the air and pavement surface temperature is at least 2.7 degrees C above the dew point and the air and pavement temperatures are above 5 degrees C and less than 35 degrees C for oil-based materials; above 10 degrees C and less than 43 degrees C for water-based materials. Maintain paint temperature within these same limits.

1.5 EQUIPMENT

Machines, tools, and equipment used in the performance of the work shall be approved by the USAID Implementing Partner and maintained in satisfactory operating condition. Submit construction equipment list for approval by the USAID Implementing Partner.

1.5.1 Mobile and Maneuverable

Application equipment shall be mobile and maneuverable to the extent that straight lines can be followed and normal curves can be made in a true arc.

1.5.2 Paint Application Equipment

1.5.2.1 Hand-Operated, Push-Type Machines

Provide hand-operated push-type applicator machine of a type commonly used for application of paint to pavement surfaces. Paint applicator machine shall be acceptable for marking small street and parking areas. Applicator machine shall be equipped with the necessary paint tanks and spraying nozzles, and shall be capable of applying paint uniformly at coverage specified. Applicator for water-based markings shall be equipped with non-stick coated hoses; metal parts in contact with the paint material shall be constructed of grade 302, 304, 316, or equal stainless steel.

1.6 WARRANTY

Provide manufacturer's standard guarantees and warranties.

PART 2 PRODUCTS

2.1 MATERIALS

Provide materials conforming to the requirements specified herein.

2.1.1 Paints for Roads and Streets

FS TT-P-1952, color shall be yellow.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Allow new pavement surfaces to cure for a period of not less than 30 days before application of marking materials. Thoroughly clean surfaces to be marked before application of the paint. Remove dust, dirt, and other granular surface deposits by sweeping, blowing with compressed air, rinsing with water, or a combination of these methods as required. Scrub affected areas, where oil or grease is present on old pavements to be marked, with several applications of trisodium phosphate solution or other approved detergent or degreaser and rinse thoroughly after each application. After cleaning oil-soaked areas, seal with shellac or primer recommended by the manufacturer to prevent bleeding through the new paint. Do not commence painting in any area until pavement surfaces are dry and clean.

3.1.1 Early Painting of Rigid Pavements

Pretreat rigid pavements that require early painting with an aqueous solution containing 3 percent phosphoric acid and 2 percent zinc chloride. Apply the solution to the areas to be marked.

3.2 APPLICATION

3.2.1 Testing for Moisture

Apply pavement markings to dry pavement only. Do not commence marking until the pavement is sufficiently dry and the pavement condition has been approved by the USAID Implementing Partner.

3.2.2 Rate of Application

3.2.2.1 Nonreflective Markings

Apply paint evenly to the pavement surface to be coated at a rate of 2.5 plus or minus 0.10 square meter per liter.

3.2.3 Painting

Apply paint pneumatically with approved equipment at rate of coverage specified herein. Provide guidelines and templates as necessary to control paint application. Take special precautions in marking numbers, letters, and symbols. Manually paint numbers, letters, and symbols. Sharply outline all edges of markings. The maximum drying time requirements of the paint specifications will be strictly enforced, to prevent undue softening of bitumen, and pickup, displacement, or discoloration by tires of traffic. Discontinue painting operations if there is a deficiency in drying of the markings until cause of the slow drying is determined and corrected.

3.3 FIELD TESTING, INSPECTION, AND DEMONSTRATIONS

3.3.1 Inspection

Examine material at the job site to determine that it is the material referenced in the report of test results or certificate of compliance. A certificate of compliance shall be accompanied by test results substantiating conformance to the specified requirements.

3.3.2 Surface Preparations and Application Procedures

Surface preparations and application procedures will be examined by the USAID Implementing Partner to determine conformance with the requirements specified. Approve each separate operation prior to initiation of subsequent operations.

3.3.2.1 Surface Preparation Demonstration

Prior to surface preparation, demonstrate surface preparation using the proposed methods and equipment. Prepare areas large enough to determine cleanliness and rate of cleaning.

3.3.2.2 Test Stripe Demonstration

Prior to paint application, demonstrate test stripe application within the work area using the proposed materials and equipment. Apply separate test stripes in each of the line widths and configurations required herein using the proposed equipment. The test stripes shall be long enough to determine the proper speed and operating pressures for the vehicle(s) and machinery, but not less than 15 meters long.

3.3.2.3 Application Rate Demonstration

During the Test Stripe Demonstration, demonstrate compliance with the application rates specified herein. Document the equipment speed and operating pressures required to meet the specified rates in each configuration of the equipment and provide a copy of the documentation to the USAID Implementing Partner 30 days prior to proceeding with the work.

3.3.2.4 Level of Performance Demonstration

The USAID Implementing Partner will be present for the application demonstrations to observe the results obtained and to validate the operating parameters of the vehicle(s) and equipment. If accepted by the USAID Implementing Partner, the test stripe shall be the measure of performance required for this project. Work shall not proceed until the demonstration results are satisfactory to the USAID Implementing Partner.

3.4 TRAFFIC CONTROL AND PROTECTION

Place warning signs near the entrance and exit of the work site for alerting approaching traffic of construction activities and prevent damage to newly painted surfaces. Mark painting equipment with large warning signs indicating slow-moving painting equipment in operation. Do not use foil-backed material for temporary pavement marking because of its potential to conduct electricity during accidents involving downed power lines.

-- End of Section --

SECTION 32 31 13

CHAIN LINK FENCES AND GATES

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A 116	(2005) Standard Specification for Metallic-Coated, Steel Woven Wire Fence Fabric
ASTM A 153/A 153M	(2005) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 702	(1989; R 2006) Standard Specification for Steel Fence Posts and Assemblies, Hot Wrought
ASTM A 780	(2001; R 2006) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A 90/A 90M	(2007) Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings
ASTM F 1043	(2008) Strength and Protective Coatings on Metal Industrial Chain-Link Fence Framework
ASTM F 1083	(2008) Standard Specification for Pipe, Steel, Hot-Dipped Zinc Coated (Galvanized) Welded, for Fence Structures
ASTM F 567	(2007) Standard Practice for Installation of Chain Link Fence
ASTM F 626	(2008) Standard Specification for Fence Fittings
ASTM F 883	(2004) Padlocks

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS RR-F-191	(Rev K) Fencing, Wire and Post Metal (and Gates, Chain-Link Fence Fabric, and Accessories)
FS RR-F-191/1	(Rev D) Fencing, Wire and Post, Metal (Chain-Link Fence Fabric)

FS RR-F-191/2	(Rev D) Fencing, Wire and Post, Metal (Chain-Link Fence Gates)
FS RR-F-191/3	(Rev D) Fencing, Wire and Post, Metal (Chain-Link Fence Posts, Top Rails and Braces)

1.2 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.

SD-02 Shop Drawings

Submit Erection/Installation Drawings for the following items in accordance with paragraph entitled, "Assembly and Installations Instructions," of this section.

Fence Assembly
Location of Gate, Corner, End, and Pull Posts
Gate Assembly
Gate Hardware and Accessories

SD-03 Product Data

Submit Manufacturer's catalog data for the following items:

Fence Assembly
Gate Assembly
Gate Hardware and Accessories

SD-07 Certificates

Submit Certificates of compliance in accordance with the applicable reference standards and descriptions of this section for the following items:

Zinc Coating
Fabric
Stretcher Bars
Gate Hardware and Accessories
Concrete

SD-08 Manufacturer's Instructions

Submit Manufacturer's instructions for the following items:

Fence Assembly
Gate Assembly
Hardware Assembly
Accessories

SD-11 Closeout Submittals

Warranty

1.3 ASSEMBLY AND INSTALLATION INSTRUCTIONS

Contractor must provide manufacturer's instructions that detail proper

assembly and materials in the design for fence, gate, hardware and accessories.

Submit Erection/Installation drawings along with manufacturer's catalog data for Complete fence assembly, gate assembly, hardware assembly and accessories.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials to site in an undamaged condition. Store materials off the ground to provide protection against oxidation caused by ground contact.

1.5 WARRANTY

Provide manufacturer standard performance guarantees and warranties.

PART 2 PRODUCTS

2.1 GENERAL

Provide fencing materials that conform to the requirements of ASTM A 116, ASTM A 702, ASTM F 626, and as specified.

2.2 ZINC COATING

Ferrous-metal components and accessories, except as otherwise specified, must be hot-dip galvanized after fabrication.

Provide zinc coating of weight not less than 550 gram per square meter, as determined from the average result of two specimens, when tested in accordance with ASTM A 90/A 90M.

Provide zinc coating that conforms to the requirements of the following:

Pipe: FS RR-F-191/3 Class 1 Grade A in accordance with ASTM F 1083 .

Hardware and accessories: ASTM A 153/A 153M, Table 1

Surface (ASTM F 1043):

External: Type B-B surface zinc with organic coating, 275 gram per square meter minimum thickness of acrylated polymer.

Internal: Surface zinc coating of 275 gram per square meter minimum.

Provide galvanizing repair material that is cold-applied zinc-rich coating conforming to ASTM A 780.

2.3 FABRIC

FS RR-F-191 and detailed specifications as referenced and other requirements as specified.

FS RR-F-191/1; Type I, zinc-coated steel, 9 gage. Mesh size, 52.4 mm. Provide selvage knuckled at one selvage and twisted and barbed at the other. Fabric must consist of 3.8 millimeter wires woven into a 50 millimeter diamond mesh, with dimensions of fabric and wire conforming to ASTM A 116, ASTM A 702 and ASTM F 626, with 366 gram per square meter zinc galvanizing.

Fence heights to 3658 millimeter must have one-piece fabric widths.

2.4 TOP AND BOTTOM SELVAGES

Fabric with 52.4 millimeter mesh and up to 1524 millimeter high must be knuckled on both top and bottom selvages, over if 1524 millimeter high, it must be twisted and barbed on the top selvage and knuckled on the bottom selvage.

Knuckle top and bottom selvages for 45 millimeter and 25 millimeter mesh fabric.

2.5 POSTS, TOP RAILS AND BRACES

FS RR-F-191/3 line posts; Class 1, steel pipe, Grade A. End, corner, and pull posts; Class 1, steel pipe, Grade A. Braces and rails; Class 1, steel pipe, Grade A, in minimum sizes listed in FS RR-F-191/3 for each class and grade.

2.6 LINE POSTS

Minimum acceptable line posts must be as follows:

Up to 1829 millimeter high:

Grade A: DN50 O.D. pipe weighing 4.05 kilogram per linear meter.

Over 1829 millimeter high:

DN50 O.D. pipe weighing 5.44 kilogram per linear meter.

2.7 END, CORNER, AND PULL POSTS

Provide minimally acceptable end, corner, and pull posts as follows:

Up to 1829 millimeter high:

Grade A: DN50 O.D. pipe weighing 5.44 kilogram per linear meter.

Over 1829 millimeter high:

Grade A: DN70 O.D. pipe weighing 8.62 kilogram per linear meter.

2.8 SLEEVES

Provide sleeves for setting into concrete construction of the same material as post sections. Size must be 25 millimeter greater than the diameter or dimension of the post. Weld flat plates to each sleeve base to provide anchorage and prevent intrusion of concrete.

2.9 TOP RAIL

Rails must be a minimum of DN40 O.D. pipe Grade A weighing 3.38 kilograms per linear meter. Provide expansion couplings 150 millimeters long at each joint in top rails.

2.10 CENTER RAILS BETWEEN LINE POSTS

For fencing over 1829 millimeter high, center rails must be DN40 O.D. pipe

Grade A weighing 3.38 kilograms per linear meter

2.11 POST-BRACE ASSEMBLY

Bracing must consist of DN40 O.D. pipe Grade A weighing 3.38 kilograms per linear meter and 10 millimeter adjustable truss rods and turnbuckles.

2.12 TENSION WIRE

Wire must be galvanized, 3.7 millimeter, coiled spring wire, provided at the bottom of the fabric only. Provide Zinc Coating that weighs not less than 490 gram per square meter.

2.13 STRETCHER BARS

Provide bars that have one-piece lengths equal to the full height of the fabric with a minimum cross section of 5 by 20 millimeter, in accordance with ASTM A 116, ASTM A 702 and ASTM F 626.

2.14 POST TOPS

Provide tops that are steel, wrought iron, or malleable iron designed as a weathertight closure cap. Provide one cap for each post, unless equal protection is provided by a combination post-cap and barbed-wire supporting arm. Caps must have an opening to permit through passage of the top rail.

2.15 STRETCHER BAR BANDS

Provide bar bands for securing stretcher bars to posts that are steel, wrought iron, or malleable iron spaced not over 381 millimeter on center. Bands may also be used in conjunction with special fittings for securing rails to posts. Provide bands with projecting edges chamfered or eased.

2.16 GATE POSTS

Provide a gate post for supporting each gate leaf as follows:

Up to 1829 millimeter wide:

DN75 O.D. pipe Grade A weighing 8.62 kilograms per linear meter.

Over 1829 millimeter wide and up to 3962 millimeter wide:

DN75 O.D. pipe Grade A weighing 13.6 kilograms per linear meter.

Over 3962 millimeter and up to 5486 millimeter wide:

Provide DN150 O.D. pipe weighing 28.26 kilograms per linear meter.

Over 5486 millimeter wide:

Provide DN220 O.D. pipe weighing 36.79 kilograms per linear meter.

2.17 GATES

FS RR-F-191/2; Type II, double swing. Shape and size of gate frame, as indicated on Contract Documents. Framing and bracing members, round of steel alloy. Steel member finish, zinc-coated. Gate frames and braces of minimum sizes listed in FS RR-F-191/3 for each Class and Grade except that

steel pipe frames must be 48 mm O.D., 3 mm minimum wall thickness and intermediate braces must be 47.5 mm O.D., 1.4 kg per meter of length. Gate fabric, as specified for fencing fabric. Coating for steel latches, stops, hinges, keepers, and accessories, galvanized. Gate latches, fork type. Special gate frames, as indicated on Contract Documents. Gate leaves more than 2.4 m wide must have intermediate members as necessary to provide rigid construction, free from sag or twist. Gate leaves less than 2.4 m wide must have truss rods or intermediate braces. Attach gate fabric to gate frame in accordance with manufacturer's standards, except that welding is not permitted. Arrange padlocking latches to be accessible from both sides of gate, regardless of latching arrangement.

For gate leaves up to 1829 millimeter high or 1829 millimeter wide, perimeter gate frames must be DN32 O.D. pipe Grade A weighing 3.38 kilogram per linear meter.

For gate leaves over 1829 millimeter high or 1829 millimeter wide, perimeter gate frames must be DN40 O.D. pipe Grade A weighing 4.05 kilogram per linear meter.

Provide gate frame assembly that is welded or assembled with special malleable or pressed-steel fittings and rivets to provide rigid connections. Install fabric with stretcher bars at vertical edges; stretcher bars may also be used at top and bottom edges. Attach stretcher bars and fabric to gate frames on all sides at intervals not exceeding 381 millimeter. Attach hardware with rivets or by other means which provides equal security against breakage or removal.

Diagonal cross-bracing, consisting of 10 millimeter diameter adjustable-length truss rods on welded gate frames, must be provided where necessary to obtain frame rigidity without sag or twist. Provide nonwelded gate frames with diagonal bracing.

2.18 GATE HARDWARE AND ACCESSORIES

Provide gate hardware and accessories that conforms to ASTM A 116, ASTM A 702, ASTM F 626, and be as specified:

Provide hinges to suit gate size, non-lift-off type, offset to permit 180-degree opening.

Provide latch that permits operation from either side of the gate, with a padlock eye provided as an integral part of the latch.

Provide stops and holders of malleable iron for vehicular gates. Provide stops that automatically engage the gate and hold it in the open position until manually released.

Provide double gates with a cane bolt and ground-set keeper, with latch or locking device and padlock eye designed as an integral part.

2.19 MISCELLANEOUS HARDWARE

Provide miscellaneous hot-dip galvanized hardware as required.

2.20 WIRE TIES

Wires for tying fabric to line posts must be 1.6 millimeter galvanized steel wire spaced 300 millimeter on center. For tying fabric to rails and

braces, wire ties must be spaced 600 millimeter on center. For tying fabric to tension wire, 2.7 millimeter hog rings must be spaced 600 millimeter on center.

Manufacturer's standard procedure will be accepted if of equal strength and durability.

2.21 CONCRETE

Shall be in accordance with Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE

2.22 PADLOCKS

Provide padlocks conforming to ASTM F 883, with chain.

PART 3 EXECUTION

Completed installation must conform to ASTM F 567.

3.1 GENERAL

Final grading and established elevations must be complete prior to commencing fence installation.

3.2 EXCAVATION

Excavations for post footings must be in virgin or compacted soil, of minimum sizes as indicated on Contract Documents.

Space footings for line posts 3048 millimeter on center maximum and at closer intervals when indicated.

Bottoms of the holes must be approximately 75 millimeter below the bottoms of the posts. Set bottom of each post not less than 915 millimeter below finished grade when in firm, undisturbed soil. Set posts deeper, as required, in soft and problem soils and for heavy, lateral loads.

Soil from excavations must be spread uniformly adjacent to the fence line or on areas of the project site, as directed by the USAID Implementing Partner.
When solid rock is encountered near the surface, the Contractor must drill into the rock at least 305 millimeter for line posts and at least 457 millimeter for end, pull, corner, and gate posts. Drill holes at least 25.4 millimeter greater in diameter than the largest dimension of the placed post.

If solid rock is below the soil overburden, Contractor must drill to the full depth required except that penetration into rock need not exceed the minimum depths specified above.

3.3 SETTING POSTS

Remove loose and foreign materials from holes and the soil moistened prior to placing concrete.

Provide tops of footings that are trowel finished and sloped or domed to shed water away from posts. Set hold-open devices, sleeves, and other accessories in concrete.

Keep exposed concrete moist for at least 7 calendar days after placement or cured with a membrane curing material, as approved.

Posts set into sleeved holes in concrete must be grouted in with an approved grouting material.

Posts set in concrete construction must be set vertically, with tops aligned and held in position until concrete has set.

3.3.1 Earth

Provide concrete bases of dimensions indicated. Compact concrete to eliminate voids, and finish to a dome shape. In bedrock, set posts with a minimum of 25.4 mm of grout around each post. Work grout into hole to eliminate voids, and finish to a dome shape.

3.3.2 Concrete Slabs and Walls

Set posts into zinc-coated sleeves, set in concrete slab or wall, to a minimum depth of 305 mm. Fill sleeve joint with lead, nonshrink grout, or other approved material. Set posts for support of removable fence sections into sleeves that provide a tight sliding joint and hold posts aligned and plumb without use of lead or setting material.

3.3.3 Bracing

Brace gate, corner, end, and pull posts to nearest post with a horizontal brace used as a compression member, placed at least 305 mm below top of fence, and a diagonal truss rod and truss tightener used as a tension member.

3.4 CONCRETE STRENGTH

Provide Concrete that has attained at least 75 percent of its minimum 28-day compressive strength, but in no case sooner than 7 calendar days after placement, before rails, tension wire, or fabric are installed. Fabric and wires must not be stretched or gates hung until the concrete has attained its full design strength.

Samples and test concrete must be taken to determine strength as specified.

3.5 TOP RAILS

Provide top rails that run continuously through post caps or extension arms, bending to radius for curved runs. Provide expansion couplings as recommended by the fencing manufacturer.

3.6 CENTER RAILS

Center rails must be one piece between posts set flush with posts on the fabric side, using special offset fittings where necessary.

3.7 BRACE ASSEMBLY

Contractor must provide bracing assemblies at end and gate posts and at both sides of corner and pull posts, with the horizontal brace located at midheight of the fabric.

Install brace assemblies so posts are plumb when the diagonal rod is under

proper tension.

Provide two complete brace assemblies at corner and pull posts where required for stiffness and as indicated.

3.8 TENSION WIRE INSTALLATION

Install tension wire by weaving them through the fabric and tying them to each post with not less than 3.9 millimeter galvanized wire or by securing the wire to the fabric with 3.5 millimeter ties or clips spaced 610 millimeter on center.

3.9 FABRIC INSTALLATION

Provide Fabric in single lengths between stretch bars with bottom barbs placed approximately 38 millimeter above the ground line. Pull fabric taut and tied to posts, rails, and tension wire with wire ties and bands.

Install fabric on the security side of fence, unless otherwise directed.

Fabric must remain under tension after the pulling force is released.

3.10 STRETCHER BAR INSTALLATION

Thread stretcher bars through or clamped to fabric 102 millimeter on center and secured to posts with metal bands spaced 381 millimeter on center.

3.11 GATE INSTALLATION

Install gates plumb, level, and secure, with full opening without interference. Install ground set items in concrete for anchorage as recommended by the fence manufacturer. Adjust hardware for smooth operation and lubricated where necessary.

3.12 TIE WIRES

Provide tie wires that are U-shaped to the pipe diameters to which attached. Twist ends of tie wires not less than two full turns and bent so as not to present a hazard.

3.13 FASTENERS

Install nuts for tension bands and hardware on the side of the fence opposite the fabric side. Peen ends of bolts to prevent removal of nuts.

3.14 ZINC-COATING REPAIR

Clean and repair galvanized surfaces damaged by welding or abrasion, and cut ends of fabric, or other cut sections with specified galvanizing repair material applied in strict conformance with the manufacturer's printed instructions.

3.15 TOLERANCES

Provide posts that are straight and plumb within a vertical tolerance of 6.35 millimeter after the fabric has been stretched. Provide fencing and gates that are true to line with no more than 12.7 millimeter deviation from the established centerline between line posts. Repair defects as directed.

3.16 SITE PREPARATION

3.16.1 Clearing and Grading

Clear fence line of trees, brush, and other obstacles to install fencing. Establish a graded, compacted fence line prior to fencing installation.

3.17 FENCE INSTALLATION

Install fence on prepared surfaces to line and grade indicated. Secure fastening and hinge hardware in place to fence framework by peening or welding. Allow for proper operation of components. Coat peened or welded areas with a repair coating matching original coating. Install fence in accordance with fence manufacturer's written installation instructions except as modified herein.

3.17.1 Post Spacing

Provide line posts spaced equidistantly apart, not exceeding 3.048 m on center. Provide gate posts spaced as necessary for size of gate openings. Do not exceed 152.4 m on straight runs between braced posts. Provide corner or pull posts, with bracing in both directions, for changes in direction of 0.26 rad or more, or for abrupt changes in grade. Provide drawings showing location of gate, corner, end, and pull posts.

3.17.2 Bottom Tension Wire

Install bottom tension wires before installing chain-link fabric, and pull wires taut. Place tension wire within 203 mm of respective fabric line.

3.18 ACCESSORIES INSTALLATION

3.18.1 Post Caps

Design post caps to accommodate top rail. Install post caps as recommended by the manufacturer.

3.18.2 Padlocks

Provide padlocks for gate openings and provide chains that are securely attached to gate or gate posts. Provide padlocks keyed alike, and provide two keys for each padlock.

3.19 CLEANUP

Remove waste fencing materials and other debris from the work site.

-- End of Section --

SECTION 33 11 00

WATER DISTRIBUTION

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C111/A21.11	(2000) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C500	(2009) Metal-Seated Gate Valves for Water Supply Service
AWWA C508	(2001) Swing-Check Valves for Waterworks Service, 2 In. (50 mm) Through 24 In. (600 mm) NPS
AWWA C509	(2009) Resilient-Seated Gate Valves for Water Supply Service
AWWA C600	(2005) Installation of Ductile-Iron Water Mains and Their Appurtenances
AWWA C605	(2005) Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water
AWWA C651	(2005; Errata 2005) Standard for Disinfecting Water Mains
AWWA C900	(2007; Errata 2008) Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 In. Through 12 In. (100 mm Through 300 mm), for Water Distribution
AWWA M23	(2002) Manual: PVC Pipe - Design and Installation

ASTM INTERNATIONAL (ASTM)

ASTM D 3139	(1998; R 2005) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals

UNDERWRITERS LABORATORIES (UL)

UL 262	(2004) Standard for Gate Valves for Fire-Protection Service

UL 312	(2004; Rev thru Jun 2009) Check Valves for Fire-Protection Service
UL 789	(2004; Rev thru Aug 2008) Indicator Posts for Fire-Protection Service

UNI-BELL PVC PIPE ASSOCIATION (UBPPA)

UBPPA UNI-B-3	(1992) Recommended Practice for the Installation of Polyvinyl Chloride (PVC) Pressure Pipe (Nominal Diameters 4-36 Inch)
UBPPA UNI-B-8	(2000) Recommended Practice for the Direct Tapping of Polyvinyl Chloride (PVC) Pressure Water Pipe (Nominal Diameters 6-12 Inch)

1.2 DESIGN REQUIREMENTS

1.2.1 Water Distribution Mains

Provide water distribution mains as 150 mm or as indicated lines of polyvinyl chloride (PVC) plastic pipe. Provide water main accessories, gate valves and check valves as specified and where indicated.

Above ground piping shall be either schedule 80 CPVC or Schedule 40 Steel, and painted in accordance with the manufacturers recommendations.

1.3 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.

SD-03 Product Data

Piping Materials

Water distribution main piping, fittings, joints, valves, and coupling

Indicator posts

Corporation stops

Valve boxes

Submit manufacturer's standard drawings or catalog cuts, except submit both drawings and cuts for push-on joints. Include information concerning gaskets with submittal for joints and couplings.

SD-06 Test Reports

Bacteriological

Test results from commercial laboratory verifying disinfection

SD-07 Certificates

Water distribution main piping, fittings, joints, valves, and coupling

Shop-applied lining and coating

Certificates shall attest that tests set forth in each applicable referenced publication have been performed, whether specified in that publication to be mandatory or otherwise and that production control tests have been performed at the intervals or frequency specified in the publication. Other tests shall have been performed within 3 years of the date of submittal of certificates on the same type, class, grade, and size of material as is being provided for the project.

SD- 11 Warranties

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery and Storage

Inspect materials delivered to site for damage. Unload and store with minimum handling. Store materials on site in enclosures or under protective covering. Store plastic piping, jointing materials and rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes, fittings, and valves free of dirt and debris.

1.4.2 Handling

Handle pipe, fittings, valves, and other accessories in a manner to ensure delivery to the trench in sound undamaged condition. Take special care to avoid injury to coatings and linings on pipe and fittings; make repairs if coatings or linings are damaged. Do not place any other material or pipe inside a pipe or fitting after the coating has been applied. Carry, do not drag pipe to the trench. Use of pinch bars and tongs for aligning or turning pipe will be permitted only on the bare ends of the pipe. The interior of pipe and accessories shall be thoroughly cleaned of foreign matter before being lowered into the trench and shall be kept clean during laying operations by plugging or other approved method. Before installation, the pipe shall be inspected for defects. Material found to be defective before or after laying shall be replaced with sound material without additional expense to the Government. Store rubber gaskets that are not to be installed immediately, under cover out of direct sunlight.

1.4.2.1 Miscellaneous Plastic Pipe and Fittings

Handle Polyvinyl Chloride (PVC) pipe and fittings in accordance with the manufacturer's recommendations. Store plastic piping and jointing materials that are not to be installed immediately under cover out of direct sunlight.

PART 2 PRODUCTS

2.1 WATER DISTRIBUTION MAIN MATERIALS

2.1.1 Piping Materials

2.1.1.1 High Density Polyethylene (HDPE)

a. Where shown, HDPE pipe is to be smooth wall, with the SDR as indicated in the drawings. All joints are to be butt joint thermal weld, or flanged, as required.

2.1.1.2 Polyvinyl Chloride (PVC) Plastic Piping

a. Where shown, PVC pipe is to be schedule 80.

b. Joints and Jointing Material: Joints for pipe shall be glued or flanged, as required.

2.1.1.3 CPVC Pipe

Where indicated in the drawings, CPCVC pipe shall be Schedule 80 and shall be manufactured from a Type IV, Grade I Chlorinated Polyvinyl Chloride (CPVC) compound with a minimum Cell Classification of 23447 per ASTM D1784. The pipe shall be manufactured in strict compliance to ASTM F441, consistently meeting the Quality Assurance test requirements of this standard with regarding to material, workmanship, burst pressure, flattening, and extrusion quality. This pipe shall carry the National Sanitation Foundation (NSF) seal of approval for potable water applications.

a. Pipe shall be solvent weld joints or flanged, to be installed in accordance with the manufacturers recommendations.

b. Pipes with exposed elements shall be painted in accordance with Section 09 90 00 PAINTING AND COATING.

2.1.2 Valves and Other Water Main Accessories

2.1.2.1 Gate Valves on Buried Piping

AWWA C500, AWWA C509, or UL 262. Unless otherwise specified, valves conforming to: (1) AWWA C500 shall be nonrising stem type with double-disc gates and mechanical-joint ends or push-on joint ends as appropriate for the adjoining pipe, (2) AWWA C509 shall be nonrising stem type with mechanical-joint ends or resilient-seated gate valves 80 to 300 mm in sizes, and (3) UL 262 shall be inside-screw type with operating nut, double-disc or split-wedge type gate, designed for a hydraulic working pressure of 1035 kPa, and shall have mechanical-joint ends or push-on joint ends as appropriate for the pipe to which it is joined. Materials for UL 262 valves shall conform to the reference standards specified in AWWA C500. Valves shall open by counterclockwise rotation of the valve stem. Stuffing boxes shall have 0-ring stem seals , except for those valves for which gearing is specified, in which case use conventional packing in place of 0-ring seal. Stuffing boxes shall be bolted and constructed so as to permit easy removal of parts for repair. Where a post indicator is shown, the valve shall have an indicator post flange; indicator post flange for AWWA C500 valve shall conform to the applicable requirements of UL 262.

2.1.2.2 Gate Valves in Valve Pit(s) and Aboveground Location s

AWWA C500, AWWA C509, or UL 262. Unless otherwise specified, valves conforming to: (1) AWWA C500 shall beoutside-screw-and-yoke rising-stemtype with double-discgates and flanged ends, (2) AWWA C509 shall be outside-

screw-and-yoke rising-stemtype with flanged ends, and (3) UL 262 shall be outside-screw-and-yoketype, shall have double-disc or split-wedge solid or one-piece type gate and flanged ends, and shall be designed for a hydraulic working pressure of 1035 kPa. Materials for UL 262 valves shall conform to the reference standards specified in AWWA C500. Valves 150 mm size shall have solid-wedge gates or solid or one-piece type gates where indicated. Provide valves with handwheels that open by counterclockwise rotation of the valve stem.Stuffing boxes shall be bolted and constructed so as to permit easy removal of parts for repair.

2.1.2.3 Check Valves

Swing-check type, AWWA C508 or UL 312. Valves conforming to: (1) AWWA C508 shall have iron or steel body and cover and flanged ends, and (2) UL 312 shall have cast iron or steel body and cover, flanged ends, and designed for a working pressure of 1035 kPa. Materials for UL 312 valves shall conform to the reference standards specified in AWWA C508. Valves shall have clear port opening. Valves shall be spring-loaded. Flanges shall be Class 125 conforming to ASME B16.1.Valves shall be of one manufacturer.

2.1.2.4 Air Relief Valves

Air relief valves shall be of the size shown and shall be of a type that will release air. The valves shall automatically release air when the lines are being filled with water and shall admit air into the line when water is being withdrawn in excess of the inflow. Valves shall be iron body with bronze trim and stainless steel float.

2.1.2.5 Indicator Posts

UL 789. Provide for gate valves where indicated.

2.1.2.6 Valve Boxes

Provide a valve box for each gate valve on buried piping. Valve boxes shall be of cast iron of a size suitable for the valve on which it is to be used and shall be adjustable. Cast-iron boxes shall have a minimum cover and wall thickness of 5 mm. Provide a round head. Cast the word "WATER" on the lid. The least diameter of the shaft of the box shall be 135 mm. Cast-iron box shall have a heavy coat of bituminous paint.

2.1.2.7 Tracer Wire for Nonmetallic Piping

Provide bare copper or aluminum wire not less than 2.5 mm in diameter in sufficient length to be continuous over each separate run of nonmetallic pipe.

PART 3 EXECUTION

3.1 INSTALLATION OF PIPELINES

3.1.1 General Requirements for Installation of Pipelines

These requirements shall apply to all pipeline installation except where specific exception is made in the "Special Requirements..." paragraphs.

3.1.1.1 Location of Water Line

Where water piping is required to be installed within 1 m of existing structures, the water pipe shall be sleeved as required in Paragraph "Casting Pipe". The Contractor shall install the water pipe and sleeve ensuring that there will be no damage to the structures and no settlement or movement of foundations or footings.

Terminate the work covered by this section at a point approximately 1.5 mfrom the building, unless otherwise indicated. Do not lay water lines in the same trench with fuel lines or electric wiring.

a. Water Piping Installation Parallel With Sewer Piping

(1) Normal Conditions: Lay water piping at least 3 m horizontally from a sewer or sewer manhole whenever possible. Measure the distance edge-to-edge.

(2) Unusual Conditions: When local conditions prevent a horizontal separation of 3 m, the water piping may be laid closer to a sewer or sewer manhole provided that:

(a) The bottom (invert) of the water piping shall be at least 450 mm above the top (crown) of the sewer piping.

(b) Where this vertical separation cannot be obtained, the sewer piping shall be constructed of AWWA-approved water pipe and pressure tested in place without leakage prior to backfilling. Approved waste water disposal method shall be utilized.

(c) The sewer manhole shall be of watertight construction and tested in place.

b. Sewer Piping or Sewer Manholes: No water piping shall pass through or come in contact with any part of a sewer manhole.

3.1.1.2 Earthwork

Perform earthwork operations in accordance with Section 31 00 00.

3.1.1.3 Pipe Laying and Jointing

In accordance with pipe manufacturer’s instructions. Do not lay pipe when conditions of trench or weather prevent installation. Depth of cover over top of pipe shall not be less than 800 mm.

3.1.1.4 Installation of Tracer Wire

Install a continuous length of tracer wire for the full length of each run of nonmetallic pipe. Attach wire to top of pipe in such manner that it will not be displaced during construction operations.

3.1.1.5 Penetrations

Pipe passing through walls of valve pits and structures shall be in accordance with the contract drawings.

3.1.2 Installation of Gate Valves

a. Gate valves shall be installed in accordance with AWWA C509 at all locations as shown on the plans, and in accordance with the details shown in the plans.

3.1.3 Installation of Water Service Piping

3.1.3.1 Water Main Connections to Service lines

Connect service lines to the main as indicated. Connect service lines to HDPE water mains in accordance with UBPPA UNI-B-8 and the recommendations of AWWA M23, Chapter 9, "Service Connections."

3.1.4 Disinfection

Prior to disinfection, obtain Engineer's Representative approval of the proposed method for disposal of waste water from disinfection procedures. Disinfect new water piping and existing water piping affected by Contractor's operations in accordance with AWWA C651.

3.2 FIELD QUALITY CONTROL

3.2.1 Field Tests and Inspections

Prior to hydrostatic testing, obtain Engineer's Representative's approval of the proposed method for disposal of waste water from hydrostatic testing. The Engineer's Representative will conduct field inspections and witness field tests specified in this section. The Contractor shall perform field tests, and provide labor, equipment, and incidentals required for testing. The Contractor shall produce evidence, when required, that any item of work has been constructed in accordance with the drawings and specifications. Do not begin testing on any section of a pipeline where concrete thrust blocks have been provided until at least 5 days after placing of the concrete.

3.2.2 Special Testing Requirements

For pressure test, use a hydrostatic pressure 375 kPa greater than the maximum working pressure of the system, except that for those portions of the system having pipe size larger than 50 mm in diameter, hydrostatic test pressure shall be not less than 800 kPa. Hold this pressure for not less than 2 hours. Prior to the pressure test, fill that portion of the pipeline being tested with water for a soaking period of not less than 24 hours. For leakage test, use a hydrostatic pressure not less than the maximum working pressure of the system. Leakage test may be performed at the same time and at the same test pressure as the pressure test.

3.3 CLEANUP

Upon completion of the installation of water lines, and appurtenances, all debris and surplus materials resulting from the work shall be removed.

-- End of Section --

SECTION 33 20 00

WATER WELLS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA A100	(2006; Errata 2007) Water Wells

ASTM INTERNATIONAL (ASTM)

ASTM A 53	(2004) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM D 1785	(2006) Standard Specification for Poly(Vinyl Chloride)(PVC) Plastic Pipe, Schedules 40, 80, and 120

1.2 SYSTEM DESCRIPTION

The well shall be located as shown on the Contract Drawings, and be constructed in accordance with these specifications. The well shall be installed in such a manner to prevent aquifer contamination from drilling operation and equipment, intra- and inter-aquifer contaminationand vertical seepage of surface water adjacent to the well into the subsurface.

1.2.1 Abandonment of Wells

If the Contractor fails to construct a well of the required capacity, or if the well is abandoned because of loss of tools, or for any other cause, abandon the hole as specified in paragraph WELL DECOMMISSIONING/ABANDONMENT.

1.3 SUBMITTALS

Contractor shall submit the following using submittal procedures as specified in the Contract Documents.

SD-02 Shop Drawings

Installation Diagrams

Provide an as-built installation diagram for the completed well. The diagram shall be prepared by the geologist supervising the well installation operations.The diagram shall be submitted within 10 working days of the completion of the well.

SD-03 Product Data

Well Installation Plan

A plan as specified in paragraph WELL INSTALLATION PLAN describing the drilling methods, sampling, and well construction and well development 30 calendar days prior to beginning drilling operations. Mobilization activities may start prior to submittal of the plan. The plan shall be approved and signed by an experienced geologist as specified in paragraph QUALIFICATIONS.

Well Material

Provide catalog data, and name of supplier, for well screens (to include the screen slot size), casing, riser pipe, filter pack material, bentonite, cement, centralizers, surface protective covers, well vaults, locking caps, dedicated sampling equipment, pumps, and chemical specifications on drill lubricants, tracers, disinfecting agents, and drill fluid additives, if used. Catalog data shall include any information, written or otherwise, supplied by the manufacturers or suppliers of the above listed items.

Qualifications

Provide qualification documentation for key personnel.

SD-06 Test Reports

Provide the following test reports:

Survey Maps and Notes

Provide surveyed location and elevation of the well.

Well Development Records

Provide a well development record within 10 working days of development completion.

Decommissioning/Abandonment Records

Provide a well decommissioning record, for each well, or test hole abandoned, within 10 working days of the completion of the abandonment procedure.

Project Photographs

Before, during, and after completion of the work, take photographs of each well installation site. Photographs shall also be taken of any rock that is cored at the site.

Filter Pack

Provide a filter pack material test results; including sieve and chemical analyses, within 10 working days after completion of the bore hole.

Tests

Provide test Reports within 24 hours of the conclusion of each test.

SD-07 Certificates

Air line and gauge

Drilling mud

1.4 QUALITY ASSURANCE

1.4.1 Well Installation Plan

Incorporate the following requirements into the Contractor's Well Installation Plan and follow them in the field. The plan shall include, but shall not be limited to, a discussion of the following:

a. Description of well drilling methods, and installation procedures, including any temporary casing used, placement of filter pack and seal materials, drill cuttings and fluids disposal, and soil/rock sample disposition.

b. Description of well construction materials, including well screen, riser pipe, centralizers, air line and gauge, tailpiece (if used), filter pack and filter pack gradation, bentonite or drilling mud, drilling fluid additives (if used), drilling water, cement, and well protective measures.

c. Description of quality control procedures to be used for placement of filter pack and seals in the boring, including depth measurements.

d. Forms to be used for written boring logs, installation diagrams of wells, geophysical logs, well development records, well sampling data records, state well registration forms, and well abandonment records.

e. Description of contamination prevention and well materials and equipment decontamination procedures.

f. Description of protective cover surface completion procedures, including any special design criteria/features relating to frost heave prevention. The maximum frost penetration for the site shall be included in this description.

g. Description of well development methods to be used.

h. List of applicable publications, including state and local regulations and standards.

i. List of personnel assignments for this project, and personnel qualifications.

j. Description of well decommissioning/abandonment procedures.

k. Description of well capacity testing techniques.

l. Description and discussion of geophysical techniques to be employed at the site.

m. Description of permanent pump to be installed, and discussion of pump operating tests to be employed at the site.

n. Description of specific methods to be employed to control potential

contamination or pollution arising from well installation activities.

1.4.2 Qualifications

A geologist with at least 3 years experience in soil and rock logging, and well installation, shall be on site and responsible for all geophysical and borehole logging, drilling, well installation, developing and testing activities.

The driller shall be licensed and have a minimum of 3 years of experience drilling wells.

The Contractor shall have a minimum of 3 years of well installation experience.

1.4.3 Sampling

1.4.3.1 Samples and Records

The Contractor shall collect and provide a sample of material taken from each three meters of drilling and at every significant change of formation. Approximately two-liters of representative sample shall be obtained from each sampling interval.

Immediately after retrieval, samples shall be split into two halves (one liter each). One half of each sample shall be placed on a flat surface. The other half shall be placed in sample bags which allow water to drain out. Sample bags shall be securely closed to avoid spillage and contamination, and clearly labeled with the following information:

a. Name or number of the production well
b. Depth interval represented by the sample
c. Date and time taken

Sample bags shall be labeled clearly, either directly on the bag or on an attached tag, using ink, pencil, or other medium that is resistant to moisture and sunlight. The label shall not be readily removable from the container. The Contractor shall be responsible for the safe storage of formation samples until such times as they are accepted by the USAID Implementing Partner.

The Contractor shall obtain additional samples as requested by the USAID Implementing Partner in water-bearing formations for analysis by a laboratory or screen manufacturer.

1.4.4 Observation Wells

After completion of the pump well1 Observation well, or more as directed, at least 45 mm in diameter shall be drilled to the target water bearing stratum, at an appropriate location near the pump well. The observation well shall be used in conjunction with the yield test of the test hole and capacity test of the pump well. After final acceptance of the pump well by the Contracting Officer, the observation well shall be abandoned as specified in paragraph WELL DECOMMISSIONING/ABANDONMENT.

1.5 DELIVERY, STORAGE, AND HANDLING

Store and maintain well materials in a clean, uncontaminated condition throughout the course of the project. Filter pack material shall not be

allowed to freeze before installation.

1.6 SITE CONDITIONS

Access to each well site, including any utility clearance, permits, licenses, or other requirements and the payment thereof necessary for execution of the work, is the responsibility of the Contractor. If clearing, or relocation is necessary, the Contractor, and the USAID Implementing Partner shall agree on a suitable clearing or relocation plan.

PART 2 PRODUCTS

2.1 WELL CASING

Surface casing shall be supplied, installed, and properly cemented by the Contractor to a depth of 10 meters to prevent loose overburden from sloughing in. The steel surface casing shall be new material and shall have the following minimum specifications:

a. Minimum O.D. 400 mm
b. ASTM A 53, Grade B mild steel, or ASTM D 1785 Schedule 80 PVC
c. 6.35 mm wall thickness

Casings to be used in the well described in these specifications shall be as follows:

a. I.D. 200 mm
b. ASTM D 1785 Schedule 80 PVC

Casing centralizers shall be located every 20 meters on the well casing. The casing centralizers shall be installed in such a way to allow a 35-50 mm tremie tube for gravel pack to be placed to the bottom of the well.

Casing pipe sections shall be connected by flush threads or bell and spigot joints. The Contractor shall provide the opportunity for the USAID Implementing Partner to observe and photograph the joints before they are placed into the well.

No materials shall be used in the work until they have been duly inspected and approved by the USAID Implementing Partner.

A PVC end cap shall be secured to the bottom of the casing to seal the bottom of the well.

2.2 WELL SCREENS

The USAID Implementing Partner shall determine the depth position of the sections of well screen after the log is completed.

a. The well screen shall be slotted Schedule 80 PVC design. The screen shall be constructed with sufficient strength as defined by the manufacturer for a depth of at least 5 meters above static water level. The Contractor must submit screen specifications and manufacturer name, address and contact phone number to the USAID Implementing Partner for approval before notice to proceed can be given.

b. The slot size of the screen shall be determined based on aquifer characteristics.

c. The screen sections should be 1.5 meter or 3 meter sections.

2.3 FILTER PACK

Filter Pack: Clean, uniform 2.36 mm to 170 mm sized silica sand (8-12 U.S. standard sieve size) with less than 3 percent silt or clay size material (passing the No. 200 U.S. standard sieve) or Standard Ottawa Sand or approved equal.

2.4 CEMENT GROUT

The grout shall consist of Halliburton "light" cement or approved equivalent and about 1 meter of neat cement placed at the bottom of the cemented interval. The "light" cement shall be mixed at 41 liters of water per 25 kg sack of cement. The neat cement shall be mixed at 22 liters of water per 25 kg sack of cement.

PART 3 EXECUTION

3.1 EXAMINATION

Verify the location and elevation of the well to be installed.

Verify that all drill holes have been drilled at the correct locations and to the correct size, depth and orientation prior to well construction.

Verify the location of utility lines, pipelines and other features located in the vicinity of the well installation.

3.2 PROTECTION OF EXISTING STRUCTURES

Protect existing structures and facilities during drilling, construction, development and testing of the well.

3.3 GENERAL INSTALLATION REQUIREMENTS

Furnish all labor, equipment, materials, power supplies and incidentals required to install complete, fully functional, ready-for-operation wells as specified herein and shown on the Drawings.

The wells are to be completed in conformance to ANSI/AWWA A100-06 for Water Wells.

3.3.1 Drilling of Hole

The Contractor shall drill the well at the location designated on the Contract Drawings. The Contractor is responsible for verifying all Utility Locates at the well drilling site within 50 meters of the borehole location.

The well shall be drilled in accordance with the Specifications and may be drilled using the "reverse circulation" or direct rotary method. The borehole diameter shall be a minimum of 375 mm.

The Contractor shall be required to provide all tools, labor, and other machinery and appliances of whatever description necessary and adequate for the construction, development, test pumping, and completion of the well in a workmanlike manner.

3.3.2 Well Measurement

All measurements for depth shall be taken from an established point on the ground surface at the well site. The Contractor shall verify measurements with the USAID Implementing Partner.

3.3.2.1 Well Plumbness and Alignment

The completed production well shall be sufficiently plumb and straight so that there will be no interference with installation, alignment, operation or future removal of the permanent pump. The Contractor will be required to set the casing in the well sufficiently straight and plumb to permit the pump to be installed in such a manner that the pump will operate correctly, and will not be damaged due to casing alignment issues. The well shall not be out of plumb more than 1 degree at any depth.

After the casing is set, the USAID Implementing Partner may require (at Contractor's expense) that the well casing is straight and plumb within 1 degree at all depths. This may require a continuous deviation survey measuring both vertical angle and azimuth.

3.3.3 Drilling Fluid

The mud program should be designed and maintained to promote efficient drilling and keep the drill hole open. In addition, an emphasis should be made to minimize circulation of drilled solids.

3.3.4 Gravel Pack

Gravel pack will be placed in continuous intervals at the depths given on the bid schedule. USAID Implementing Partner may change this quantity in the field based on site information. Changes in this quantity will be given to the Contractor immediately following interpretation of the logs, approximately 8 hours before placement of final gravel pack. The gravel pack shall be introduced into the annulus between the well screen and the well bore wall in such a manner that it is readily known how much volume is in the hole. It shall be placed using tremie pipe(s).Water will be pumped with the gravel pack material to facilitate placement.

Prior to gravel packing the Contractor shall add chorine to the drilling fluid in the hole sufficient to break down polymer viscosity, at least of 10% chlorine bleach per barrel of hole volume. One meter of fine sand shall be placed on top of the gravel pack, prior to cementing.

3.3.5 Cementing of Casing

The Contractor shall seal the annular space between the casing and the drill hole with cement grout above the gravel pack. The cement grout must extend from the top of the gravel pack to 3 meters below the ground surface. The method and adequacy of the cementing must be approved by USAID Implementing Partner. Following the placement of the cement, there shall be no tools placed in the well for a period of 24 hours to allow the cement to cure. The cement shall be placed using a tremie pipe.

3.4 WELL DEVELOPMENT

Well development is the process of removing the mud filter cake on the borehole wall and cleaning and enlarging the passages in the gravel pack and water producing formations. Development will be performed with air lift

surging, either conventional and/or reverse, at the discretion of USAID Implementing Partner. The contractor shall furnish all necessary equipment and materials for proper development of the well. At any time during development the Engineer's Representative may choose to switch to another development method (i.e. water jetting). Tools and materials required for these development alternate methods should be on-site or readily available.

If, during surging USAID Implementing Partner determines that the equipment chosen by the contractor is insufficient to the development task, additional equipment will be brought in by the contractor at their expense to properly complete the task. Development shall be considered complete when essentially mud-free and sand-free water is obtained from the pump discharge. The Contractor shall remove any accumulated sediments from the well bore with a bailer at the completion of development.

3.5 PUMPING TESTS

The Contractor shall supply a test pump capable of pumping up to 10 L/second from a pump setting depth of approximately 30 meters and a total dynamic head of 50 meters. The pumping unit shall be complete with controls and appurtenances and shall be capable of being operated without interruption for a period of 72 hours. The test pump will be powered by an electrical generator supplied by the Contractor.

The Contractor shall provide two methods to measure the depth to water. The primary method shall be a pressure transducer connected to a digital data logger approved by USAID Implementing Partner. The second method may use either nitrogen pressurized air lines or a Solinst (or equivalent) water level meter. The probe and cable of the water level meter will require a PVC monitor tube set from the surface to the pump.

The well shall be "step" tested at rates of approximately 1/2, 3/4, 1 and 1.6 times the design yield (Design Yield = 6.3 L/second). The duration of the step test is 8 hours. The Contractor shall operate the pump and change the discharge rate as directed by USAID Implementing Partner. Discharge of the pump shall be controlled by a gate valve. The discharge shall be controlled and maintained at approximately the desired discharge for each step with an accuracy of plus or minus 5 percent. Pump discharge shall be measured with a magnetic flow meter and a circular orifice plate, or another methods approved by USAID Implementing Partner.

The discharge manifold shall consist of a backpressure gage, primary gate valve, sampling port and sand tester, flow meter, and an appropriate length of straight discharge pipe terminated by an orifice plate sized for the range of flow rates specified above. The backpressure gage readout shall have no greater than 0.5 bar increments. The flow meter shall be calibrated and be capable of totalizing and instantaneous measurements. The discharge shall be controlled and maintained at approximately the desired discharge for each step with an accuracy of plus or minus 5 percent. The totalizing meter shall be in liters, and gage readout for the instantaneous readout shall have no greater than 1 L/second increments. A water sampling port shall be installed on top of the discharge manifold between the flow meter and the valve. Besides sampling, the sampling port will be used to make sure that the discharge manifold pipe remains full to insure accurate flow readings.

A constant discharge rate pumping test will be conducted after recovery from the step test is complete. This constant rate test shall be conducted by pumping the well at the design rate or at maximum yield for a period of

approximately 24 to 72 hours, until USAID Implementing Partner terminates the test. At the end of the test, the pump shall be turned off and testing equipment shall remain in the hole at least 24 hours while recovery measurements are taken by an automatic data logger. During the pumping tests, water level and flow rate measurements shall be recorded manually according to the below schedule. Automatic measurements by the data logger shall be logarithmic with increasing measurement intervals.

Step Test Manual Measurements

Minutes after Rate Change	Measurement Schedule
0 - 10	Every minute
10 - 20	Every other minute
20 - 60	Every five minutes
60 - on	Every 10 minutes

24-72 Hour Test/Recovery Test Manual Measurements

Minutes Into Test	Measurement Schedule
0 - 60	As shown on the step test
60 - 240	Every 20 minutes
240 - 480	Every 30 minutes
480 - 960	Every hour
960 - 1440	Every two hours

The Contractor shall provide and install a Roscoe-Moss sand content tester (or approved equivalent) to the discharge apparatus. During the pumping tests, the water shall be periodically tested for sand content. Whenever continuous pumping at a uniform rate has been interrupted due to failure of pump operation for a period greater than one percent of the elapsed pumping time, USAID Implementing Partner shall require suspension of the test until the water level in the pumped well has recovered. For the purposes of this Contract, recovery shall be considered "complete," after the well has been allowed to rest for a period at least equal to the elapsed pumping time of the aborted test - except that if any three successive water level measurements spaced at least 20 minutes apart show no further rise in the water level in the pumped well, the test may be resumed immediately. The USAID Implementing Partner shall be the sole judge as to whether this latter condition exists.

3.5.1 Sand-Content Testing

The sand content shall be determined by averaging the results of 5 samples collected at the following times during the constant-discharge test: (1) 15 minutes after start of pumping; (2) 6 hours after start of pumping; (3) 12 hours after start of pumping; (4) 18 hours after start of pumping; and (5) 15 minutes before the end of pumping. The minimum volume of water sample collected for testing for sand content shall be the pumping rate in L/second multiplied by 300.

3.6 DISINFECTING

Contractor shall chlorinate the wells in the following manner, or an approved equal:

1. Place CMDC Sodium Hypochlorate 12-15%, or an approved equal, according to the chart below in a potable water truck tank

approximately 1.5 times the Total Mix volume desired. (i.e.: for 8 cubic meter Total Mix volume, use a 12 cubic meter tank).

2. Add water to tank, filling to Total Mix volume based on the chart below.
3. Drive the truck around for approximately 30 minutes to allow mixing and TAC time.
4. Pour a minimum of 4.54 cubic meters into the well by gravity flow.
5. Leave the solution in the well.
6. Refill the empty tank truck with potable water and empty in a location as directed by USAID Implementing Partner.

3.7 TESTING FOR WATER QUALITY

After the capacity test and disinfection is complete, secure samples of the water in suitable containers, and and of sufficient quality, to have bacterial, physical, and chemical analyses made by a recognized testing laboratory. Water quality analyses shall address the parameters specified below. Expenses incident to these analyses shall be borne by the Contractor and the results of the analyses shall be furnished to USAID Implementing Partner. All sampling and analyses shall be performed following approved methods, procedures, and holding times.

Arsenic
Barium
Cadmium
Chromium
Copper
Fecal Coliform
Lead
Mercury
Selenium
Silver
Zinc
Flouride as F
Manganese as MN (dissolved and total)
Iron as Fe (dissolved and total)

Total Coliform
Total Hardness as CaCO(3)
TOC
Sulphates as SO(4)
Chlorides as Cl
Bicarbonates as HCO(3)
Carbonates as CO(3)
Nitrates as NO(3)
Alkalinity as CaCO(3)
Turbidity
pH
Temperature

3.7 TERMINATION AT TOP OF PRODUCTION WELLS

At all times during the progress of the work, the Contractor shall use reasonable precautions to prevent tampering with the well or the entrance of foreign material into it. Upon completion of the production well, the Contractor shall weld a circular plate to the top of the casing. The watertight casing of the well shall extend not less than above final ground level elevation.

3.8 WELL DECOMMISSIONING/ABANDONMENT

Wells completed into unconfined aquifers and unconsolidated aquifers shall be plugged, sealed and abandoned by filling the well to the static water level with drill cuttings, clean sand or clean gravel, then with clean native clays, cement or high solid bentonite grout to the ground surface. The uppermost of casing shall be filled with grout or a permanent watertight cover shall be installed at the top of the casing. If casing is removed, the hole shall be filled as described above to within of the ground surface. The top of the hole shall be filled with materials less permeable than the surrounding soils that are adequately compacted to prevent settling.

Dewatering wells, horizontal drains, monitoring and observation holes, percolation holes, piezometer holes, sumps, test holes and dry holes shall be plugged, sealed and abandoned either pursuant to Paragraph 3.8 or by removing all casing that was installed and by filling the hole(s) with drill cuttings, clean native clay, cement or high solid bentonite grout to within of the ground surface. The top of the hole shall be filled with materials less permeable than the surrounding soils that are adequately compacted to prevent settling.

-- End of Section --

SECTION 33 30 00

SANITARY SEWERS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C605	(2005) Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water

ASTM INTERNATIONAL (ASTM)

ASTM C 150/C 150M	(2009) Standard Specification for Portland Cement
ASTM C 270	(2008a) Standard Specification for Mortar for Unit Masonry
ASTM C 33/C 33M	(2008) Standard Specification for Concrete Aggregates
ASTM C 443M	(2007) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets (Metric)
ASTM C 94/C 94M	(2009a) Standard Specification for Ready-Mixed Concrete
ASTM D 1784	(2008) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D 1785	(2006) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D 2241	(2009) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D 2321	(2005) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

ASTM D 2412	(2002; R 2008) Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
ASTM D 2466	(2006) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D 2467	(2006) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D 2680	(2001; R 2009) Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) and Poly(Vinyl Chloride) (PVC) Composite Sewer Piping
ASTM D 3034	(2008) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D 3212	(2007) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D 4101	(2009) Standard Specification for Polypropylene Injection and Extrusion Materials
ASTM F 477	(2008) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F 949	(2009) Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.27	Fixed Ladders

UNI-BELL PVC PIPE ASSOCIATION (UBPPA)

UBPPA UNI-B-6	(1998) Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe

1.2 SYSTEM DESCRIPTION

1.2.1 Sanitary Sewer Gravity Pipeline

Provide mains and laterals of corrugated wall high density polyethylene (HDPE) pipe with a ring stiffness of 16kN/M^2. Pipe joints are to be by electrofusion or extrusion welding.

1.2.2 Sanitary Sewer Pressure Lines

Provide pressure lines of smooth wall high density polyethylene (HDPE)with the SDR as indicated in the Contract Drawings. Pipe joints are to be by butt joint thermal welding.

1.2.3 GENERAL REQUIREMENTS

The construction required herein shall include appurtenant structures and building sewers to points of connection with the building drains 1.5 m outside the building to which the sewer system is to be connected. Replace damaged material and redo unacceptable work at the Contractor's expense . Backfilling shall be accomplished after inspection by the USAid Implementing Partner. Before, during, and after installation, plastic pipe and fittings shall be protected from any environment that would result in damage or deterioration to the material. Keep a copy of the manufacturer's instructions available at the construction site at all times and shall follow these instructions unless directed otherwise by the USAid Implementing Partner.

1.3 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.

SD-02 Shop Drawings

Drawings
Installation and as-built drawings, as specified.
Cast-in-place concrete manhole
Metal items
Frames, covers, and gratings
Manhole pipe penetrations

SD-03 Product Data

Pipeline Materials
Frames, covers, and gratings
Manhole pipe penetrations
Submit manufacturer's standard drawings or catalog cuts

SD-08 Warranty

1.4 QUALITY ASSURANCE

Drawings

a. Submit As-Built Drawings for the complete sanitary sewer system showing complete detail with all dimensions, both above and below grade, including invert elevation.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery and Storage

1.5.1.1 Piping

Inspect materials delivered to site for damage; store with minimum of handling. Store materials on site in enclosures or under protective coverings. Store plastic piping and jointing materials and rubber gaskets

under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes and fittings free of dirt and debris.

1.5.1.2 Metal Items

Check upon arrival; identify and segregate as to types, functions, and sizes. Store off the ground in a manner affording easy accessibility and not causing excessive rusting or coating with grease or other objectionable materials.

1.5.1.3 Cement, Aggregate, and Reinforcement

As specified in Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE.

1.5.2 Handling

Handle pipe, fittings, and other accessories in such manner as to ensure delivery to the trench in sound undamaged condition. Take special care not to damage linings of pipe and fittings; if lining is damaged, make satisfactory repairs. Carry, do not drag, pipe to trench.

PART 2 PRODUCTS

2.1 PIPELINE MATERIALS

Pipe shall conform to the respective specifications and other requirements specified below.

2.1.1 HDPE Gravity Sewer Piping and Fittings

ASTM D 3034, SDR 35, or ASTM F 949 with ends suitable for elastomeric gasket joints.

2.1.2 HDPE Forcemain Piping

Smooth wall HDPE with SDR values as indicated in the Contract Drawings. Joints are to be thermal butt fusion welded.

2.2 CONCRETE MATERIALS

2.2.1 Cement Mortar

Cement mortar shall conform to ASTM C 270, Type M with Type II cement.

2.2.2 Portland Cement

Portland cement shall conform to ASTM C 150/C 150M, Type V for concrete used in concrete pipe, concrete pipe fittings, and manholes and type optional with the Contractor for cement used in concrete cradle, concrete encasement, and thrust blocking. Where aggregates are alkali reactive, as determined by Appendix XI of ASTM C 33/C 33M, a cement containing less than 0.60 percent alkalies shall be used.

2.2.3 Portland Cement Concrete

Portland cement concrete shall conform to ASTM C 94/C 94M, compressive strength of 28 MPa at 28 days, except for concrete cradle and encasement or concrete blocks for manholes. Concrete used for cradle and encasement shall have a compressive strength of 17 MPa minimum at 28 days. Concrete in place shall be protected from freezing and moisture loss for 7 days.

2.3 MISCELLANEOUS MATERIALS

2.3.1 Concrete Manholes

Concrete manholes shall be constructed in accordance with Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE.

2.3.2 Metal Items

2.3.2.1 Frames, Covers, and Gratings for Manholes

Frames and covers shall be cast iron . Cast iron frames and covers shall be as indicated or shall be of type suitable for the application, circular, without vent holes. The frames and covers shall have a combined weight of not less than 140 kg. The word " Sewer" shall be stamped or cast into covers so that it is plainly visible.

2.3.3 Manhole Steps

Zinc-coated steel as indicated conforming to 29 CFR 1910.27. As an option, plastic or rubber coating pressure-molded to the steel may be used. Plastic coating shall conform to ASTM D 4101, copolymer polypropylene. Rubber shall conform to ASTM C 443M, except shore A durometer hardness shall be 70 plus or minus 5. Aluminum steps or rungs will not be permitted. Steps are not required in manholes less than 1.2 m deep.

PART 3 EXECUTION

3.1 INSTALLATION OF PIPELINES AND APPURTENANT CONSTRUCTION

3.1.1 General Requirements for Installation of Pipelines

These general requirements apply except where specific exception is made in the following paragraphs entitled "Special Requirements."

3.1.1.1 Location

The work covered by this section is identified on the Contract Drawings, unless otherwise indicated.

a. Sanitary piping installation parallel with water line:

(1) Normal conditions: Sanitary piping or manholes shall be laid at least 3 m horizontally from a water line whenever possible. The distance shall be measured edge-to-edge.

(2) Unusual conditions: When local conditions prevent a horizontal separation of 3 m, the sanitary piping or manhole may be laid closer to a water line provided that:

(a) The top (crown) of the sanitary piping shall be at least 450 mm below the bottom (invert) of the water main.

(b) Where this vertical separation cannot be obtained, the sanitary piping shall be constructed of AWWA-approved ductile iron water pipe pressure tested in place without leakage prior to backfilling.

(c) The sewer manhole shall be of watertight construction and tested in place.

b . Sanitary sewer manholes: No water piping shall pass through or come in contact with any part of a sanitary sewer manhole.

3.1.1.2 Earthwork

Perform earthwork operations in accordance with Section 31 00 00 EARTHWORK.

3.1.1.3 Sewer Pipe Laying and Jointing

Install HDPE sewer pipe in accordance with the manufacturer’s instructions. At the end of each work day, close open ends of pipe temporarily with wood blocks or bulkheads. Provide batterboards not more than 7.50 m apart in trenches for checking and ensuring that pipe invert elevations are as indicated. Laser beam method may be used in lieu of batterboards for the same purpose. Branch connections shall be made by use of regular fittings.

3.1.1.4 Forcemain Laying and Jointing

Install HDPE sewer pipe in accordance with the manufacturer’s instructions. Unless otherwise specified, install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section.

3.1.1.5 Thrust Blocks

Thrust blocking shall be concrete of a mix not leaner than: 1 cement, 2-1/2 sand, 5 gravel; and having a comprehensive strength of not less than 14 MPa after 28 days. Blocking shall be placed between solid ground and the fitting to be anchored. Unless otherwise indicated or directed, the base and thrust bearing sides of thrust blocks shall be poured directly against undisturbed earth. The sides of thrust blocks not subject to thrust may be poured against forms. The area of bearing shall be as shown or as directed. Blocking shall be placed so that the fitting joints will be accessible for repair. Steel rods and clamps, protected by galvanizing or by coating with bituminous paint, shall be used to anchor vertical down bends into gravity thrust blocks.

3.1.3 Concrete Work

Cast-in-place concrete is included in Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE.

3.1.4 Manhole Construction

Construct base slab of cast-in-place concrete or use precast concrete base sections. Make inverts in cast-in-place concrete and precast concrete bases

with a smooth-surfaced semi-circular bottom conforming to the inside contour of the adjacent sewer sections. For changes in direction of the sewer and entering branches into the manhole, make a circular curve in the manhole invert of as large a radius as manhole size will permit. For cast-in-place concrete construction, either pour bottom slabs and walls integrally or key and bond walls to bottom slab. No parging will be permitted on interior manhole walls. Cast-in-place concrete work shall be in accordance with the requirements specified under paragraph entitled "Concrete Work" of this section. Make joints between concrete manholes and pipes entering manholes with the resilient connectors specified for this purpose; install in accordance with the recommendations of the connector manufacturer. Where a new manhole is constructed on an existing line, remove existing pipe as necessary to construct the manhole. Cut existing pipe so that pipe ends are approximately flush with the interior face of manhole wall, but not protruding into the manhole. Use resilient connectors as previously specified for pipe connectors to concrete manholes.

3.1.5 Miscellaneous Construction and Installation

3.1.5.1 Metal Work

a. Workmanship and finish: Perform metal work so that workmanship and finish will be equal to the best practice in modern structural shops and foundries. Form iron to shape and size with sharp lines and angles. Do shearing and punching so that clean true lines and surfaces are produced. Make castings sound and free from warp, cold shuts, and blow holes that may impair their strength or appearance. Give exposed surfaces a smooth finish with sharp well-defined lines and arises. Provide necessary rabbets, lugs, and brackets wherever necessary for fitting and support.

b. Field painting: After installation, clean cast-iron frames, covers, gratings, and steps not buried in concrete to bare metal of mortar, rust, grease, dirt, and other deleterious materials and apply a coat of bituminous paint. Do not paint surfaces subject to abrasion.

3.1.6 Installations of Wye Branches

Cutting into piping for connections shall not be done except in special approved cases. When the connecting pipe cannot be adequately supported on undisturbed earth or tamped backfill, the pipe shall be encased in concrete backfill or supported on a concrete cradle as directed. Concrete required because of conditions resulting from faulty construction methods or negligence by the Contractor shall be installed at the Contractor's expense . The installation of wye branches in an existing sewer shall be made by a method which does not damage the integrity of the existing sewer. One acceptable method consists of removing one pipe section, breaking off the upper half of the bell of the next lower section and half of the running bell of wye section. After placing the new section, it shall be rotated so that the broken half of the bell will be at the bottom. The two joints shall then be made with joint packing and cement mortar.

3.2 FIELD QUALITY CONTROL

3.2.1 Field Tests and Inspections

The USAid Implementing Partner will conduct field inspections and witness field tests specified in this section. The Contractor shall p erform field tests and provide labor, equipment, and incidentals required for testing. The Contractor shall b e able to produce evidence, when required, that each item of work has been constructed in accordance with the drawings and specifications.

3.2.2 Tests for Nonpressure Lines

Check each straight run of pipeline for gross deficiencies by holding a light in a manhole; it shall show a practically full circle of light through the pipeline when viewed from the adjoining end of line. When pressure piping is used in a nonpressure line for nonpressure use, test this piping as specified for nonpressure pipe.

3.2.2.1 Leakage Tests

Test lines for leakage by low-pressure air tests. Test mainlines unless directed otherwise by the USAid Implementing Partner. When necessary to prevent pipeline movement during testing, place additional backfill around pipe sufficient to prevent movement, but leaving joints uncovered to permit inspection. When leakage or pressure drop exceeds the allowable amount specified, make satisfactory correction and retest pipeline section in the same manner. Correct visible leaks regardless of leakage test results.

a. Low-Pressure air tests: Perform test as follows:

(1) Install test plugs in the ends of the pipe section between two manholes (upstream and downstream). Pressurize the pipe section to 27.5 kPa and hold this pressure for 5 minutes. Disconnect the air hose from the test plug, and decrease the pressure to 24 KPa. The time for the pressure to drop 3.4 kPa shall not be less than 3 minutes.

3.2.2.2 Deflection Testing

Perform a deflection test on entire length of installed HDPE pipeline on completion of work adjacent to and over the pipeline, including leakage tests, backfilling, placement of fill, grading, paving, concreting, and any other superimposed loads determined in accordance with ASTM D 2412. Deflection of pipe in the installed pipeline under external loads shall not exceed 4.5 percent of the average inside diameter of pipe. Determine whether the allowable deflection has been exceeded by use of a pull-through device or a deflection measuring device.

a. Pull-through device: This device shall be a spherical, spheroidal, or elliptical ball, a cylinder, or circular sections fused to a common shaft. Circular sections shall be so spaced on the shaft that distance from external faces of front and back sections will equal or exceed diameter of the circular section. Pull-through device may also be of a design promulgated by the Uni-Bell Plastic Pipe Association, provided the device meets the applicable requirements specified in this paragraph, including those for diameter of the device, and that the mandrel has a minimum of 9 arms. Ball, cylinder, or circular sections shall conform to the following:

(1) A diameter, or minor diameter as applicable, of 95 percent of the average inside diameter of the pipe; tolerance of plus 0.5 percent will be permitted.

(2) Homogeneous material throughout, shall have a density greater than 1.0 as related to water at 4 degrees C, and shall have a surface Brinell hardness of not less than 150.

(3) Center bored and through-bolted with a 6 mm minimum diameter steel shaft having a yield strength of not less than 483 MPa, with eyes or loops at each end for attaching pulling cables.

(4) Each eye or loop shall be suitably backed with a flange or heavy washer such that a pull exerted on opposite end of shaft will produce compression throughout remote end.

b. Deflection measuring device: Sensitive to 1.0 percent of the diameter of the pipe being tested and shall be accurate to 1.0 percent of the indicated dimension. Deflection measuring device shall be approved prior to use.

c. Pull-through device procedure: Pass the pull-through device through each run of pipe, either by pulling it through or flushing it through with water. If the device fails to pass freely through a pipe run, replace pipe which has the excessive deflection and completely retest in same manner and under same conditions.

d. Deflection measuring device procedure: Measure deflections through each run of installed pipe. If deflection readings in excess of 4.5 percent of average inside diameter of pipe are obtained, retest pipe by a run from the opposite direction. If retest continues to show a deflection in excess of 4.5 percent of average inside diameter of pipe, replace pipe which has excessive deflection and completely retest in same manner and under same conditions.

3.2.3 Tests for Pressure Lines

Test pressure lines in accordance with the applicable standard specified in this paragraph, except for test pressures. For hydrostatic pressure test, use a hydrostatic pressure 345 kPa in excess of the maximum working pressure of the system, but not less than 690 kPa, holding the pressure for a period of not less than one hour. For leakage test, use a hydrostatic pressure not less than the maximum working pressure of the system. Leakage test may be performed at the same time and at the same test pressure as the pressure test.

-- End of Section --

SECTION 33 32 13.14

PACKAGED SEWAGE LIFT STATIONS, GRINDER PUMP TYPE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C600	(2005) Installation of Ductile-Iron Water Mains and Their Appurtenances
AWWA M23	(2002) Manual: PVC Pipe - Design and Installation

ASTM INTERNATIONAL (ASTM)

ASTM A 36/A 36M	(2008) Standard Specification for Carbon Structural Steel
ASTM A 53/A 53M	(2007) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM D 1784	(2008) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D 1785	(2006) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM F 1970	(2005) Standard Specification for Special Engineered Fittings, Appurtenances or Valves for use in Poly(Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Systems
ASTM D 2241	(2005) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D 2466	(2006) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D 2467	(2006) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80

1.2 DESCRIPTION OF WORK

The work includes providing submersible sewage grinder pump station and related work as indicated on the drawings. Provide system complete and ready for operations. Grinder pump station system including equipment, materials, installation, and workmanship as specified herein.

The work also includes providing all piping, fittings and valves to 300 mm beyond limits of pit opening.

1.3 SUBMITTALS

Contractor shall submit the following using submittal procedures as specified in the Contract Documents.

SD-03 Product Data

Pipe and fittings
Check valves
Submersible sewage grinder pumps
Pump motor

SD-10 Operation and Maintenance Data

Submersible Sewage Grinder Pumps

Include pumps, alarms, and motors. Include all information on all equipment, alarm panel and controls, pumps and pump performance curves, and station layout in data for submersible sewage grinder pump station. Submit operation and maintenance data in accordance with the Contract Documents.

SD-11 Closeout Submittals

Manufacturer's standard guarantees and warranties

1.4 DELIVERY, STORAGE, AND HANDLING OF MATERIALS

1.4.1 Delivery and Storage

Inspect materials delivered to site for damage. Unload and store with minimum handling. Store materials in enclosures or under protective covering. Store rubber gaskets not to be installed immediately under cover, out of direct sunlight. Do not store materials directly on the ground. Keep interior of pipes and fittings free of dirt and debris.

1.4.2 Handling

Handle pipe, fittings, valves, and other accessories in such manner as to ensure delivery to the trench in sound, undamaged condition. Avoid injury to coatings and linings on pipe and fittings; make satisfactory repairs if coatings or linings are damaged. Carry pipe to the trench; do not drag it.

1.5 EXCAVATION, TRENCHING, AND BACKFILLING

Provide in accordance with Section 31 00 00 EARTHWORK, except as specified herein.

1.6 WARRANTY

Provide manufacturer's standard guarantees and warranties.

PART 2 PRODUCTS

2.1 PIPE AND FITTINGS

Provide pressure piping, and related accessories for force main piping outside the sewage wet well in accordance with Section 33 30 00 SANITARY SEWERS.

2.1.1 PVC Plastic Pressure Pipe and Associated Fittings

2.1.1.1 Pipe and Fittings Less Than 100 mm Diameter

Use pipe, couplings and fittings manufactured of materials conforming to ASTM D 1784, Class 12454-B.

(1) Solvent Cement Joint: Use pipe conforming to dimensional requirements of ASTM D 1785 or ASTM D 2241 with joints meeting the requirements of 1.03 MPa working pressure and 1.38 MPa hydrostatic test pressure. Use fittings for solvent cement jointing conforming to ASTM D 2466 or ASTM D 2467.

2.1.2 Insulating Joints

Provide between pipes of dissimilar metals a rubber gasket or other approved type of insulating joint or dielectric coupling to effectively prevent metal-to-metal contact between adjacent sections of piping.

2.1.3 Accessories

Provide flanges, connecting pieces, transition glands, transition sleeves, and other adapters as required and as shown on the Drawings.

2.2 VALVES AND OTHER PIPING ACCESSORIES

2.2.1 Check Valves Less Than 100 mm Diameter

Neoprene ball check valve with integral hydraulic sealing flange, designed for a hydraulic working pressure of 1.21 MPa.

2.2.2 Identification Tags and Plates

Provide valves with tags or plates numbered and stamped for their usage. Use plates and tags of brass or nonferrous material and mounted or attached to the valve.

2.2.3 Gate Valves Less than 100 mm Diameter

Plastic body gate valves shall conform to ASTM F 1970.

2.2.4 Miscellaneous Metals

Use stainless steel bolts, nuts, washers, anchors, and supports for installation of equipment.

2.2.5 Wet Well Vent

Vent assembly shall be provided as an integral part of the packaged station. In the event an external vent is required it shall be galvanized ASTM A 53/A 53M pipe or painted steel pipe conforming to ASTM A 36/A 36M with insect screening.

2.3 SUBMERSIBLE SEWAGE GRINDER PUMPS

Provide submersible sewage pumps with grinder units as shown on the drawings. Pumps shall be easily removed from the unit using a quick disconnect coupling or fitting. Provide submersible, centrifugal sewage pumps and grinder units capable of grinding all materials found in normal domestic sewage, including plastics, rubber, sanitary napkins, disposable diapers, and wooden articles into a finely ground slurry with particle dimensions no greater than 6 mm. Pump capacity and motor characteristics as indicated herein. Design pump to operate in a submerged or partially submerged condition.

Pump	liters per second at total rated head, m H(2)O
Sanitary pump station	7 lps, 7.05 m
Graywater tanks	2.35 lps, 14.6 m

Pumps shall operate at optimum efficiencies to produce the most economical pumping system under the conditions encountered and shall be sized to make optimum match with the system head curve as shown. Pumps shall furnish not less than 150% of rated capacity at a total discharge head of not less than 65% of total rated head.

2.3.1 Casing

Provide hard, close-grained cast iron casing which is free from blow holes, porosity, hard spots, shrinkage defects, cracks, and other injurious defects. Design casings to permit replacement of wearing parts. Design passageways to permit smooth flow of sewage and to be free of sharp turns and projections.

2.3.2 Impeller

Provide non-clogging type cast-iron impeller. Make impeller with smooth surfaces, free flowing with the necessary clearance to permit objects in the sewage to pass. Fit and key, spline, or thread impeller on shaft, and lock in such manner that lateral movement will be prevented and reverse rotation will not cause loosening.

2.3.3 Shaft and Shaft Seals

Provide shaft of stainless steel. Provide mechanical seal of double carbon and ceramic construction with mating surfaces lapped to a flatness tolerance of one light band. Hold rotating ceramics in mating position with stationary carbons by a stainless steel spring. Oil lubricate bearings.

2.3.4 Bearings

Provide heavy duty ball thrust bearing or roller type bearing of adequate

size to withstand imposed loads. Oil lubricate bearings.

2.3.5 Pump and Motor

Use pump and motor assembled on a single stainless steel shaft in a heavy duty cast-iron shell. Use free standing pump support legs of cast-iron providing enough clearance for the solids to get into the grinder.

2.4 PUMP MOTOR

Motor horsepower must be not less than pump horsepower at any point on the pump performance curve. Fit motors with lifting "eyes" capable of supporting entire weight of pump and motor. Motors must be suitable for operation at 50 Hz.

2.5 PUMP CONTROL SYSTEM

Provide manual "on-off" switch for the pump. Provide independent adjustable high and low water level switches. Provide floats, supports, and alarm. Metal parts, if used, must be of bronze or equivalent corrosion resistant material.

2.5.1 Float Assembly Description

Float assembly shall be provided as an integral part of the packaged station and shall be adequate to control the pumps.

2.5.2 Sewage Pump Alarm and Control Panel

Enclose alarm panel in NEMA IV enclosure with a flashing red light with long life bulb in guarded enclosure and 15 mm diameter horn. Panel shall be mounted as shown on the drawings. Horn must emit 120 DB at 3 meters. Power alarm horn and light from 12V DC power supply with battery backup. Provide a rechargeable battery rated to power both the horn and light for a minimum of two hours upon loss of main power. Provide circuitry to automatically recharge the battery after main power is restored. Full charge of battery must take no more than 20 hours. Use panels with power on light, push to test button for horn and light and push to silence button for horn and light with automatic reset for next alarm. Use alarm designed to activate under the following conditions:

a. High liquid level as sensed by float switch

b. Loss of main power

2.5.3 Leak Sensor

The pumps shall be equipped with a leak sensor.

2.5.4 Temperature Alarm

The pumps shall be equipped with a temperature alarm.

2.5.5 Electrical Requirements

Furnish motors with their respective pieces of equipment. Furnish internal wiring for components of packaged equipment as an integral part of the equipment. Provide power wiring and conduit for field installed equipment.

2.5.6 Electric Motor

Use hermetically sealed electric motor. Seal the power cable inside the motor end bell. Provide a neoprene covered cable with a flexible metal cover over it for its full length.

PART 3 EXECUTION

3.1 INSTALLATION

Provide pump station in accordance with drawings and requirements of the respective equipment manufacturers. Dampen and isolate equipment vibration.

3.1.1 Installation of PVC Plastic Pressure Pipe and Fittings

Unless otherwise specified, install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the recommendations for pipe joint assembly and appurtenance installation in AWWA M23, Chapter 7, "Installation."

a. Pipe Less than 100 mm Diameter:

(1) Push-On Joints: Bevel ends of pipe for push-on joints to facilitate assembly. Mark pipe to indicate when the pipe is fully seated. Lubricate gasket to prevent displacement. Exercise care to ensure that the gasket remains in proper position in the bell or coupling while making the joint.

(2) Solvent-weld joints: comply with the manufacturer's instructions.

3.1.2 Valves

Installation of Valves: Install check valves in accordance with the applicable requirements of AWWA C600 for valve-and-fitting installation, except as otherwise indicated. Make and assemble joints to check valves as specified for making and assembling the same type joints between pipe and fittings.

3.1.3 Force Main

Provide in accordance with Section 33 30 00 SANITARY SEWERS.

3.1.4 Equipment Installation

Install equipment in accordance with these specifications and the manufacturer's installation instructions. Grout equipment mounted on concrete foundations before installing piping. Install piping to avoid imposing stress on any equipment. Match flanges accurately before securing bolts.

3.2 FIELD TESTS AND INSPECTIONS

Perform all field tests, and provide all labor, equipment, and incidentals required for testing. Produce evidence, when required, that any item of work has been constructed in accordance with contract requirements. Allow concrete to cure a minimum of 5 days before testing any section of piping where concrete thrust blocks have been provided.

3.2.1 Testing Procedure

Test piping in accordance with the Section 33 30 00 SANITARY SEWERS. Test in operation all equipment to demonstrate compliance with the contract requirements.

3.2.2 Sewage Grinder Pump Lift Station

Test pumps and controls, in operation, under design conditions to insure proper operation of all equipment. Provide all appliances, materials, water, and equipment for testing. Conduct testing after all equipment is properly installed, electrical services and piping are installed, liquid is flowing, and the pump station is ready for operation. Correct all defects discovered to the satisfaction of the USAID Implementing Partner, and all tests repeated, at the expense of the Contractor, until the equipment is in proper working order.

-- End of Section --

SECTION 33 56 10

FACTORY-FABRICATED FUEL STORAGE TANKS

PART 1 GENERAL

1.1 SUMMARY

This section defines the requirements for factory-fabricated fuel storage tanks.

1.2 SUBMITTALS

Contract shall submit the following using submittal procedures as specified in the Contract Documents.

SD-02 Shop Drawings
Grounding and Bonding

SD-03 Product Data

Aboveground Storage Tank
Tank Protective Coatings
Tank Gauges

SD-06 Test Reports
Aboveground Storage Tank Tightness Tests
Tank Manufacturer's Tests
Tank Fill Tests

SD-08 Manufacturer's Instructions
Aboveground Storage Tank
Tank Gauges

SD-10 Operation and Maintenance Data
Aboveground Storage Tank
Tank Gauges

1.3 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the USAID Implementing Partner . Replace damaged or defective items.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 General

Provide materials and equipment that are standard products of a manufacturing regularly engaged in the manufacturing of such products, that are of a similar material, design

2.1.2 Nameplates

Attach nameplates to all specified equipment defined herein. List on each nameplate the manufacturer's name, address, contract number, acceptance date, component type or style, model or serial number, catalog number, capacity or size, and the system that is controlled. Construct plates of stainless steel . Install nameplates in prominent locations with nonferrous screws, nonferrous bolts, or permanent adhesive. Minimum size of nameplates shall be 25 by 65 mm. Lettering shall be the normal block style with a minimum 6 mm height. Accurately align all lettering on nameplates. Key the nameplates to a chart and schedule for each system. Frame charts and schedule under glass, and locate where directed near each system. Furnish two copies of each chart and schedule. Each nameplate description shall identify its function.

2.2 MATERIALS

Internal parts and components of equipment, piping, piping components, and valves that could be exposed to fuel during system operation shall not be constructed of zinc coated (galvanized) metal, brass, bronze, or other copper bearing alloys. Do not install cast iron bodied valves in piping systems that could be exposed to fuel during system operation.

2.3 ELECTRICAL WORK

2.3.1 Grounding and Bonding

Grounding and bonding shall be in accordance with,the contract drawing Provide jumpers to overcome the insulating effects of gaskets, paints, or nonmetallic components.

2.4 ABOVEGROUND STORAGE TANK

2.4.1 Steel Tank With Integral Steel Supports

Provide a factory-welded, single wall steel tank. Tank shall be designed and manufactured for a horizontal cylindrical installation. Tank shall be mounted on the tank manufacturer's standard tank saddle that elevates the tank above the underlying concrete slab a minimum of 305 mm.

2.5 TANK PROTECTIVE COATINGS

2.5.1 Interior Surfaces

Coat 100 percent of a metal tank's interior surfaces including all metal piping and metal appurtenances with a minimum 0.13 mm thick interior epoxy coating.

2.5.2 Exterior Surfaces, Aboveground Tanks

Protect the exterior surfaces of each aboveground tank as specified in with a minimum 0.13mm thick exterior coating.

2.6 TANK COMPONENTS

2.6.1 Tank Manway

Tank manway shall have an internal diameter of 760 mm. Provide each manway with a matching flanged watertight manway cover. Manway covers shall be UL constructed of pressed or mild steel, and include a gasket.

2.6.2 Tank Piping Penetrations

Provide a welded-in-place double tapered threaded coupling for each tank piping connection.

2.6.3 Tank Striker/Impact Plates

Provide an interior striker/impact plate under each tank manway and pipe connection. Each plate shall be a minimum of 3 mm in thickness, be larger in diameter than the tank penetration, fit the curvature of the tank bottom, and be completely coated in the same fashion as the interior tank bottom coating. Each plate shall be welded to the tank bottom at the factory (full circumference connection).

2.6.4 Tank Cleanout and Gauge Assembly

Provide a combination cleanout and gauge assembly. The assembly shall include a bronze top-seal type adapter with a corresponding locking type cap (adapter and cap both externally-mounted to the top of the tank) and a steel or aluminum pipe mounted internal to the tank. The pipe shall be a minimum 50 mm in size and extend downward through the top of the tank to within 75 mm of the tank bottom. Provide the entire length of pipe inside the tank with 13 mm wide by 300 mm long slots at alternate locations. Coat the pipe in the same fashion as the interior tank bottom coating.

2.6.6 Aboveground Tank Emergency Vent

Vent shall be the normally-closed, UL listed type that vents outward and upward. Vent shall conform with NFPA 30 and UL 142. Provide vent with the Liters per second (L/s) rating permanently labeled on the the vent's exterior.

2.7 TANK GAUGES

2.7.1 Stick Gauge

For each tank, provide 2 wooden stick gauges. Gauge length shall allow the measurement of the entire level of fuel in the corresponding tank. Gauges shall be compatible with the fuel to be measured (no swelling or damage from fuel contact). Provide gauge with non-sparking caps on each end. Mark gauges in m and mm. The smallest unit of measure on the gauge shall be 1 cm.

2.7.3 Analog Tank Gauge

Gauge shall be the level sensing, mechanically actuated type that provides the tank level readout in a sealed glass cap contained in a gauge box. Gauge shall be accurate to plus or minus 6 mm and shall measure the liquid

level over the full range of a tank's height. Gauge shall have vapor tight seals to prevent condensation from fogging the viewing glass.

2.8.1 Piping Penetrations

Sump sides shall allow the penetration of carrier pipes, exterior containment pipes, conduits, and vapor pipes as required. Sump penetrations shall be booted or sealed to ensure that liquid will not escape from the sump in the event that the liquid level within the sump rises above the pipe penetration. Boots and seals used shall be compatible with the fuel to be handled. Boots and seals shall be water resistant to the influx of water from outside the sump. Boots and seals shall be designed and installed to accommodate the anticipated amount of thermal expansion and contraction in the piping system.

2.11 ACCESSORIES

2.11.1 Concrete Anchor Bolts

Concrete anchors shall be hot-dipped galvanized.

2.11.2 Bolts and Studs

Carbon steel bolts and studs shall be hot-dipped galvanized. Stainless steel bolts and studs are also acceptable.

2.11.3 Nuts

Carbon steel nuts shall be hot-dipped galvanized. Stainless steel nuts are also acceptable.

2.11.4 Washers

Provide flat circular washers under each bolt head and each nut. Washer materials shall be the same as the connecting bolt and nut.

2.12 FINISHES

2.12.1 Factory Coating

Unless otherwise specified, provide equipment and components fabricated from ferrous metal with the manufacturer's standard factory finish. For equipment and component surfaces subject to temperatures above 50 degrees C, the factory coating shall be appropriately designed for the temperature service.

PART 3 EXECUTION

3.1 INSTALLATION

Install work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Handle storage tanks with extreme care to prevent damage during placement and install in accordance with the manufacturer's installation instructions. Inspect the exterior surface of each tank for obvious visual damage prior to and during the placement of each storage tank. Repair surface damage to a storage tank according to manufacturer's requirements before proceeding with the system

installation. Provide the termination of fill lines within a tank with an antisplash deflector. Provide nylon dielectric bushings on pipe connections to a steel tank.

3.1.1.1 Steel Tank Handling

Store, handle, and place externally coated steel tanks with care and in a manner that will minimize damage to the coating and will not reduce its protective value. Place coated tanks in position carefully and with a minimum of handling. Prior to backfilling a tank, visually inspect the tank exterior protective coating for damage. Repair any damaged tank coating.

3.1.1.2 Steel Tank Installation Procedures

Anchor tank to a reinforced concrete anchor pad. Separate tank from an anchor pad by a minimum of 300 mm of backfill material. Coat anchors and accessories to resist corrosion.

3.1.2 Equipment

Properly level, align, and secure equipment in place in accordance with manufacturer's instructions. Provide supports for equipment, appurtenances, and pipe as required. Install anchors, bolts, nuts, washers, and screws where required for securing the work in place. Sizes, types, and spacings of anchors and bolts not indicated or specified shall be as required for proper installation.

3.2 FIELD QUALITY CONTROL

3.3 DEMONSTRATIONS

Conduct a training session for designated USAID Implementing Partner personnel in the operation and maintenance procedures related to the equipment/systems specified herein. Include pertinent safety operational procedures in the session as well as physical demonstrations of the routine maintenance operations. Furnish instructors who are familiar with the installation/equipment/systems, both operational and practical theories, and associated routine maintenance procedures.

3.4 TANK FILL TESTS

Tank fill tests shall not be performed until after the flushing, cleaning, and adjusting requirements. Do not overfill any storage tank more than the 98 percent level. Verify that all tank gauges are calibrated and operating appropriately.

3.5 FIELD PAINTING

Painting required for surfaces not otherwise specified shall be field painted as specified in Section 09 90 00 PAINTS AND COATINGS . Do not paint stainless steel and aluminum surfaces. Do not coat equipment or components provided with a complete factory coating. Prior to any field painting, clean surfaces to remove dust, dirt, rust, oil, and grease.

-- End of Section --

SECTION 33 71 02.00 20

UNDERGROUND ELECTRICAL DISTRIBUTION

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACI INTERNATIONAL (ACI)

ACI 318M	(2008; Errata 2008; Errata 2009) Metric Building Code Requirements for Structural Concrete and Commentary
ACI SP-66	(2004) ACI Detailing Manual

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO HB-17	(2002; Errata 2003; Errata 2005) Standard Specifications for Highway Bridges
AASHTO M 198	(2008) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8	(2000) Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM B 1	(2001; R 2007) Standard Specification for Hard-Drawn Copper Wire
ASTM B 3	(2001; R 2007) Standard Specification for Soft or Annealed Copper Wire
ASTM B 496	(2004) Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors
ASTM B 8	(2004) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B 800	(2005) Standard Specification for 8000 Series Aluminum Alloy Wire for Electrical Purposes-Annealed and Intermediate Tempers

ASTM B 801	(2007) Standard Specification for Concentric-Lay-Stranded Conductors of 8000 Series Aluminum Alloy for Subsequent Covering or Insulation
ASTM C 139	(2005) Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes
ASTM C 309	(2007) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 32	(2009) Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale)
ASTM C 478M	(2009) Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric)
ASTM C 857	(2007) Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
ASTM F 512	(2006) Smooth-Wall Poly (Vinyl Chloride) (PVC) Conduit and Fittings for Underground Installation

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2007; Errata 2006 & 2007; INT 44-56 2007; INT 47, 49, 50, 52-56 2008; INT 57, 58, 51, 48, 59 2009) National Electrical Safety Code
IEEE C37.20.3	(2001; R 2006) Metal-Enclosed Interrupter Switchgear
IEEE Std 100	(2000) The Authoritative Dictionary of IEEE Standards Terms
IEEE Std 386	(2006) Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V
IEEE Std 400.2	(2004) Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)
IEEE Std 404	(2006) Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V Through 500 000 V
IEEE Std 48	(2009) Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV through 765 kV
IEEE Std 81	(1983) Guide for Measuring Earth

	Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1)Normal Measurements

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2009) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C119.1	(2006) Sealed Insulated Underground Connector Systems Rated 600 Volts
NEMA RN 1	(2005) Standard for Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	(2003) Standard for Electrical Polyvinyl Chloride (PVC) Tubing and Conduit
NEMA TC 3	(2004) Standard for Polyvinyl Chloride PVC Fittings for Use With Rigid PVC Conduit and Tubing
NEMA TC 6 & 8	(2003) Standard for Polyvinyl Chloride PVC Plastic Utilities Duct for Underground Installations
NEMA TC 9	(2004) Standard for Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation
NEMA WC 71	(1999) Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
NEMA WC 74	(2006) Standard for 5-46 kV Shielded Power Cable for use in the Transmission and Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2008; AMD 1 2008) National Electrical Code - 2008 Edition

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-758-A	(2004) Customer-Owned Outside Plant Telecommunications Cabling Standard

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 1751F-644	(2002) Underground Plant Construction

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-60005	(Basic; Notice 1) Frames, Covers, Gratings, Steps, Sump And Catch Basin, Manhole

UNDERWRITERS LABORATORIES (UL)

UL 1072	(2006; Rev thru Sep 2007) Medium-Voltage Power Cables
UL 1242	(2006; Rev thru Jul 2007) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 44	(2005; Rev thru Nov 2005) Thermoset-Insulated Wires and Cables
UL 467	(2007) Standard for Grounding and Bonding Equipment
UL 486A-486B	(2003; Rev thru Apr 2009) Standard for Wire Connectors
UL 510	(2005; Rev thru Aug 2005) Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape
UL 514A	(2004; Rev thru Oct 2009) Standard for Metallic Outlet Boxes
UL 514B	(2004; Rev thru Nov 2009) Standard for Conduit, Tubing and Cable Fittings
UL 6	(2007) Standard for Electrical Rigid Metal Conduit-Steel
UL 651	(2005; Rev thru May 2007) Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings
UL 83	(20086) Standard for Thermoplastic-Insulated Wires and Cables
UL 854	(2004; Rev thru Oct 2007) Service-Entrance Cables

1.2 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE Std 100.

b. In the text of this section, the words conduit and duct are used interchangeably and have the same meaning.

c. In the text of this section, "medium voltage cable splices," and "medium voltage cable joints" are used interchangeably and have the same meaning.

1.3 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.

SD-02 Shop Drawings

Precast underground structures

SD-03 Product Data

Medium voltage cable

Medium voltage cable joints

Medium voltage cable terminations

Live end caps

Precast concrete structures

Sealing Material

Pulling-In Irons

Manhole frames and covers

Handhole frames and covers

Composite/fiberglass handholes

Cable supports (racks, arms and insulators)

SD-06 Test Reports

Arc-proofing test for cable fireproofing materials

Medium voltage cable qualification and production tests

Field Acceptance Checks and Tests

Arc-proofing test for cable fireproofing tape

Cable Installation Plan and Procedure

Six copies of the information described below in 215.9 by 279.4 mm (8-1/2 by 11 inch) binders having a minimum of three rings from which material may readily be removed and replaced, including a separate section for each cable pull. Sections shall be separated by heavy plastic dividers with tabs, with all data sheets signed and dated by the person supervising the pull.

a. Site layout drawing with cable pulls numerically identified.

b. A list of equipment used, with calibration certifications. The manufacturer and quantity of lubricant used on pull.

c. The cable manufacturer and type of cable.

d. The dates of cable pulls, time of day, and ambient temperature.

e. The length of cable pull and calculated cable pulling tensions.

f. The actual cable pulling tensions encountered during pull.

SD-07 Certificates

Cable splicer/terminator

Cable Installer Qualifications

1.4 QUALITY ASSURANCE

1.4.1 Precast Underground Structures

Submittal required for each type used. Provide calculations and drawings for precast manholes and handholes bearing the seal of a registered professional engineer including:

a. Material description (i.e., f'c and Fy)

b. Manufacturer's printed assembly and installation instructions

c. Design calculations

d. Reinforcing shop drawings in accordance with ACI SP-66

e. Plans and elevations showing opening and pulling-in iron locations and details

1.4.2 Certificate of Competency for Cable Splicer/Terminator

Certification of the qualification of the cable splicer/terminator shall be submitted, for approval, 30 days before splices or terminations are to be made in medium voltage (5 kV to 35 kV) cables. The certification shall include the training, and experience of the individual on the specific type and classification of cable to be provided under this contract. The certification shall indicate that the individual has had three or more years recent experience splicing and terminating medium voltage cables. The certification shall also list a minimum of three splices/terminations that have been in operation for more than one year. In addition, the individual may be required to perform a dummy or practice splice/termination in the presence of the Contracting Officer, before being approved as a qualified cable splicer. If that additional requirement is imposed, the Contractor shall provide short sections of the approved types of cables along with the approved type of splice/termination kit, and detailed manufacturer's instructions for the cable to be spliced. The USAID Implementing Partner reserves the right to require additional proof of competency or to reject the individual and call for certification of an alternate cable splicer.

1.4.3 Cable Installer Qualifications

Provide at least one onsite person in a supervisory position with a documentable level of competency and experience to supervise all cable pulling operations. Provide a resume showing the cable installers' experience in the last three years, including a list of references complete with points of contact, addresses and telephone numbers.

1.4.4 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the USAID Implementing Partner. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.4.5 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.5.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.5.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

PART 2 PRODUCTS

2.1 CONDUIT, DUCTS, AND FITTINGS

2.1.1 Rigid Metal Conduit

UL 6.

2.1.1.1 Rigid Metallic Conduit, PVC Coated

NEMA RN 1, Type A40, except that hardness shall be nominal 85 Shore A durometer, dielectric strength shall be minimum 15.75 kV per mm at 60 Hz, and tensile strength shall be minimum 25 MPa.

2.1.2 Intermediate Metal Conduit

UL 1242.

2.1.2.1 Intermediate Metal Conduit, PVC Coated

NEMA RN 1, Type A40, except that hardness shall be nominal 85 Shore A durometer, dielectric strength shall be minimum 15.75 kV per mm at 60 Hz, and tensile strength shall be minimum 25 MPa.

2.1.3 Plastic Conduit for Direct Burial

UL 651,Schedule 40 or Schedule 80 as indicated, NEMA TC 2, EPC-40-PVC or EPC-80-PVCas indicated.

2.1.4 Plastic Duct for Concrete Encasement

NEMA TC 6 & 8 and ASTM F 512, UL 651, EPC-40-PVC.

2.1.5 Innerduct

Provide corrugated polyethylene (PE) or PVC innerducts with pullwire. Size as indicated.

2.1.6 Conduit Sealing Compound

Compounds for sealing ducts and conduit shall have a putty-like consistency workable with the hands at temperatures as low as 2 degrees C (35 degrees F), shall neither slump at a temperature of 150 degrees C (300 degrees F), nor harden materially when exposed to the air. Compounds shall adhere to clean surfaces of fiber or plastic ducts; metallic conduits or conduit coatings; concrete, masonry, or lead; any cable sheaths, jackets, covers, or insulation materials; and the common metals. Compounds shall form a seal without dissolving, noticeably changing characteristics, or removing any of the ingredients. Compounds shall have no injurious effect upon the hands of workmen or upon materials. Inflatable bladders may be used as an option.

2.1.7 Fittings

2.1.7.1 Metal Fittings

UL 514B.

2.1.7.2 PVC Conduit Fittings

NEMA TC 3.

2.1.7.3 PVC Duct Fittings

NEMA TC 9.

2.1.7.4 Outlet Boxes for Steel Conduit

Outlet boxes for use with rigid or flexible steel conduit shall be cast-metal cadmium or zinc-coated if of ferrous metal with gasketed closures and shall conform to UL 514A.

2.2 LOW VOLTAGE INSULATED CONDUCTORS AND CABLES

Insulated conductors shall be rated 600 volts and conform to the requirements of NFPA 70, including listing requirements. Wires and cables manufactured more than 12 months prior to date of delivery to the site shall not be accepted. Service entrance conductors shall conform to UL 854, type USE.

2.2.1 Conductor Types

Cable and duct sizes indicated are for copper conductors and THHN/THWN unless otherwise noted. Conductors No. 10 AWG and smaller shall be solid copper. Conductors No. 8 AWG and larger shall be stranded copper. All conductors shall be copper.

2.2.2 Conductor Material

Unless specified or indicated otherwise or required by NFPA 70, wires in conduit, other than service entrance, shall be 600-volt, Type THWN/THHN conforming to UL 83 or Type XHHW or RHW conforming to UL 44. Copper conductors shall be annealed copper complying with ASTM B 3 and ASTM B 8. Aluminum conductors shall be Type AA-8000 aluminum conductors complying with ASTM B 800 and ASTM B 801, and shall be of an aluminum alloy listed or labeled by UL as "component aluminum-wire stock (conductor material). Type EC/1350 is not acceptable. Intermixing of copper and aluminum conductors is not permitted.

2.2.3 Jackets

Multiconductor cables shall have an overall PVC outer jacket.

2.2.4 Direct Buried

Single-conductor and multi-conductor cables shall be of a type identified for direct burial.

2.2.5 In Duct

Cables shall be single-conductor cable.

2.2.6 Cable Marking

Insulated conductors shall have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout the cable length.

Each cable shall be identified by means of a fiber, laminated plastic, or non-ferrous metal tags, or approved equal, in each manhole, handhole, junction box, and each terminal. Each tag shall contain the following information; cable type, conductor size, circuit number, circuit voltage, cable destination and phase identification.

Conductors shall be color coded. Conductor identification shall be provided within each enclosure where a tap, splice, or termination is made. Conductor identification shall be by color-coded insulated conductors, plastic-coated self-sticking printed markers, colored nylon cable ties and plates, heat shrink type sleeves,or colored electrical tape. Control circuit terminations shall be properly identified. Color shall be green for grounding conductors and white for neutrals; except where

neutrals of more than one system are installed in same raceway or box, other neutrals shall be white with a different colored (not green) stripe for each. Color of ungrounded conductors in different voltage systems shall be as follows

a. 400/230, three-phase

(1) Phase A - brown

(2) Phase B - orange

(3) Phase C - yellow

b. 230 volt, single phase: Black and red

2.3 LOW VOLTAGE WIRE CONNECTORS AND TERMINALS

Shall provide a uniform compression over the entire conductor contact surface. Use solderless terminal lugs on stranded conductors.

a. For use with copper conductors: UL 486A-486B.

b. For use with aluminum conductors: UL 486A-486B. For connecting aluminum to copper, connectors shall be the circumferentially compressed, metallurgically bonded type.

2.4 LOW VOLTAGE SPLICES

Provide splices in conductors with a compression connector on the conductor and by insulating and waterproofing using one of the following methods which are suitable for continuous submersion in water and comply NEMA C119.1.

2.4.1 Heat Shrinkable Splice

Provide heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material which shall be applied in accordance with the manufacturer's written instructions.

2.4.2 Cold Shrink Rubber Splice

Provide a cold-shrink rubber splice which consists of EPDM rubber tube which has been factory stretched onto a spiraled core which is removed during splice installation. The installation shall not require heat or flame, or any additional materials such as covering or adhesive. It shall be designed for use with inline compression type connectors, or indoor, outdoor, direct-burial or submerged locations.

2.5 MEDIUM VOLTAGE CABLE

Cable (conductor) sizes are designated by American Wire Gauge (AWG) and Thousand Circular Mils (Kcmil). Conductor and conduit sizes indicated are for copper conductors unless otherwise noted. Insulated conductors shall have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout cable length. Wires and cables manufactured more than 24 months prior to date of delivery to the site shall not be accepted. Provide single conductor type cables unless otherwise indicated.

2.5.1 Cable Configuration

Provide Type MV cable, conforming to NEMA WC 74 and UL 1072 . Provide cables manufactured for use in duct or direct burial applications as indicated. Cable shall be rated as indicated with 133 percent insulation level.

2.5.2 Conductor Material

Provide concentric-lay-stranded, Class B compact round conductors. Provide soft drawn copper cables complying with ASTM B 3 and ASTM B 8 for regular concentric and compressed stranding or ASTM B 496 for compact stranding.

2.5.3 Insulation

Provide ethylene-propylene-rubber (EPR) insulation conforming to the requirements of NEMA WC 71.

2.5.4 Shielding

Cables rated for 2 kV and above shall have a semiconducting conductor shield, a semiconducting insulation shield, and an overall copper tape or wire shield for each phase.

2.5.5 Neutrals

Neutral conductors of shall be copper, employing the same insulation and jacket materials as phase conductors, except that a 600-volt insulation rating is acceptable.

2.5.6 Jackets

Cables shall be provided with a PVC jacket. Direct buried cables shall be rated for direct burial. Provide PVC jackets with a separator that prevents contact when underlying semiconducting insulating shield.

2.6 MEDIUM VOLTAGE CABLE TERMINATIONS

IEEE Std 48 Class 1; of the molded elastomer, prestretched elastomer, or heat-shrinkable elastomer. Acceptable elastomers are track-resistant silicone rubber or track-resistant ethylene propylene compounds, such as ethylene propylene rubber or ethylene propylene diene monomer. Separable insulated connectors may be used for apparatus terminations, when such apparatus is provided with suitable bushings. Terminations, where required, shall be provided with mounting brackets suitable for the intended installation and with grounding provisions for the cable shielding, metallic sheath, or armor. Terminations shall be provided in a kit, including: skirts, stress control terminator, ground clamp, connectors, lugs, and complete instructions for assembly and installation. Terminations shall be the product of one manufacturer, suitable for the type, diameter, insulation class and level, and materials of the cable terminated. Do not use separate parts of copper or copper alloy in contact with aluminum alloy parts in the construction or installation of the terminator.

2.6.1 Cold-Shrink Type

Terminator shall be a one-piece design, utilizing the manufacturer's latest technology, where high-dielectric constant (capacitive) stress control is

integrated within a skirted insulator made of silicone rubber. Termination shall not require heat or flame for installation. Termination kit shall contain all necessary materials (except for the lugs). Termination shall be designed for installation in low or highly contaminated indoor and outdoor locations and shall resist ultraviolet rays and oxidative decomposition.

2.6.2 Heat Shrinkable Type

Terminator shall consist of a uniform cross section heat shrinkable polymeric construction stress relief tubing and environmentally sealed outer covering that is nontracking, resists heavy atmospheric contaminants, ultra violet rays and oxidative decomposition. Provide heat shrinkable sheds or skirts of the same material. Termination shall be designed for installation in low or highly contaminated indoor or outdoor locations.

2.6.3 Separable Insulated Connector Type

IEEE Std 386. Provide connector with steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material. Provide connectors of the loadbreak or deadbreak type as indicated, of suitable construction for the application and the type of cable connected, and that include cable shield adaptors. Provide external clamping points and test points.

a. 200 Ampere loadbreak connector ratings: Voltage: 15 kV, 95 kV BIL, 25 kV, 125 kV BIL. Short time rating: 10,000 rms symmetrical amperes.

b. 600 Ampere deadbreak connector ratings: Voltage: 15 kV, 95 kV BIL, 25 kV, 125 kV BIL. Short time rating: 25,000 rms symmetrical amperes. Connectors shall have 200 ampere bushing interface for surge arresters.

c. Provide one set of three grounding elbows and one set of three feed-thru inserts. Grounding elbows and feed-thru inserts shall be delivered to the USAID Implementing Partner.

2.7 MEDIUM VOLTAGE CABLE JOINTS

Provide joints (splices) in accordance with IEEE Std 404 suitable for the rated voltage, insulation level, insulation type, and construction of the cable. Joints shall be certified by the manufacturer for waterproof, submersible applications. Upon request, supply manufacturer's design qualification test report in accordance with IEEE Std 404. Connectors for joint shall be tin-plated electrolytic copper, having ends tapered and having center stops to equalize cable insertion.

2.7.1 Heat-Shrinkable Joint

Consists of a uniform cross-section heat-shrinkable polymeric construction with a linear stress relief system, a high dielectric strength insulating material, and an integrally bonded outer conductor layer for shielding. Replace original cable jacket with a heavy-wall heat-shrinkable sleeve with hot-melt adhesive coating.

2.7.2 Cold-Shrink Rubber-Type Joint

Joint shall be of a cold shrink design that does not require any heat

source for its installation. Splice insulation and jacket shall be of a one-piece factory formed cold shrink sleeve made of black EPDM rubber. Splice shall be packaged three splices per kit, including complete installation instructions.

2.8 LIVE END CAPS

Provide live end caps using a "kit" including a heat-shrinkable tube and a high dielectric strength, polymeric plug overlapping the conductor. End cap shall conform to applicable portions of IEEE Std 48.

2.9 TAPE

2.9.1 Insulating Tape

UL 510, plastic insulating tape, capable of performing in a continuous temperature environment of 80 degrees C.

2.9.2 Buried Warning and Identification Tape

Provide detectable tape in accordance with Section 31 00 00 EARTHWORK

2.9.3 Fireproofing Tape

Provide tape composed of a flexible conformable unsupported intumescent elastomer. Tape shall be not less than 0.762 mm thick, noncorrosive to cable sheath, self-extinguishing, noncombustible, and shall not deteriorate when subjected to oil, water, gases, salt water, sewage, and fungus.

2.10 PULL ROPE

Shall be plastic or flat pull line (bull line) having a minimum tensile strength of 890 N.

2.11 GROUNDING AND BONDING

2.11.1 Driven Ground Rods

Provide copper-clad steel ground rods conforming to UL 467 not less than 19 mm (3/4 inch) in diameter by 3.1 m (10 feet) in length. Sectional type rods may be used for rods 20 feet or longer.

2.11.2 Grounding Conductors

Stranded-bare copper conductors shall conform to ASTM B 8, Class B, soft-drawn unless otherwise indicated. Solid-bare copper conductors shall conform to ASTM B 1 for sizes No. 8 and smaller. Insulated conductors shall be of the same material as phase conductors and green color-coded, except that conductors shall be rated no more than 600 volts. Aluminum is not acceptable.

2.12 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE. In addition, provide concrete for encasement of underground ducts with 20 MPa minimum 28-day compressive strength. Concrete associated with electrical work for other than encasement of underground ducts shall be 30 MPa minimum 28-day compressive strength unless specified otherwise.

2.13 UNDERGROUND STRUCTURES

Provide precast concrete underground structures or standard type cast-in-place manhole types as indicated, conforming to ASTM C 857 and ASTM C 478M . Top, walls, and bottom shall consist of reinforced concrete. Walls and bottom shall be of monolithic concrete construction. Locate duct entrances and windows near the corners of structures to facilitate cable racking. Covers shall fit the frames without undue play. Form steel and iron to shape and size with sharp lines and angles. Castings shall be free from warp and blow holes that may impair strength or appearance. Exposed metal shall have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. Install a pulling-in iron in the wall opposite each duct line entrance. Cable racks, including rack arms and insulators, shall be adequate to accommodate the cable.

2.13.1 Cast-In-Place Concrete Structures

Concrete shall conform to Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE.

2.13.2 Precast Concrete Structures, Risers and Tops

In lieu of cast-in-place, Contractors, at their option, may provide precast concrete underground structures subject to the requirements specified below. Precast units shall be the product of a manufacturer regularly engaged in the manufacture of precast concrete products, including precast manholes.

2.13.2.1 General

Precast concrete structures shall have the same accessories and facilities as required for cast-in-place structures. Likewise, precast structures shall have plan area and clear heights not less than those of cast-in-place structures. Concrete materials and methods of construction shall be the same as for cast-in-place concrete construction, as modified herein. Slope in floor may be omitted provided precast sections are poured in reinforced steel forms. Concrete for precast work shall have a 28-day compressive strength of not less than 30 MPa. Structures may be precast to the design and details indicated for cast-in-place construction, precast monolithically and placed as a unit, or structures may be assembled sections, designed and produced by the manufacturer in accordance with the requirements specified. Structures shall be identified with the manufacturer's name embedded in or otherwise permanently attached to an interior wall face.

2.13.2.2 Design for Precast Structures

ACI 318M. In the absence of detailed on-site soil information, design for the following soil parameters/site conditions:

a. Angle of Internal Friction (phi) = 0.523 rad

b. Unit Weight of Soil (Dry) = 1760 kg/m^3, (Saturated) = 2080 kg/m^3

c. Coefficient of Lateral Earth Pressure (Ka) = 0.33

d. Ground Water Level = 915 mm below ground elevation

e. Vertical design loads shall include full dead, superimposed dead, and live loads including a 30 percent magnification factor for impact. Live loads shall consider all types and magnitudes of vehicular (automotive, industrial, or aircraft) traffic to be encountered. The minimum design vertical load shall be for H20 highway loading per AASHTO HB-17.

f. Horizontal design loads shall include full geostatic and hydrostatic pressures for the soil parameters, water table, and depth of installation to be encountered. Also, horizontal loads imposed by adjacent structure foundations, and horizontal load components of vertical design loads, including impact, shall be considered, along with a pulling-in iron design load of 26,700 N.

g. Each structural component shall be designed for the load combination and positioning resulting in the maximum shear and moment for that particular component.

h. Design shall also consider the live loads induced in the handling, installation, and backfilling of the manholes. Provide lifting devices to ensure structural integrity during handling and installation.

2.13.2.3 Construction

Structure top, bottom, and wall shall be of a uniform thickness of not less than 150 mm. Thin-walled knock-out panels for designed or future duct bank entrances shall not be permitted. Quantity, size, and location of duct bank entrance windows shall be as directed, and cast completely open by the precaster. Size of windows shall exceed the nominal duct bank envelope dimensions by at least 305 mm vertically and horizontally to preclude in-field window modifications made necessary by duct bank misalignment. However, the sides of precast windows shall be a minimum of 150 mm from the inside surface of adjacent walls, floors, or ceilings. Form the perimeter of precast window openings to have a keyed or inward flared surface to provide a positive interlock with the mating duct bank envelope. Provide welded wire fabric reinforcing through window openings for in-field cutting and flaring into duct bank envelopes. Provide additional reinforcing steel comprised of at least two No. 4 bars around window openings. Provide drain sumps a minimum of 305 mm in diameter and 100 mm deep for precast structures.

2.13.2.4 Joints

Provide tongue-and-groove joints on mating edges of precast components. Shiplap joints are not allowed. Design joints to firmly interlock adjoining components and to provide waterproof junctions and adequate shear transfer. Seal joints watertight using preformed plastic strip conforming to AASHTO M 198, Type B. Install sealing material in strict accordance with the sealant manufacturer's printed instructions. Provide waterproofing at conduit/duct entrances into structures, and where access frame meets the top slab, provide continuous grout seal.

2.13.3 Manhole Frames and Covers

Provide cast iron frames and covers for manholes conforming to CID A-A-60005. Cast the words "ELECTRIC" or "TELECOMMUNICATIONS" in the top face of power

and telecommunications manhole covers, respectively.

2.13.4 Handhole Frames and Covers

Frames and covers of steel shall be welded by qualified welders in accordance with standard commercial practice. Steel covers shall be rolled-steel floor plate having an approved antislip surface. Hinges shall be of wrought steel, 125 by 125 mm by approximately 4.75 mm thick, without screw holes, and shall be for full surface application by fillet welding. Hinges shall have nonremovable pins and five knuckles. The surfaces of plates under hinges shall be true after the removal of raised antislip surface, by grinding or other approved method.

2.13.5 Brick for Manhole Collar

Brick shall be sewer and manhole brick conforming to ASTM C 32, Grade MS.

2.13.6 Composite/Fiberglass Handholes and Covers

Provide handholes and covers of polymer concrete, reinforced with heavy weave fiberglass.

2.14 CABLE SUPPORTS (RACKS, ARMS, AND INSULATORS)

The metal portion of racks and arms shall be zinc-coated after fabrication.

2.14.1 Cable Racks

The wall bracket shall be 100 mm by approximately 38 mm by 4.76 mm channel steel, 1220 mm long (minimum) in manholes. Slots for mounting cable rack arms shall be spaced at 200 mm intervals.

2.14.2 Rack Arms

Cable rack arms shall be steel or malleable iron or glass reinforced nylon and shall be of the removable type. Rack arm length shall be a minimum of 200 mm and a maximum of 305 mm.

2.14.3 Insulators

Insulators for metal rack arms shall be dry-process glazed porcelain. Insulators are not required for nylon arms.

2.15 CABLE TAGS IN MANHOLES

Provide tags for each power cable located in manholes. The tags shall be polyethylene. Do not provide handwritten letters. The first position on the power cable tag shall denote the voltage. The second through sixth positions on the tag shall identify the circuit. The next to last position shall denote the phase of the circuit and shall include the Greek "phi" symbol. The last position shall denote the cable size. As an example, a tag could have the following designation: "11.5 NAS 1-8(Phase A)500," denoting that the tagged cable is on the 11.5kV system circuit number NAS 1-8, underground, Phase A, sized at 500 kcmil.

2.15.1 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 22.4 MPa (3250 pounds per square inch); and that are two millimeter (0.08 inch)

thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 77 degrees C. Provide 1.3 mm (0.05 inch) (minimum) thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ties shall have a minimum loop tensile strength of 778.75 N (175 pounds). The cable tags shall have black block letters, numbers, and symbols 25 mm (one inch) high on a yellow background. Letters, numbers, and symbols shall not fall off or change positions regardless of the cable tags' orientation.

2.16 CABLE TERMINATING CABINETS

Cable terminating cabinets shall be hook-stick operable, deadfront construction conforming to the requirements of IEEE C37.20.3, Category A. Cabinets shall be provided with with 600 A. dead-break junctions and elbow-type separable dead-break connectors, cable parking stands, and grounding lugs. Provide cable terminating equipment in conformance with IEEE Std 386.

Ratings at 50 Hz shall be:

Nominal voltage (kV).....20

Rated maximum voltage (kV).....25

Rated continuous current (A).....200

Three-second short-time current-carrying capacity (kA).....10

BIL (kV).....150

2.17 SOURCE QUALITY CONTROL

2.17.1 Arc-Proofing Test for Cable Fireproofing Tape

Manufacturer shall test one sample assembly consisting of a straight lead tube 305 mm long with a 65.5 mm outside diameter, and a 3.175-mm thick wall, and covered with one-half lap layer of arc and fireproofing material per manufacturer's instructions. The arc and fireproofing tape shall withstand extreme temperature of a high-current fault arc 13,000 degrees K for 70 cycles as determined by using an argon directed plasma jet capable of constantly producing and maintaining an arc temperature of 13,000 degrees K. Temperature (13,000 degrees K) of the ignited arc between the cathode and anode shall be obtained from a dc power source of 305 (plus or minus 5) amperes and 20 (plus or minus 1) volts. The arc shall be directed toward the sample assembly accurately positioned 5 (plus or minus 1) millimeters downstream in the plasma from the anode orifice by fixed flow rate of argon gas (0.18 g per second). Each sample assembly shall be tested at three unrelated points. Start time for tests shall be taken from recorded peak current when the specimen is exposed to the full test temperature. Surface heat on the specimen prior to that time shall be minimal. The end point is established when the plasma or conductive arc penetrates the protective tape and strikes the lead tube. Submittals for arc-proofing tape shall indicate that the test has been performed and passed by the manufacturer.

2.17.2 Medium Voltage Cable Qualification and Production Tests

Results of AEIC CS8 qualification and production tests as applicable for

each type of medium voltage cable.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment and devices in accordance with the manufacturer's published instructions and with the requirements and recommendations of NFPA 70 and IEEE C2 as applicable. In addition to these requirements, install telecommunications in accordance with TIA-758-A and RUS Bull 1751F-644.

3.2 CABLE INSPECTION

Prior to installation, each cable reel shall be inspected for correct storage positions, signs of physical damage, and broken end seals. If end seal is broken, moisture shall be removed from cable prior to installation in accordance with the cable manufacturer's recommendations.

3.3 CABLE INSTALLATION PLAN AND PROCEDURE

The Contractor shall obtain from the manufacturer an installation manual or set of instructions which addresses such aspects as cable construction, insulation type, cable diameter, bending radius, cable temperature limits for installation, lubricants, coefficient of friction, conduit cleaning, storage procedures, moisture seals, testing for and purging moisture, maximum allowable pulling tension, and maximum allowable sidewall bearing pressure. The Contractor shall then perform pulling calculations and prepare a pulling plan which shall be submitted along with the manufacturers instructions in accordance with SUBMITTALS. Cable shall be installed strictly in accordance with the cable manufacturer's recommendations and the approved installation plan.

Calculations and pulling plan shall include:

a. Site layout drawing with cable pulls identified in numeric order of expected pulling sequence and direction of cable pull.

b. List of cable installation equipment.

c. Lubricant manufacturer's application instructions.

d. Procedure for resealing cable ends to prevent moisture from entering cable.

e. Cable pulling tension calculations of all cable pulls.

f. Cable percentage conduit fill.

g. Cable sidewall bearing pressure.

h. Cable minimum bend radius and minimum diameter of pulling wheels used.

i. Cable jam ratio.

j. Maximum allowable pulling tension on each different type and size of conductor.

k. Maximum allowable pulling tension on pulling device.

3.4 UNDERGROUND FEEDERS SUPPLYING BUILDINGS

Terminate underground feeders supplying building at a point 1525 mm outside the building and projections thereof, except that conductors shall be continuous to the terminating point indicated. Coordinate connections of the feeders to the service entrance equipment with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Conduit shall be PVC, Type EPC-40 from the supply equipment to a point 1525 mm outside the building and projections thereof. Protect ends of underground conduit with plastic plugs until connections are made.

Encase the underground portion of the conduit in a concrete envelope and bury as specified for underground duct with concrete encasement.

3.5 UNDERGROUND STRUCTURE CONSTRUCTION

Provide standard type cast-in-place construction as specified herein and as indicated, or precast construction as specified herein. Horizontal concrete surfaces of floors shall have a smooth trowel finish. Cure concrete by applying two coats of white pigmented membrane forming-curing compound in strict accordance with the manufacturer's printed instructions, except that precast concrete may be steam cured. Curing compound shall conform to ASTM C 309. Locate duct entrances and windows in the center of end walls (shorter) and near the corners of sidewalls (longer) to facilitate cable racking and splicing. Covers for underground structures shall fit the frames without undue play. Steel and iron shall be formed to shape and size with sharp lines and angles. Castings shall be free from warp and blow holes that may impair strength or appearance. Exposed metal shall have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete.

3.5.1 Cast-In-Place Concrete Structures

Construct walls on a footing of cast-in-place concrete except that precast concrete base sections may be used for precast concrete manhole risers. Provide concrete block conforming to ASTM C 139 and Section 04 20 00 MASONRY.

3.5.2 Precast Concrete Construction

Set commercial precast structures on 150 mm of level, 90 percent compacted granular fill, 19 mm to 25 mm size, extending 305 mm beyond the structure on each side. Compact granular fill by a minimum of four passes with a plate type vibrator. Installation shall additionally conform to the manufacturer's instructions.

3.5.3 Pulling-In Irons

Provide steel bars bent as indicated, and cast in the walls and floors. Alternatively, pipe sleeves may be precast into the walls and floors where required to accept U-bolts or other types of pulling-in devices possessing the strengths and clearances stated herein. The final installation of pulling-in devices shall be made permanent. Cover and seal exterior projections of thru-wall type pulling-in devices with an appropriate protective coating. In the floor the irons shall be a minimum of 150 mm from the edge of the sump, and in the walls the irons shall be located within 150 mm of the projected center of the duct bank pattern or precast

window in the opposite wall. However, the pulling-in iron shall not be located within 150 mm of an adjacent interior surface, or duct or precast window located within the same wall as the iron. If a pulling-in iron cannot be located directly opposite the corresponding duct bank or precast window due to this clearance limitation, locate the iron directly above or below the projected center of the duct bank pattern or precast window the minimum distance required to preserve the 150 mm clearance previously stated. In the case of directly opposing precast windows, pulling-in irons consisting of a 915 mm length of No. 5 reinforcing bar, formed into a hairpin, may be cast-in-place within the precast windows simultaneously with the end of the corresponding duct bank envelope. Irons installed in this manner shall be positioned directly in line with, or when not possible, directly above or below the projected center of the duct bank pattern entering the opposite wall, while maintaining a minimum clear distance of 75 mm from any edge of the cast-in-place duct bank envelope or any individual duct. Pulling-in irons shall have a clear projection into the structure of approximately 100 mm and shall be designed to withstand a minimum pulling-in load of 26,700 N. Irons shall be hot-dipped galvanized after fabrication.

3.5.4 Cable Racks, Arms and Insulators

Cable racks, arms and insulators shall be sufficient to accommodate the cables. Racks in power manholes shall be spaced not more than 915 mm apart, and each manhole wall shall be provided with a minimum of two racks. Racks in signal manholes shall be spaced not more than 420 mm apart with the end rack being no further than 305 mm from the adjacent wall. Methods of anchoring cable racks shall be as follows:

a. Provide a 15 mm diameter by 125 mm long anchor bolt with 75 mm foot cast in structure wall with 50 mm protrusion of threaded portion of bolt into structure. Provide 15 mm steel square head nut on each anchor bolt. Coat threads of anchor bolts with suitable coating immediately prior to installing nuts.

b. Provide concrete channel insert with a minimum load rating of 1192 kg per meter. Insert channel shall be steel of the same length as "vertical rack channel;" channel insert shall be cast flush in structure wall. Provide 15 mm steel nuts in channel insert to receive 15 mm diameter by 75 mm long steel, square head anchor bolts.

c. Provide concrete "spot insert" at each anchor bolt location, cast flush in structure wall. Each insert shall have minimum 365 kg load rating. Provide 15 mm diameter by 75 mm long steel, square head anchor bolt at each anchor point. Coat threads of anchor bolts with suitable coating immediately prior to installing bolts.

3.5.5 Field Painting

Cast-iron frames and covers not buried in concrete or masonry shall be cleaned of mortar, rust, grease, dirt and other deleterious materials, and given a coat of bituminous paint.

3.6 DIRECT BURIAL CABLE SYSTEM

Cables shall be buried directly in the earth below the frostline as indicated to the requirements of NFPA 70 and IEEE C2, whichever is more stringent.

3.6.1 Trenching

Trenches for direct-burial cables shall be excavated to depths required to provide the minimum necessary cable cover. When rock is encountered, remove to a depth of at least 75 mm below the cable and fill the space with sand or clean earth free from particles larger than 6 mm Bottoms of trenches shall be smooth and free of stones and sharp objects. Where materials in bottoms of trenches are other than sand, a 75 mm 3 inch layer of sand shall be laid first and compacted to approximate densities of surrounding firm soil. Trenches shall be not less than 150 mm wide, and shall be in straight lines between cable markers. Cable plows shall not be used. Bends in trenches shall have a radius of not less than 915 mm.

3.6.2 Cable Installation.

Cables shall be unreeled along the sides of or in trenches and carefully placed on sand or earth bottoms. Pulling cables into direct-burial trenches from a fixed reel position will not be permitted, except as required to pull cables through conduits under paving or railroad tracks.

Where two or more cables are laid parallel in the same trench, space cables laterally at not less than 75 mm apart, except that communication cable shall be separated from power cable by a minimum distance of 305 mm.

Where direct-burial cables cross under roads or other paving exceeding 1.5 m in width, such cables shall be installed in concrete-encased ducts. Ducts shall extend at least 300 mm beyond each edge of any paving and at least 1.5 m beyond each side of any railroad tracks. Cables may be pulled into duct from a fixed reel where suitable rollers are provided in the trench. Where direct burial cable transitions to duct-enclosed cable, direct-burial cables shall be centered in duct entrances, and a waterproof nonhardening mastic compound shall be used to facilitate such centering. If paving or railroad tracks are in place where cables are to be installed, coated rigid steel conduits driven under the paving or railroad tracks may be used in lieu of concrete-encased ducts. Damage to conduit coatings shall be prevented by providing ferrous pipe jackets or by predrilling. Where cuts are made in any paving, the paving and subbase shall be restored to their original condition. Where cable is placed in duct(e.g. under paved areas, roads, or railroads), slope ducts to drain.

3.6.3 Splicing

Provide cables in one piece without splices between connections except where the distance exceeds the lengths in which cables are manufactured. Where splices are required, provide splices designed and rated for direct burial.

3.6.4 Bends

Bends in cables shall have an inner radius not less than those specified in NFPA 70 for the type of cable, or manufacturer's recommendation.

3.6.5 Horizontal Slack

Leave approximately 915 mm of horizontal slack in the ground on each end of cable runs, on each side of connection boxes, and at points where connections are brought above ground. Where cable is brought above ground, leave additional slack to make necessary connections.

3.6.6 Identification Slabs

Provide a slab at each change of direction of cable, over the ends of ducts or conduits which are installed under paved areas and roadways, and over each splice. Identification slabs shall be of concrete, approximately 500 mm square by 150 mm thick and shall be set flat in the ground so that top surface projects not less than 20 mm, nor more than 30 mm above ground. Concrete shall have a compressive strength of not less than 20 MPa and have a smooth troweled finish on exposed surface. Inscribe an identifying legend such as "electric cable," "telephone cable," "splice," or other applicable designation on the top surface of the slab before concrete hardens. Inscribe circuit identification symbols on slabs as indicated. Letters or figures shall be approximately 50 mm high and grooves shall be approximately 6 mm in width and depth. Install slabs so that the side nearest the inscription on top shall include an arrow indicating the side nearest the cable. Provide color, type and depth of warning tape as specified in Section 31 00 00 EARTHWORK.

3.7 UNDERGROUND CONDUIT AND DUCT SYSTEMS

3.7.1 Requirements

Depths to top of the conduit shall be in accordance with NFPA 70. Run conduit in straight lines except where a change of direction is necessary. Numbers and sizes of ducts shall be as indicated. Ducts shall have a continuous slope downward toward underground structures and away from buildings, laid with a minimum slope of 100 mm per 30 m. Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Short-radius manufactured 90-degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable. The minimum manufactured bend radius shall be 450 mm (18 inches) for ducts of less than 80 mm (3 inch) diameter, and 900 mm (36 inches) for ducts 80 mm (3 inches) or greater in diameter. Otherwise, long sweep bends having a minimum radius of 7.6 m shall be used for a change of direction of more than 5 degrees, either horizontally or vertically. Both curved and straight sections may be used to form long sweep bends, but the maximum curve used shall be 30 degrees and manufactured bends shall be used. Ducts shall be provided with end bells whenever duct lines terminate in structures.

3.7.2 Treatment

Ducts shall be kept clean of concrete, dirt, or foreign substances during construction. Field cuts requiring tapers shall be made with proper tools and match factory tapers. A coupling recommended by the duct manufacturer shall be used whenever an existing duct is connected to a duct of different material or shape. Ducts shall be stored to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Ducts shall be thoroughly cleaned before being laid. Plastic ducts shall be stored on a flat surface and protected from the direct rays of the sun.

3.7.3 Conduit Cleaning

As each conduit run is completed, for conduit sizes 75 mm and larger, draw a flexible testing mandrel approximately 305 mm long with a diameter less than the inside diameter of the conduit through the conduit. After which, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs. For

conduit sizes less than 75 mm, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs.

3.7.4 Jacking and Drilling Under Roads and Structures

Conduits to be installed under existing paved areas which are not to be disturbed, and under roads and railroad tracks, shall be zinc-coated, rigid steel, jacked into place.Where ducts are jacked under existing pavement, rigid steel conduit will be installed because of its strength. To protect the corrosion-resistant conduit coating, predrilling or installing conduit inside a larger iron pipe sleeve (jack-and-sleeve) is required. For crossings of existing railroads and airfield pavements greater than 15 m in length, the predrilling method or the jack-and-sleeve method will be used. Separators or spacing blocks shall be made of steel, concrete, plastic, or a combination of these materials placed not farther apart than 1.2 m on centers. Hydraulic jet method shall not be used.

3.7.5 Galvanized Conduit Concrete Penetrations

Galvanized conduits which penetrate concrete (slabs, pavement, and walls) in wet locations shall be PVC coated and shall extend from at least 50 mm within the concrete to the first coupling or fitting outside the concrete (minimum of 150 mm from penetration).

3.7.6 Multiple Conduits

Separate multiple conduits by a minimum distance of 65 mm, except that light and power conduits shall be separated from control, signal, and telephone conduits by a minimum distance of 300 mm. Stagger the joints of the conduits by rows (horizontally) and layers (vertically) to strengthen the conduit assembly. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly shall consist of base spacers, intermediate spacers, ties, and locking device on top to provide a completely enclosed and locked-in conduit assembly. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 3050 mm of conduit assembly.

3.7.7 Conduit Plugs and Pull Rope

New conduit indicated as being unused or empty shall be provided with plugs on each end. Plugs shall contain a weephole or screen to allow water drainage. Provide a plastic pull rope having 915 mm of slack at each end of unused or empty conduits.

3.7.8 Conduit and Duct Without Concrete Encasement

Provide not less than 75 mm clearance from the conduit to each side of the trench. Grade bottom of trench smooth; where rock, soft spots, or sharp-edged materials are encountered, excavate the bottom for an additional 75 mm, fill and tamp level with original bottom with sand or earth free from particles, that would be retained on a 6.25 mm sieve. The first 150 mm layer of backfill cover shall be sand compacted as previously specified. The rest of the excavation shall be backfilled and compacted in 75 to 150 mm layers. Provide color, type and depth of warning tape as specified in Section 31 00 00 EARTHWORK.

3.7.8.1 Encasement Under Roads and Structures

Under roads, paved areas, and railroad tracks, install conduits in concrete encasement of rectangular cross-section providing a minimum of 75 mm concrete cover around ducts. Concrete encasement shall extend at least 1525 mm beyond the edges of paved areas and roads, and 3660 mm beyond the rails on each side of railroad tracks.

3.7.9 Duct Encased in Concrete

Construct underground duct lines of individual conduits encased in concrete. Do not mix different kinds of conduit in any one duct bank. Concrete encasement surrounding the bank shall be rectangular in cross-section and shall provide at least 75 mm of concrete cover for ducts. Separate conduits by a minimum concrete thickness of 65 mm, except separate light and power conduits from control, signal, and telecommunications conduits by a minimum concrete thickness of 75 mm. Before pouring concrete, anchor duct bank assemblies to prevent the assemblies from floating during concrete pouring. Anchoring shall be done by driving reinforcing rods adjacent to duct spacer assemblies and attaching the rods to the spacer assembly. Provide color, type and depth of warning tape as specified in Section 31 00 00 EARTHWORK.

3.7.9.1 Connections to Manholes

Duct bank envelopes connecting to underground structures shall be flared to have enlarged cross-section at the manhole entrance to provide additional shear strength. Dimensions of the flared cross-section shall be larger than the corresponding manhole opening dimensions by no less than 300 mm in each direction. Perimeter of the duct bank opening in the underground structure shall be flared toward the inside or keyed to provide a positive interlock between the duct bank and the wall of the structure. Use vibrators when this portion of the encasement is poured to assure a seal between the envelope and the wall of the structure.

3.7.9.2 Connections to Existing Underground Structures

For duct bank connections to existing structures, break the structure wall out to the dimensions required and preserve steel in the structure wall. Cut steel and extend into the duct bank envelope. Chip the perimeter surface of the duct bank opening to form a key or flared surface, providing a positive connection with the duct bank envelope.

3.7.9.3 Connections to Existing Concrete Pads

For duct bank connections to concrete pads, break an opening in the pad out to the dimensions required and preserve steel in pad. Cut the steel and extend into the duct bank envelope. Chip out the opening in the pad to form a key for the duct bank envelope.

3.7.9.4 Connections to Existing Ducts

Where connections to existing duct banks are indicated, excavate the banks to the maximum depth necessary. Cut off the banks and remove loose concrete from the conduits before new concrete-encased ducts are installed. Provide a reinforced concrete collar, poured monolithically with the new duct bank, to take the shear at the joint of the duct banks. Abandon in place those no longer used ducts and cables which do not interfere with the work.

3.7.9.5 Partially Completed Duct Banks

During construction wherever a construction joint is necessary in a duct bank, prevent debris such as mud, and, and dirt from entering ducts by providing suitable conduit plugs. Fit concrete envelope of a partially completed duct bank with reinforcing steel extending a minimum of 610 mm back into the envelope and a minimum of 610 mm beyond the end of the envelope. Provide one No. 4 bar in each corner, 75 mm from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately 305 mmapart. Restrain reinforcing assembly from moving during concrete pouring.

3.7.9.6 Removal of Ducts

Where duct lines are removed from existing underground structures, close the openings to waterproof the structure. Chip out the wall opening to provide a key for the new section of wall.

3.8 CABLE PULLING

Test existing duct lines with a mandrel and thoroughly swab out to remove foreign material before pulling cables. Pull cables down grade with the feed-in point at the manhole or buildings of the highest elevation. Use flexible cable feeds to convey cables through manhole opening and into duct runs. Do not exceed the specified cable bending radii when installing cable under any conditions, including turnups into switches, transformers, switchgear, switchboards, and other enclosures. Cable with tape shield shall have a bending radius not less than 12 times the overall diameter of the completed cable. If basket-grip type cable-pulling devices are used to pull cable in place, cut off the section of cable under the grip before splicing and terminating.

3.8.1 Cable Lubricants

Use lubricants that are specifically recommended by the cable manufacturer for assisting in pulling jacketed cables.

3.9 CABLES IN UNDERGROUND STRUCTURES

Do not install cables utilizing the shortest path between penetrations, but route along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances, and support on brackets and cable insulators. Support cable splices in underground structures by racks on each side of the splice. Locate splices to prevent cyclic bending in the spliced sheath. Install cables at middle and bottom of cable racks, leaving top space open for future cables, except as otherwise indicated for existing installations. Provide one spare three-insulator rack arm for each cable rack in each underground structure.

3.9.1 Cable Tag Installation

Install cable tags in each manhole as specified, including each splice. Tag wire and cable provided by this contract. Install cable tags over the fireproofing, if any, and locate the tags so that they are clearly visible without disturbing any cabling or wiring in the manholes.

3.10 CONDUCTORS INSTALLED IN PARALLEL

Conductors shall be grouped such that each conduit of a parallel run contains 1 Phase A conductor, 1 Phase B conductor, 1 Phase C conductor, and 1 neutral conductor.

3.11 LOW VOLTAGE CABLE SPLICING AND TERMINATING

Make terminations and splices with materials and methods as indicated or specified herein and as designated by the written instructions of the manufacturer. Do not allow the cables to be moved until after the splicing material has completely set. Make splices in underground distribution systems only in accessible locations such as manholes,handholes, or aboveground termination cabinets.

3.11.1 Terminating Aluminum Conductors

a. Use particular care in making up joints and terminations. Remove surface oxides by cleaning with a wire brush or emery cloth. Apply joint compound to conductors, and use UL-listed solid aluminum connectors for connecting aluminum conductors. When connecting aluminum to copper conductors, use connectors specifically designed for this purpose.

b. Terminate aluminum conductors to copper bus either by: (1) in line splicing a copper pigtail to the aluminum conductor (copper pigtail shall have a ampacity at least that of the aluminum conductor); or (2) using a circumferential compression type, aluminum bodied terminal lug UL listed for AL/CU and steel Belleville spring washers, flat washers, bolts, and nuts. Belleville spring washers shall be cadmium-plated hardened steel. Install the Belleville spring washers with the crown up toward the nut or bolt head, with the concave side of the Belleville bearing on a heavy-duty, wide series flat washer of larger diameter than the Belleville. Tighten nuts sufficient to flatten Belleville and leave in that position. Lubricate hardware with joint compound prior to making connection. Wire brush and apply joint compound to conductor prior to inserting in lug.

c. Terminate aluminum conductors to aluminum bus by using all-aluminum nuts, bolts, washers, and lugs. Wire brush and apply inhibiting compound to conductor prior to inserting in lug. Lubricate hardware with joint compound prior to making connection; if bus contact surface is unplated, scratch-brush and coat with joint compound (without grit).

3.12 MEDIUM VOLTAGE CABLE TERMINATIONS

Make terminations in accordance with the written instruction of the termination kit manufacturer.

3.13 MEDIUM VOLTAGE CABLE JOINTS

Provide power cable joints (splices) suitable for continuous immersion in water. Make joints only in accessible locations in manholes or handholes by using materials and methods in accordance with the written instructions of the joint kit manufacturer.

3.13.1 Joints in Shielded Cables

Cover the joined area with metallic tape, or material like the original cable shield and connect it to the cable shield on each side of the splice. Provide a bare copper ground connection brought out in a watertight manner and grounded to the manhole grounding loop as part of the splice installation. Ground conductors, connections, and rods shall be as specified elsewhere in this section. Wire shall be trained to the sides of the enclosure to prevent interference with the working area.

3.14 CABLE END CAPS

Cable ends shall be sealed at all times with coated heat shrinkable end caps. Cables ends shall be sealed when the cable is delivered to the job site, while the cable is stored and during installation of the cable. The caps shall remain in place until the cable is spliced or terminated. Sealing compounds and tape are not acceptable substitutes for heat shrinkable end caps. Cable which is not sealed in the specified manner at all times will be rejected.

3.15 LIVE END CAPS

Provide live end caps for single conductor medium voltage cables where indicated.

3.16 FIREPROOFING OF CABLES IN UNDERGROUND STRUCTURES

Fireproof (arc proof) wire and cables which will carry current at 2200 volts or more in underground structures.

3.16.1 Fireproofing Tape

Tightly wrap strips of fireproofing tape around each cable spirally in half-lapped wrapping. Install tape in accordance with manufacturer's instructions.

3.16.2 Tape-Wrap

Tape-wrap metallic-sheathed or metallic armored cables without a nonmetallic protective covering over the sheath or armor prior to application of fireproofing. Wrap shall be in the form of two tightly applied half-lapped layers of a pressure-sensitive 0.254 mm thick plastic tape, and shall extend not less than 25 mm into the duct. Even out irregularities of the cable, such as at splices, with insulation putty before applying tape.

3.17 GROUNDING SYSTEMS

Provide grounding system as indicated, in accordance with NFPA 70 and IEEE C2, and as specified herein.

Noncurrent-carrying metallic parts associated with electrical equipment shall have a maximum resistance to solid earth ground not exceeding the following values:

Pad-mounted transformers without protective fences	5 ohms

Ground in manholes	5 ohms
Grounding other metal enclosures of primary voltage electrical and electrically-operated equipment	5 ohms

3.17.1 Grounding Electrodes

Provide cone pointed driven ground rods driven full depth plus 150 mm, installed to provide an earth ground of the appropriate value for the particular equipment being grounded.

If the specified ground resistance is not met, an additional ground rod shall be provided in accordance with the requirements of NFPA 70 (placed not less than 6 feet from the first rod). Should the resultant (combined) resistance exceed the specified resistance, measured not less than 48 hours after rainfall, the Contracting Officer shall be notified immediately.

3.17.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, by exothermic weld or compression connector.

a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.

b. Make compression connections using a hydraulic compression tool to provide the correct circumferential pressure. Tools and dies shall be as recommended by the manufacturer. An embossing die code or other standard method shall provide visible indication that a connector has been adequately compressed on the ground wire.

3.17.3 Grounding Conductors

Provide bare grounding conductors, except where installed in conduit with associated phase conductors. Ground cable sheaths, cable shields, conduit, and equipment with No. 6 AWG. Ground other noncurrent-carrying metal parts and equipment frames of metal-enclosed equipment. Ground metallic frames and covers of handholes and pull boxes with a braided, copper ground strap with equivalent ampacity of No. 6 AWG. Provide direct connections to the grounding conductor with 600 v insulated, full-size conductor for each grounded neutral of each feeder circuit, which is spliced within the manhole.

3.17.4 Ground Cable Crossing Expansion Joints

Protect ground cables crossing expansion joints or similar separations in structures and pavements by use of approved devices or methods of installation which provide the necessary slack in the cable across the joint to permit movement. Use stranded or other approved flexible copper cable across such separations.

3.17.5 Manhole Grounding

Loop a 4/0 AWG grounding conductor around the interior perimeter, approximately 305 mm above finished floor. Secure the conductor to the

manhole walls at intervals not exceeding 914 mm . Connect the conductor to the manhole grounding electrode with 4/0 AWG conductor. Connect all incoming 4/0 grounding conductors to the ground loop adjacent to the point of entry into the manhole. Bond the ground loop to all cable shields, metal cable racks, and other metal equipment with a minimum 6 AWG conductor.

3.17.6 Fence Grounding

Fences shall be grounded with a ground rod at each fixed gate post and at each corner post. Drive ground rods until the top is 305 mm below grade. Attach a No. 4 AWG copper conductor, by exothermic weld to the ground rods and extend underground to the immediate vicinity of fence post. Lace the conductor vertically into 305 mm of fence mesh and fasten by two approved bronze compression fittings, one to bond wire to post and the other to bond wire to fence. Each gate section shall be bonded to its gatepost by a 3 by 25 mm flexible braided copper strap and ground post clamps. Clamps shall be of the anti-electrolysis type.

3.18 EXCAVATING, BACKFILLING, AND COMPACTING

Provide in accordance with NFPA 70 and Section 31 00 00 EARTHWORK.

3.18.1 Reconditioning of Surfaces

3.18.1.1 Unpaved Surfaces

Restore to their original elevation and condition unpaved surfaces disturbed during installation of duct or direct burial cable. Preserve sod and topsoil removed during excavation and reinstall after backfilling is completed. Replace sod that is damaged by sod of quality equal to that removed. When the surface is disturbed in a newly seeded area, re-seed the restored surface with the same quantity and formula of seed as that used in the original seeding, and provide topsoiling, fertilizing, liming, seeding, sodding, sprigging, or mulching.

3.18.1.2 Paving Repairs

Where trenches, pits, or other excavations are made in existing roadways and other areas of pavement where surface treatment of any kind exists, restore such surface treatment or pavement the same thickness and in the same kind as previously existed, except as otherwise specified, and to match and tie into the adjacent and surrounding existing surfaces.

3.19 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE.

3.19.1 Concrete Slabs for Equipment

Unless otherwise indicated, the slab shall be at least 200 mm thick, reinforced with a 152 mm x 152 mm - MW19 by MW19 (6 by 6 - W2.9 by W2.9) mesh, placed uniformly 100 mm from the top of the slab. Slab shall be placed on a 150 mm thick, well-compacted gravel base. Top of concrete slab shall be approximately 100 mm above finished grade with gradual slope for drainage. Edges above grade shall have 15 mm chamfer. Slab shall be of adequate size to project at least 200 mm beyond the equipment.

Stub up conduits, with bushings, 50 mm into cable wells in the concrete

pad. Coordinate dimensions of cable wells with transformer cable training areas.

3.19.2 Sealing

When the installation is complete, the Contractor shall seal all conduit and other entries into the equipment enclosure with an approved sealing compound. Seals shall be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

3.20 FIELD QUALITY CONTROL

3.20.1 Performance of Field Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.20.1.1 Medium Voltage Cables

Perform tests after installation of cable, splices, and terminators and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection

(1) Inspect exposed cable sections for physical damage.

(2) Verify that cable is supplied and connected in accordance with contract plans and specifications.

(3) Inspect for proper shield grounding, cable support, and cable termination.

(4) Verify that cable bends are not less than ICEA or manufacturer's minimum allowable bending radius.

(5) Inspect for proper fireproofing.

(6) Visually inspect jacket and insulation condition.

(7) Inspect for proper phase identification and arrangement.

b. Electrical Tests

(1) Perform a shield continuity test on each power cable by ohmmeter method. Record ohmic value, resistance values in excess of 10 ohms per 1000 feet of cable must be investigated and justified.

(2) Perform acceptance test on new cables before the new cables are connected to existing cables and placed into service, including terminations and joints. Perform maintenance test on complete cable system after the new cables are connected to existing cables and placed into service, including existing cable, terminations, and joints. Tests shall be very low frequency (VLF) alternating voltage withstand tests in accordance with IEEE Std 400.2. VLF test frequency shall be 0.05 Hz minimum for a duration of 60 minutes using a sinusoidal waveform. Test voltages

shall be as follows:

CABLE RATING	AC TEST VOLTAGE for ACCEPTANCE TESTING
5 kV	10kV rms(peak)
8 kV	13kV rms(peak)
15 kV	20kV rms(peak)
25 kV	31kV rms(peak)
35 kV	44kV rms(peak)

CABLE RATING	AC TEST VOLTAGE for MAINTENANCE TESTING
5 kV	7kV rms(peak)
8 kV	10kV rms(peak)
15 kV	16kV rms(peak)
25 kV	23kV rms(peak)
35 kV	33kV rms(peak)

3.20.1.2 Grounding System

a. Visual and mechanical inspection

Inspect ground system for compliance with contract plans and specifications

b. Electrical tests

Perform ground-impedance measurements utilizing the fall-of-potential method in accordance with IEEE Std 81. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable megohmmeter tester in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument shall be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

3.20.2 Follow-Up Verification

Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, the Contracting Officer shall be given 5 working days advance notice of the dates and times of checking and testing.

-- End of Section --

SECTION 33 77 36.00 40

MEDIUM-VOLTAGE UTILITY FUSES

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C37.42	(1996) High Voltage Expulsion Type Distribution Class Fuses, Cutouts, Fuse Disconnecting Switches and Fuse Links**

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA SG 2	(1993) Standard for High-Voltage Fuses

1.2 SUBMITTALS

Contractor shall submit the following using submittal procedures as specified in the Contract Documents.

SD-03 Product Data

Submit Equipment and Performance Data for distribution fuse cutouts in accordance with paragraph entitled, "General Requirements," of this section.

Submit manufacturer's catalog data for the following items:

Distribution Fuse Cutouts

SD-02 Shop Drawings

Submit Fabrication Drawings for fuse cutouts in accordance with paragraph entitled, "General Requirements," of this section.

Submit installation drawings for Distribution Fuse Cutouts in accordance with the paragraph entitled, "Installation," of this section.

SD-08 Manufacturer's Instructions

Submit manufacturer's instructions for Fuse Cutouts including special provisions required to install equipment components and system packages. Special notices must detail impedances, hazards and safety precautions.

1.3 GENERAL REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS applies to work specified in this section.

Submit Fabrication Drawings for fuse cutouts consisting of fabrication and assembly details to be performed in the factory.

Submit Equipment and Performance Data for distribution fuse cutouts including life, test, system functional flows, safety features, and mechanical automated details.

PART 2 PRODUCTS

2.1 EQUIPMENT STANDARDS

Distribution fuse cutouts must conform to the requirements of NEMA SG 2 and IEEE C37.42 and as specified.

2.2 FUSE CUTOUTS

Distribution fuse cutouts for application on distribution systems must be the self-contained, enclosed, dropout type, or open type when required for higher voltage or interrupting rating. Install loadbreak cutouts only if specifically indicated.

The interrupting capacity must be sufficient to break the maximum system fault current to which the cutout will be subjected. The minimum interrupting capacity must be 16,000 amperes root mean square asymmetric.

Cutouts must be either heavy-duty or extra-heavy-duty classification. Cutouts installed on three-phase, 13.2-kilovolt (kV) or 13.8-kV systems must be rated at 15 kV. The installation of cutouts rated at 7.8 kV on these systems will not be allowed.

Fuse links must have a continuous rating equal to approximately 150 percent of the full-load line current when used for transformer protection, and approximately 100 percent of the conductor rated capacity when used for circuit protection. The 15-kV cutout must have a wet withstand, 10-second voltage rating of 37 kV, with a 95-kV basic impulse level (BIL). The continuous current rating must be 100 amperes unless otherwise indicated. Fuse disconnects must be rated not less than 100 amperes and have attachments to permit manual operation of the disconnect under load without external arcing.

Where indicated,combine lightning arresters and fuse cutouts.

PART 3 EXECUTION

3.1 INSTALLATION

Install Distribution fuse cutouts in accordance with the manufacturer's installation instructions.

-- End of Section --

SECTION 43 21 13

DOMESTIC DISTRIBUTION PUMPS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASME INTERNATIONAL (ASME)

ASME B1.1	(2003; R 2008) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B16.1	(2005) Standard for Gray Iron Threaded Fittings; Classes 125 and 250
ASME B16.5	(2003) Standard for Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24
ASME B40.100	(2005) Pressure Gauges and Gauge Attachments

ASSOCIATION FOR IRON AND STEEL TECHNOLOGY (AIST)

AIST PB-224	(1999) Stainless Steels

ASTM INTERNATIONAL (ASTM)

ASTM A 153/A 153M	(2005) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 307	(2007b) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength

HYDRAULIC INSTITUTE (HI)

HI 1.1-1.2	(2000) Centrifugal Pump Nomenclature

NSF INTERNATIONAL (NSF)

NSF 61	(2003e) Drinking Water System Components - Health Effects

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 21	(1982; E 2004) Paint Specification No. 21 White or Colored Silicone Alkyd Paint (Type I, High Gloss and Type II, Medium Gloss)

SSPC Paint 25	(1997; E 2004) Paint Specification No. 25Zinc Oxide, Alkyd, Linseed Oil Primer for Use Over Hand Cleaned Steel Type I and Type II

1.2 SYSTEM DESCRIPTION

1.2.1 Selection Criteria

Design pumps using hydraulic criteria based upon actual model developmental test data. Select pumps at a point within the maximum efficiency for a given impeller casing combination. Deviations within 3 percent of maximum efficiency are permissible, provided the lesser efficiency is not less than the scheduled efficiency. Pumps having impeller diameters larger than 90 percent of the published maximum diameter of the casing or less than 15 percent larger than the published minimum diameter of the casing will be rejected. Acceptable maximum impeller diameter calculations shall not be based on percentage of impeller diameter range for a given casing.

1.2.2 Conformance With Agency Requirements

Where materials or equipment are specified to be an approved type, the seal or label of approval from a nationally recognized testing agency, adequately equipped and competent to perform such services, shall be attached thereto. A written certificate from the testing agency shall accompany the materials or equipment and shall be submitted to the USAID Implementing Partner stating that the items have been tested and that they conform to the applicable requirements of the specifications and to the standards listed herein. The certificate shall indicate the methods of testing used by the testing agency. In lieu of a certificate from a testing agency, published catalog specification data, accompanied by the manufacturer's certified statement to the effect that the items are in accordance with the applicable requirements of the specifications and the referenced standards, will be considered by the USAID Implementing Partner and may be acceptable as evidence that the items conform with agency requirements.

1.2.3 Safety Requirements

Fully enclose or properly guard gears, couplings, projecting set-screws, keys, and other rotating parts, so located that any person can come in close proximity thereto.

1.3 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.

SD-02 Shop Drawings

Installation

Drawings containing complete wiring and schematic diagrams and any other details required to demonstrate that the system including the control panel has been coordinated and will properly function as a unit. Show on the Drawings proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation. Provide a complete listing of equipment and materials.

SD-03 Product Data

Materials and Equipment

Manufacturer's descriptive data and technical literature, performance charts and curves for all impeller sizes for a given casing, catalog cuts, and installation instructions. Spare parts data for each different item of material and equipment specified, after approval of the detail drawings and not later than 1 month prior to the date of beneficial occupancy. Data shall include a complete list of parts and supplies, with current unit prices and source of supply.

Instructions

Proposed diagrams, instructions, and other sheets, prior to posting. Approved wiring and control diagrams showing the complete layout of the entire system, including equipment, piping valves, and control sequence, framed under glass or in approved laminated plastic, shall be posted where directed. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified above for the wiring and control diagrams, and posted beside the diagrams. The framed instructions shall be posted before acceptance testing of the systems.

Training Period

Training course curriculum and training instructions shall be furnished to the USAID Implementing Partner 14 days prior to the start of training.

SD-06 Test Reports

Field Tests

Test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall indicate the final position of controls.

SD-07 Certificates

Manufacturer's Representative

The names and qualifications of the manufacturer's representative and training engineers and written certification from the manufacturer that the representative and trainers are technically qualified.

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

Six complete sets of instructions containing the manufacturer's

operating and maintenance instructions for each piece of equipment. One complete set at the time the tests procedure is submitted; remaining sets before the contract is completed. Each set shall be permanently bound and shall have a hard cover. The following identification shall be inscribed on the covers: the words "OPERATING AND MAINTENANCE INSTRUCTIONS," name and location of the building, name of the Contractor, and contract number. Flysheets shall be placed before instructions covering each subject. Instruction sheets shall be approximately216 by 279 mm, with large sheets of drawings folded in. Instructions shall include, but not be limited to, the following:

a. System layout showing piping, valves, and controls.

b. Approved wiring and control diagrams.

c. A control sequence describing startup, operation, and shutdown.

d. Operating and maintenance instructions for each piece of equipment, including lubrication instructions and troubleshooting guide.

e. Manufacturer's bulletins, cuts, and descriptive data; and parts list and recommended spare parts.

SD-11 Closeout Submittals

Warranty

1.4 QUALITY ASSURANCE

Provide the services of a manufacturer's representative for the commissioning of the pump(s) and ancillary equipment. The representative shall supervise the initial start-up, adjustment, and testing of the equipment. The manufacturer's representative shall remain on-site until the testing and commissioning process has been accepted by the USAID Implementing Partner, at no additional expense to the Government.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect all equipment, delivered and designated for storage, from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.6 WARRANTY

Provide manufacturer's standard guarantees and warranties.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Provide materials and equipment which are as specified below, as shown, and are suitable for the service intended. Provide materials and equipment which are new and unused, except for tests. Where two or more pieces of equipment performing the same function are required, they shall be duplicate products of the same manufacturer. All material supplied shall be manufactured and installed in conformance with NSF 61 requirements.

2.1.1 Standard Products

Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate equipment that has been in satisfactory waterworks operation at least 2 years. Equipment shall be supported by a service organization that is, in the opinion of the USAID Implementing Partner, reasonably convenient to the jobsite. Pumps and, and engines of the same types shall each be the product of one manufacturer.

2.1.2 Description

The pumps shall be horizontal centrifugal water pumps of the types indicated and specified. The driving units for the pumps shall be as indicated and specified.

2.1.3 Nameplates

Pumps and motors shall have a standard nameplate securely affixed in a conspicuous place showing the manufacturer's name, address, type or style, model, serial number, and catalog number. In addition, the nameplate for each pump shall show the capacity in L/second at rated speed in rpm and head in mm of water.

2.2 CENTRIFUGAL WATER PUMPS

The pumps shall be the centrifugal, designed for waterworks service in the following configurations:

	Pump No.
Horizontal	1, 2

2.2.1 Pump Service

The pumps shall be utilized for the following service:

	Pump No.
Line pressure booster pump	1, 2

2.2.2 Pump Drives

The pumps shall have the following driving units and shall be directly connected to the driving units through solid shafts, flexible couplings, or free wheeling clutches (as appropriate):

	Pump No.
Variable speed drive	1, 2

2.2.3 Integrated Varable Frequency Drive Motors

a. Each motor shall be of the Integrated Variable Frequency Drive design consisting of a motor and a Variable Frequency Drive (VFD) built and tested as one unit by the same manufacturer.

b. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of

motor. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump control and to eliminate the need for motor de-rating.

c. The VFD shall utilize an energy optimization algorithm to minimize energy consumption. The output voltage shall be adjusted in response to the load, independent of speed.

d. The VFD shall automatically reduce the switching frequency and/or the output voltage and frequency to the motor during periods of sustained ambient temperatures that are higher than the normal operating range. The switching frequency shall be reduced before motor speed is reduced.

e. An integral RFI filter shall be standard in the VFD.

f. The VFD shall have a minimum of two skip frequency bands which can be field adjustable.

g. The VFD shall have internal solid-state overload protection designed to trip within the range of 125-150% of rated current.

h. The integrated VFD motor shall include protection against input transients, phase imbalance, loss of AC line phase, over-voltage, under-voltage, VFD over-temperature, and motor over-temperature. Three-phase integrated VFD motors shall be capable of providing full output voltage and frequency with a voltage imbalance of up to 10%.

i. The integrated VFD motor shall have, as a minimum, the following input/output capabilities:

1) Speed Reference Signal: 0-10 VDC, 4-20mA
2) Digital remote on/off
3) Fault Signal Relay (NC or NO)
4) Fieldbus communication port (RS485)

j. The motor shall be Totally Enclosed Fan Cooled (TEFC) with a standard NEMA C-Face, Class F insulation with a temperature rise no higher than Class B.

k. The cooling design of the motor and VFD shall be such that a Class B motor temperature rise is not exceeded at full rated load and speed at a minimum switching frequency of 9.0 kHz.

l. Motor drive end bearings shall be adequately sized so that the minimum L10 bearing life is 17,500 hours at the minimum allowable continuous flow rate for the pump at full rated speed.

2.2.4 Pump Construction

Except as below specified, centrifugal water pumps shall be constructed in accordance with the Hydraulic Institute HI 1.1-1.2.

2.2.5 Pump Characteristics

The pumps shall be capable of discharging quantities at total rated heads measured at the discharge flange:

Pump No.	liters per second at total rated head, m H(2)O
1	20 L/s, 49 m
2	20 L/s, 49 m

Pumps shall operate at optimum efficiencies to produce the most economical pumping system under the conditions encountered and shall be sized to make optimum match with the system head curve as shown. Pumps shall furnish not less than 150% of rated capacity at a total discharge head of not less than 65% of total rated head. The Contractor shall coordinate with the pump manufacturer to ensure the NPSH requirements of the selected pump are addressed based on the orientation of the pumps, associated piping and storage configuration as established in the field.

2.2.6 Pump Casings

Pump casings shall be cast iron of the following design:

	Pump No.
Horizontal shaft, horizontal split casing	1,2

The casings shall be designed to permit replacement of wearing parts. Horizontal-split casings shall have the suction and discharge nozzles cast integrally with the lower half, so that the upper part of the casings may be removed for inspection of the rotating parts without disturbing pipe connections or pump alignment. Pump casings shall be of uniform quality and free from blowholes, porosity, hard spots, shrinkage defects, cracks and other injurious defects. Defects in casings shall not be repaired except when such work is approved and is done by or under the supervision of the pump manufacturer, and then only when the defects are small and do not adversely affect the strength or use of the casing. Casings shall be single or double volute with flanged piping connections conforming to ASME B16.1, Class 125. The direction of shaft rotation shall be conspicuously indicated. The casing shall have tapped openings for air venting, priming, draining, and suction and discharge gauges. A brass or bronze umbrella or vent cock shall be furnished for venting except where automatic air vents are indicated. Drain openings in the volute, intake, or other passages capable of retaining trapped water shall be located in the low point of such passages.

2.2.7 Impellers

Impellers shall be of enclosed design and shall be constructed of bronze, carefully finished with smooth water passageways, and shall be statically and dynamically balanced. Impellers shall be securely keyed to the pump shaft.

2.2.8 Wearing Rings

Wearing rings of bronze shall be provided for impellers. Wearing rings of a different composition or of a suitable ferrous material shall be provided for pump casings. Casing rings shall be securely fixed in position to prevent rotation. Rings shall be renewable and designed to ensure ease of

maintenance.

2.2.9 Shaft

Shaft shall be of high grade steel, accurately machined, and shall be of sufficient size and strength to perform the work required. Bronze renewable shaft sleeves shall be provided for protection of the shaft in contact with water, and in the stuffing boxes. Shaft sleeves shall be keyed to the pump shaft.

2.2.10 Mechanical Seals

Mechanical seals shall be balanced or unbalanced, as necessary to conform to specified service requirements. Mechanical seals shall be constructed in a manner and of materials particularly suitable for the temperature service range and quality of water being pumped. Seal construction shall not require external source cooling for pumped-fluid service temperatures up to 120 degrees C. Seal pressure rating shall be suitable for maximum system hydraulic conditions. Materials of construction shall include AIST PB-224 series stainless steel, solid tungsten-carbide rotating-seal face, and Buna-N vinylidene-fluoride-hexafluoropropylene, EPT, or tetrafluoroethylene seals. Bypass flushing water supply shall be free of iron rust products and other abrasive materials and shall be directed onto face of seal without dead ending. All piping and accessories shall be provided. Throttling bushing shall have clearances to minimize leakage in case of complete seal failure without restriction of flushing water. Mechanical seals shall not be subjected to hydrostatic test pressures in excess of the manufacturer's recommendations.

2.2.11 Couplings

Couplings shall be of the heavy-duty flexible type, keyed and locked to the shaft. The outside surface of the couplings for horizontal pumps shall be machined parallel to the axis of the shaft. The faces of the couplings shall be machined perpendicular to the axis of the shaft. Disconnecting the couplings shall be accomplished without removing the driver half or the pump half of the couplings from the shaft. Flexible couplings shall not be used to compensate for misalignment of pump.

2.2.12 Balance

All rotating parts of the equipment shall operate throughout the required range without excessive end thrust, vibration, or noise. Defects of this type that cannot be eliminated by installation adjustments will be sufficient cause for rejection of the equipment. Pump impeller assemblies shall be statically and dynamically balanced to within 1/2 percent of W times R squared, where W equals weight and R equals impeller radius. Shaft construction shall be substantial to prevent seal or bearing failure due to vibration. Total shaft peak-to-peak dynamic deflection measured by vibrometer at pump-seal face shall not exceed 0.051 mm under shutoff-head operating conditions. Flow from 6 mm iron pipe size (ips) pipe shall be provided during testing.

2.2.13 Bearings

Bearings shall be ball or roller type, and the main bearings shall take all radial and end thrust. Pumps that depend only on hydraulic balance to overcome end thrust will not be acceptable.

2.2.14 Lubrication

Bearings on horizontal-shaft pumps shall be either oil-bath type or grease type. Each oil reservoir shall be liberal in size and provided with an opening for filling, an overflow opening at the proper location to prevent overfilling, an oil-level sight glass, and a drain at the lowest point. Pumps with oil-lubrication systems shall be designed so that all shaft bearings will be isolated from the pumped liquid. An automatic sight feed oiler shall be provided on a suitable mounting bracket with connection to the shaft tube. Grease type bearings shall be provided with fittings for a grease gun and, if the bearings are not easily accessible, with grease tubing extending to convenient locations. The grease fittings shall be of a type that prevent over lubrication and the buildup of pressure injurious to the bearings.

2.2.15 Base Plates

Horizontal-shaft centrifugal pumps shall be provided with a common base for mounting each pump and driving unit of the pump on the same base. Each base shall be constructed of cast iron with a raised lip tapped for drainage, or of welded steel shapes with suitable drainage pan. The drainage structure shall collect the packing box leakage and shall have a 13 mm NPT connection to connect it to a drain.

2.2.16 Cocks, Plugs, and Accessories

The pumps shall be equipped with air cocks, drain plugs, and gauges indicating discharge pressures for all pumps and suction pressures for pumps without suction lift. Gauges, equipped with a shutoff cock and snubber, shall conform to ASME B40.100, and shall be calibrated in kPa and psi in not more than 10 kPa and 2 psi increments. Gauge ranges shall be appropriate for the particular installation. Normal operating suction and discharge pressures of the pump shall be indicated on the mid-point range of the gauges.

2.2.17 Piping Connections

The pump suction and discharge shall be provided with flanged connections of suitable size and suitably arranged for piping shown. Pipe flanges shall conform to ASME B16.1 and ASME B16.5. Piping shall be installed to preclude the formation of air pockets.

2.2.18 Finish

Pump shall have painted or enameled finish as is standard with the manufacturer.

2.2.19 Pump Control System

The pumps are to be controlled by a 4-20 mA signal from a pressure sensor in the expansion tanks, to provide variable speed control of the pumps. There shall be high pressure and a low pressure alarm which shuts down the pumps. Enclose alarm panel in NEMA IV enclosure and with a flashing red light with long life bulb in guarded enclosure and 15 mm diameter horn. Panel shall be mounted as shown on the drawings. Horn must emit 120 DB at 3 meters. Power alarm horn and light from 12V DC power supply with battery backup. Provide a rechargeable battery rated to power both the horn and light for a minimum of two hours upon loss of main power. Provide circuitry to automatically recharge the battery after main power is

restored. Fullcharge of battery must take no more than 20 hours. Use panels with power on light, push to test button for horn and light and push to silence button for horn and light with automatic reset for next alarm. Use alarm designed to activate under the following conditions:

a. High or low pressure

b. Loss of main power

2.3 EQUIPMENT APPURTENANCES

2.3.1 Attachments

All necessary bolts, nuts, washers, bolt sleeves, and other types of attachments for the installation of the equipment shall be furnished with the equipment. Bolts shall conform to the requirements of ASTM A 307 and nuts shall be hexagonal of the same quality as the bolts used. Threads shall be clean-cut and shall conform to ASME B1.1. Bolts, nuts, and washers specified to be galvanized or not otherwise indicated or specified, shall be zinc coated after being threaded, by the hot-dip process conforming to ASTM A 153/A 153M as appropriate. Bolts, nuts, and washers specified or indicated to be stainless steel shall be Type 316.

2.3.2 Equipment Guards

Equipment driven by open shafts, belts, chains, or gears shall be provided with all-metal guards enclosing the drive mechanism. Guard shall be constructed of galvanized sheet steel or galvanized woven wire or expanded metal set in a frame of galvanized steel members. Guards shall be secured in position by steel braces or straps which will permit easy removal for servicing the equipment. The guards shall conform in all respects to all applicable safety codes and regulations.

2.3.3 Tools

A complete set of all special tools which may be necessary for the adjustment, operation, maintenance, and disassembly of all equipment shall be furnished. Special tools are considered to be those tools which because of their limited use are not normally available, but which are necessary for the particular equipment. Special tools shall be high-grade, smooth, forged, alloy, tool steel. One pressure grease gun for each type of grease required for motors shall also be furnished. All tools shall be delivered at the same time as the equipment to which they pertain. Properly store and safeguard such tools until completion of the work, at which time they shall be delivered to the USAID Implementing Partner.

2.3.4 Shop Painting

All motors, pump casings, and similar parts of equipment customarily finished in the shop shall be thoroughly cleaned, primed, and given two finish coats of paint at the factory in accordance with the recommendations of the manufacturer. Ferrous surfaces not to be painted shall be given a shop coat of grease or other suitable rust-resistant coating.

2.4 FACTORY TESTS

Pumps shall be tested by the manufacturer or a nationally recognized testing agency in compliance with Hydraulic Institute Standards. Where two or more identical pumps are specified, only one representative pump shall

be tested. Certified test results shall be submitted to the USAID Implementing Partner.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field and advise the USAID Implementing Partner of any discrepancy before performing the work.

3.2 INSTALLATION

Install each pump in accordance with the written instructions of the manufacturer. Concrete for equipment foundations/ house keeping pads shall be as specified in Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE. Concrete foundations shall be integral with and of the same class as that of the building floor unless otherwise indicated. Concrete having a compressive strength of at least 17 MPa shall be used in foundations that are entirely separated from the surrounding floor. A premolded filler strip shall be installed between the foundation and floor slab. Foundation bolts, as required, shall be furnished for proper positioning during the placement of the concrete.

3.3 FIELD TESTS

After installation of the pumping units and appurtenances is complete, operating tests shall be carried out to assure that the pumping installation operates properly. Each pumping unit shall be given a running field test in the presence of the USAID Implementing Partner for a minimum of 2 hours. Each pumping unit shall be operated at its rated capacity or such other point on its head-capacity curve selected by the USAID Implementing Partner. Provide an accurate and acceptable method of measuring the discharge flow. Tests shall assure that the units and appurtenances have been installed correctly, that there is no objectionable heating, vibration, or noise from any parts, and that all manual and automatic controls function properly. If any deficiencies are revealed during any tests, such deficiencies shall be corrected and the tests shall be reconducted.

3.4 FIELD PAINTING

Do not paint stainless steel, galvanized steel, and nonferrous surfaces.

3.4.1 Touch-Up Painting

Factory painted items requiring touching up in the field shall be thoroughly cleaned of all foreign material and shall be primed and topcoated with the manufacturer's standard factory finish.

3.4.2 Exposed Ferrous Surfaces

Exposed ferrous surfaces shall be painted with two coats of enamel paint conforming to SSPC Paint 21. Factory primed surfaces shall be solvent-cleaned before painting. Surfaces that have not been factory primed shall be prepared and primed with one coat of SSPC Paint 25 or in accordance with the enamel paint manufacturer's recommendations.

3.5 DEMONSTRATION

Upon completion of the work, and at a time designated by the USAID Implementing Partner, the services of the authorized representative of the manufacturer shall be provided for a training period of not less than 4 hours to provide instruction on the contents of the operation and maintenance manuals for the equipment furnished under these specifications. These field instructions shall cover all the items contained in the bound instructions.

-- End of Section --

SECTION 43 21 39

WELL PUMPS

PART 1 GENERAL

1.1 JOB REQUIREMENTS

Contractor shall furnish all labor, materials, tools, equipment, and perform all work and services necessary for the installation of one (1) constant speed submersible motor vertical turbine pump as shown on the Contract Drawings and as specified, in accordance with the provisions of the Contract Documents, and completely coordinated with work of all other trades.

Although not specifically indicated, furnish and install all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure and complete installation. All submersible motor turbine pumps shall be from the same manufacturer.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA E101	(1988) Vertical Turbine Pumps - Line Shaft and Submersible Types

1.3 SUBMITTALS

Contractor shall submit the following using submittal procedures as specified in the Contract Documents.

SD-02 Shop Drawings

Installation

Detail drawings consisting of a complete list of equipment and materials. Detail drawings containing complete wiring and schematic diagrams and any other details required to demonstrate that the system and control panel has been coordinated and will properly function as a unit. Show on the Drawings proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

Detail drawings showing the layout of the freeze protection system for the pump discharge piping.

SD-03 Product Data

Vertical Turbine Pumping Units

Manufacturer's descriptive data and technical literature, performance charts and curves, catalog cuts, and installation instructions including the following:.

a. Pump Speed
b. Flow vs. Head Curve
c. Efficiency Curve
d. Horsepower Curve
e. NPSHR Curve
f. Motor Efficiency vs. Load

Proposed diagrams, instructions, and other sheets, prior to posting.

SD-06 Test Reports

Factory Inspection and Testing

Testing

Test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Indicate in each test report the final position of controls.

SD-10 Operation and Maintenance Data

Vertical Turbine Pumping Units

Six complete copies of operating manual outlining the step-by-step procedures required for system startup, operation and shutdown. Include in the manual the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. Six complete copies of maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. Include in the manuals simplified wiring, layout, and control diagrams of the system as installed.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.5 EXTRA MATERIALS

1.5.1 Spare parts

Submit spare parts data for each different item of material and equipment specified, after approval of the detail drawings and not later than 2 months prior to the date of beneficial occupancy. Include in the data a complete list of parts and supplies, with current unit prices and source of supply, and a list of the parts recommended by the manufacturer to be replaced after 1 and 3 year(s) of service.

Provide one complete spare pumping unit to be kept onsite.

1.5.2 Special tools

A complete set of all special tools which may be necessary for the adjustment, operation, maintenance, and disassembly of all equipment shall be furnished. Special tools are considered to be those tools which because of their limited use are not normally available, but which are necessary for the particular equipment. Tools shall be high-grade, smooth, forged, alloy, tool steel. Special tools shall be delivered at the same time as the equipment to which they pertain. Properly store and safeguard such special tools until completion of the work, at which time they shall be delivered to the USAID Implementing Partner.

PART 2 PRODUCTS

2.1 GENERAL

2.1.1 Standard Products

Impellers shall be closed and dynamically balanced. Each impeller shall be secured to the impeller shaft with keys, taper collets or locknuts. The upper shaft bearing shall be bronze.

The suction strainer shall have a net inlet area equal to at least three (3) times the impeller inlet area. The maximum unit opening shall not be more than 75% of the minimum opening of the water passage through the bowl or impeller. The strainer shall be secured with stainless steel 302 or better fasteners.

The pump to motor coupling flange shall conform to NEMA specifications and be capable of transmitting the total torque and total thrust of the bowl assembly in either direction of rotation. A coupling guard shall be furnished, integral to the discharge head. The pump/motor interconnector case shall conform to NEMA specifications. Non NEMA frame motor adapters are unacceptable.

All components of the pump system shall be capable of operating at the pump shut-off head pressure. Refer to Contract Drawings for well pump system dimensional requirements.

The pump Contractor shall verify that the thrust bearing of the motor is not overloaded. The Contractor shall submit the "K," maximum thrust constant for the pump and thrust bearing rating for the motor. It is the responsibility of the pump Contractor to integrate the pump and motor.

2.2 PUMP AND APPURTENANCES

2.2.1 Pump Performance

The performance specifications for the pump assemblies are tabulated below. Pump to motor flange coupling must be NEMA to fit motor.

Performance Specifications

Design Points	Flow Rate lps	TDH m	Efficiency %	Frequency hz
Primary	6.25	(a)	65	50

(a) TDH to be determined in field after well installation and approved by the USAID Implementing Partner. TDH equals the static head (difference between elevation of potable water tank and elevation of the lowest drawdown within the well) plus friction losses.

2.2.2 Materials of Construction

Materials of construction shall be as follows:

PART	MATERIAL
Bearings	Thermoplastic
Pump Shaft	Stainless Steel 316 SS
Bowls/Cases	Stainless Steel 316 SS
Impeller	Stainless Steel 316 SS
Inlet Screen	Stainless Steel 304 SS
Pump Motor Coupling	Stainless Steel 316 SS
Fastener and Screws	Stainless Steel 316 SS
Cable Guard	Stainless Steel 304 SS

2.2.3 Water Level Indicators

Pressure Transducer: The submersible pressure transducer shall be hermetically sealed stainless steel unit with ± 0.25 % FS accuracy. The transducer shall have a 2-wire, 4-20 mA output and a repairable/replaceable sensor/cable assembly and top side indicating transmitter. Transducer shall be manufactured by In-Situ, Druck or approved equivalent. Transducer shall have a dedicated PVC tube that is accessible from inside the top of the well head. The PVC tube shall extend from the well head down below pump alongside the motor. The PVC tube shall be perforated with four ¼ inch drill holes every foot for the lowest 20 feet to allow water entry. The PVC tube shall have a cap or plug on bottom.

2.2.4 Miscellaneous

Nameplates and other data plates shall be stainless steel, suitably secured to the pump and motor.

All machine bolts, nuts and capscrews shall be 304 stainless steel of the hex head type. Hardware requiring special tools or wrenches shall not be used.

2.3 MOTORS AND APPURTENANCES

2.3.1 Submersible Motors

Performance. The minimum performance specifications for the submersible motor assembly are as follows:

Service factor above rated HP	Shall not be utilized
Voltage, VAC,	400/230 V
Phase	3
Frequency	50 Hz
Motor Size	(a)
Full Load Efficiency, min.	85 %

(a) to be determined in the field to meet the pump performance specifications in 2.2.1 PUMP PERFORMANCE and approved by the USAID

Implementing Partner.

2.3.2 Construction of Submersible Well Pump Motor

Materials and methods of construction shall permit the motor to operate within the latest NEMA standards for temperature rise.

A thrust bearing of the Kingsbury type shall support all rotating and hydraulic loads of both pump and motor. Each thrust pad shall be individually tilting with the entire group self leveling and aligning. The bearing shall be bi-directional. The losses at full load shall not exceed 12 watts per 100 lbs. of thrust.

The frame of the pump interconnector and shaft shall conform to the latest revision of NEMA standards for submersible motors especially made for water lubrication. This motor has a NEMA flange coupling.

Windings shall be completely sealed in a stainless steel enclosure. Sand and other foreign materials shall be filtered from the water with a bronze and nickel plated brass filter. Motor leads shall be of sufficient length that the splice to the cable can be made above the pump.

2.3.3 Motor Manufacturers

Approved manufacturers: Franklin Electric, or pre-approved equivalent.

2.4 Submersible Cable

2.4.1 Conductors

One (1) continuous length of cable shall connect the submersible motor pigtails to the above ground well head junction box. An additional 1.5 meters of cable shall be housed inside the well head for splicing

This cable shall consist of three (3) individual color coded conductors. Each copper conductor shall be insulated for 600 VAC by rubber, synthetic rubber, or approved plastic insulation suitable for continuous immersion in water at well temperature. All three (3) conductors shall be enclosed in an overall jacket material that is impervious to oil and water and made from rubber, synthetic rubber, metal or other approved mechanically protective material. All filler material shall be non-hydroscopic. Jute or hemp is not acceptable.

Individual cable stranding shall meet ASTM class designations as follows:

AWG #10 or smaller - Class B - 7 strands minimum
AWG #1 through 4/0 - Class B - 19 strands minimum
AWG #9 through #2 - Class C - 19 strands minimum

The cable shall have sufficient conductor cross sectional area to meet the minimum requirements of the Insulated Power Cable Engineers Association Code of Operation in Free Air or shall meet the requirements of the motor manufacturer, as dictated by horsepower, voltage and well water temperature. A 150 mm long sample of the proposed cable shall be submitted to the USAID Implementing Partner for approval prior to installation of the submersible pump. This sample shall have the manufacturer's identifying stencil on the outer jacket.

2.4.2 Cable Support

The pump cable, water level indicator access PVC tube, and transducer PVC tube shall be secured to the riser pipe with high strength polypropylene pipe tape and 10 mm 303 stainless steel banding. Each stainless steel band shall be protected by a nonslip, rubber, protector over the submersible cable. The spacing schedule of banding and tape is as follows:

AWG Size	Tape	SS Banding
10 or smaller	3 meter centers	30 meter centers
9 through 4	3 meter centers	9 meter centers
2 through 3/0	3 meter centers	3 meter centers

2.4.3 Mechanical Shielding

The electrical conductors shall be protected by a corrosion-resistant cable guard where they pass the pump bowls. This guard shall be secured to the pump with 303 Stainless Steel bands.

2.4.4 Splices

Only one (1) splice will be permitted in the submersible cable. This splice, at the motor pigtail, shall be completed in a staggered manner so that no individual conductor splice shall be directly opposite another.

The conductors of the pigtail and power cable shall be joined with rosin core soldered copper butt connectors. The insulating overlay shall be of rubber manufactured by 3M Company of Plymouth or shall be of submersible adhesive heat shrink insulations as made by Sigma Corporation. This insulation shall be a minimum of 30 mm in length overlay with polypropylene pipe tape and "Scotch-Kote" as made by 3M Company. The entire splice shall be banded to the riser pipe with protected stainless steel banding and polypropylene pipe tape.

Termination of the cable at the surface junction box shall be made with electrical split bolts and rubber tape for 600 VAC splices and of the manufacturers approved method for those splices above 600. Each 600 VAC surface splice shall be overlaid with vinyl and "Scotch-Kote." Wire nuts are not acceptable.

2.5 RISER PIPE AND FITTINGS

2.5.1 Pipe

The riser pipe connecting the pump to the surface shall be PVC Certanteed Certa-Lok Drop Pipe as follows:

a. Top and bottom of drop pipe string shall be fitted with stainless steel Certa-Lok Drop Pipe adapters

2.5.2 Makeup Torque

All pipe and fittings shall be secured to prevent unthreading during pump start-up. A minimum of 6.7 kg-m (10 ft-lbs) per horsepower is recommended; however, this is intended only as a guideline. Pipe torque shall be in accordance with API 5C1.

2.5.3 Pipe Lubricant

Each connection shall be coated with a pipe dope that is approved for use in water systems by the National Sanitation Foundation. Lead based doping compounds are not permissible.

2.5.4 Adapter Fittings

The Contractor shall provide all fittings to adapt the riser pipe to the well head surface plate and above ground discharge pipes. These adapters shall be of the swedge type, threaded both ends and of stainless steel material equal to or better than the specified riser pipe

2.5.5 Centralizing Spiders

Riser pipe centralizing spiders shall be installed on the downwell piping. The spiders are to be spaced at average intervals of 12 meters, however, the intervals are to be random and not evenly spaced, i.e., at 7.6 meters, 12 meters, 18 meters. Spiders shall be the equivalent of "Black Widow," the trade name of Bean Rubber Mfg. Company.

2.6 CHECK VALVES

2.6.1 Materials and Construction

Check valves in the downhole string shall be stainless steel and rated for the depth of set and extreme conditions of operating or line surface pressures. Each valve shall be threaded on both ends with a thread pattern identical to that of the line pipe.

The outer diameter shall not be larger than the coupling diameter for the line pipe. The body of the valve shall be machined from carbon steel of tensile strength equal or greater than the line pipe. Check valves shall be manufactured by Flomatic or pre-approved equal.

2.6.2 Location

Check valve shall be set within 1.5 meters above the pump and as shown on the Contract Drawings.

2.7 KNOCKOUT VALVES

Individual knockout valves shall be placed above or be integral with each check valve. The valve bodies shall be constructed of equal or better materials than the line pipe.

The drain plug shall be replaceable and made of brass or monel. It shall be capable of withstanding the hydraulic pressure above each check.

2.7.1 Submersible Vertical Turbine Pumps

2.7.1.1 Control Equipment

Automatically controlled pumps shall have three-position MANUAL-OFF-AUTOMATIC selector switch in cover. Additional controls or protective devices shall be as indicated.

A pump low-water cutoff shall be installed in the well or on the suction pipe and shall shut the pump off when the water level in the well reaches

the level shown. The control panel shall contain the display for the pressure transducer noted in Section 2.2.3.

The control panel shall receive the signals from the float switches (high water alarm, well pump off, well pump on, and low water alarm) in the potable water storage tank.

The control panel shall contain a display for the flow water.

Control panel is to have a NEMA 4 enclosure and with a flashing red light with long life bulb in guarded enclosure and 15 mm diameter horn. Panel shall be mounted as shown on the drawings. Horn must emit 120 DB at 3 meters. Power alarm horn and light from 12V DC power supply with battery backup. Provide a rechargeable battery rated to power both the horn and light for a minimum of two hours upon loss of main power. Provide circuitry to automatically recharge the battery after main power is restored. Full charge of battery must take no more than 20 hours. Provide panel with power on light, push to test button for horn and light and push to silence button for horn and light with automatic reset for next alarm. Use alarm designed to activate under the following conditions:

a. Low water level as indicated by the pressure transducer

b. Loss of main power

c. High water alarm in potable water storage tank.

Well pump shall shut down when the alarm activates.

2.7.1.2 Float Assembly Description

For the switches in the potable water tank, use a direct acting float switch consisting of a normally-open mercury switch enclosed in a float. use pipe mounted float assembly. Use floats molded of rigid high-density polyurethane foam, color-coded and coated with a durable, water and corrosion-resistant jacket or clear urethane. Provide connecting cable and support pole in accordance with manufacturers recommendations. Provide a cast aluminum NEMA Type 4 junction box to connect float assembly. Use box with gasketed cover with tapped float fitting and conduit entrance pipe threaded opening. Mount floats at fixed elevations as shown. Use floats designed to tilt and operate their switches causing sequential turn-on turn-off of the well pump, when the liquid level being sensed rises or falls past the float.

2.7.1.3 Electric Motors

Submersible motors shall be designed and manufactured expressly for the intended use. Motors shall be rated 400 volts, 3 phase, 50 Hz and such rating shall be stamped on the nameplate. Submersible motors may be the wet-stator type, dry-stator type, or oil-filled stator type. Wet-stator motors shall be filled at the factory with water treated to minimize corrosion, and shall be provided with a seal to keep interchange of cooling water and water being pumped to a minimum. Windings shall be insulated with a waterproof material. Dry-stator motors shall have rotor bearings immersed in a coolant lubricant of water-oil or water-glycol mixture, or a water-grease emulsion. When the coolant is water, it may be sealed in the motor or allowed to flow through the motor, depending upon design. Stator case shall be hermetically sealed and may be filled with a solid plastic material to help dissipate heat. Oil-filled stator motors shall be

completely filled with high-dielectric constant oil. A mechanical seal shall be provided between the shaft and the motor housing and shall be designed to minimize the loss of oil. An oil reservoir shall be provided to replenish the oil loss for the life of the motor. Wet-stator motors and oil-filled stator motors shall employ a system to automatically balance the liquid pressure in the motor at any depth of submergence up to the maximum allowable. Motor bearings shall provide smooth operations under the conditions encountered for the life of the motor. Adequate thrust bearings shall be provided in the motor to carry the weight of all rotating parts plus the hydraulic thrust, and shall be capable of withstanding the upthrust imposed during pump starting.

PART 3 EXECUTION

3.1 FIELD REVIEWS

3.1.1 Field Inspections

The USAID Implementing Partner shall be present at the following installation inspection points. The USAID Implementing Partner shall accept or reject the installation inspection results.

1. Motor/pump models and serial number.

2. Meggering of the motor by Contractor with a 500 volt resistance megger and measurement of the motor winding resistance.

3. Placement of the airline end or water level transducer assembly.

4. Start-up.

The Contractor is responsible for notifying the USAID Implementing Partner 48 hours in advance of setting the pump and initiating start-up.

3.2 FACTORY INSPECTION AND TESTS

Factory tests shall be conducted in accordance with section B6 of the latest issue of ANSI/AWWA E-101 and the Hydraulic Standards Institute. Certified performance reports shall be provided to the USAID Implementing Partner for review and shall be accepted or rejected by the USAID Implementing Partner prior to shipment. The specific tests and inspections are as follows:

1. Non-witnessed certified performance test; flow, TDH, voltage, current, BHP, efficiency, etc.

2. Sample calculation from test readings.

3. Shop inspection.

4. Hydrostatic test of the bowl assembly.

3.3 RESISTANCE READINGS

Resistance readings shall be taken on the motor with pigtail and motor with cable attached. A new motor and new cable shall have the minimum insulation resistance as measured with a 500 volt megger after one (1) minute of applied voltage. Resistance readings shall be witnessed by the

USAID Implementing Partner.

1. Motor only with pigtail-ten (10) meg ohms.
2. Motor with cable attached and installed in well-two (2) meg ohms.

3.4 SUPPLIER/MANUFACTURER'S SERVICES

A supplier's and/or manufacturer's representative for the equipment specified shall be at the job site for installation assistance, inspection and certification of the installation, testing, start-up assistance, and training. These efforts by the representative shall be coordinated by the Contractor and shall be witnessed by the USAID Implementing Partner.

3.5 TESTING

3.5.1 Factory Pump Test

Factory pump performance test shall be made in conformance with AWWA E101 for the following:

a. Running test.

b. Witnessed running test.

c. Sample calculation from test readings.

d. Shop inspection.

e. Hydrostatic test of bowl assembly.

f. Hydrostatic test of discharge head.

3.5.2 Field Equipment Test

After installation of the pumping units and appurtenances is complete, operating tests shall be carried out to assure that the pumping installation operates properly.Each pumping unit shall be given a running field test in the presence of the USAID Implementing Partner for a minimum of 2 hours. Each pumping unit shall be operated at its rated capacity or such other point on its head-capacity curve selected by the USAID Implementing Partner.Provide an accurate and acceptable method of measuring the discharge flow.

-- End of Section --

SECTION 43 32 76

CHLORINE-FEEDING MACHINES (AUTOMATIC, SEMIAUTOMATIC AND MANUAL)

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2009) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)

1.2 SUBMITTALS

Contractor shall submit the following using procedures as specified in the Contract Documents.

SD-02 Shop Drawings

Installation

Detail drawings containing complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Show on the drawings proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

SD-03 Product Data

Material and Equipment

A complete list of equipment and material, including manufacturer's descriptive data and technical literature, performance charts and curves, catalog cuts, and installation instructions. Spare parts data for each different item of material and equipment specified, after approval of the detail drawings and not later than 1 month prior to the date of beneficial occupancy. Include in the data a complete list of parts and supplies, with current unit prices and source of supply, and a list of the parts recommended by the manufacturer to be replaced after 1 and 3 year(s) of service.

Diagrams, instructions, and other sheets, proposed for posting.

SD-06 Test Reports

Testing

Test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Indicate in each test report the final position of controls.

SD-10 Operation and Maintenance Data

Operating and Maintenance Instructions

Six complete copies of operating manuals outlining the step-by-step procedures required for system startup, operation and shutdown. Include in the manuals the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. Six complete copies of maintenance manuals listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides.

1.3 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, humidity and temperature variation, dirt and dust, or other contaminants.

1.4 MAINTENANCE, EXTRA MATERIALS AND TOOLS

1.4.1 Auxiliary Equipment and Spare Parts

Furnish auxiliary equipment and spare parts as follows:

a. One spare rotameter and solenoid valve for each chlorination system.

b. Three each of all special gaskets to fit all joints and unions.

c. One spare diaphragm valve.

d. One emergency repair kit for chlorine tablet containers.

1.4.2 Special Tools

For each type of equipment furnished provide:

a. Special tools necessary for adjustment, operation, maintenance, and disassembly.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

2.1.1 Standard Products

Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably

convenient to the site.

2.1.2 Nameplates

Major equipment items shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

2.1.3 Miscellaneous Supports

Bolts, nuts, anchors, washers, and all other types of supports necessary for the installation of the equipment shall be galvanized steel, cadmium plated steel, or Type 316 stainless steel.

2.2 CHLORINATOR

The machine shall be designed for the treatment of water by the application of chlorine tablet system using slow release 65 percent calcium hypochlorite tablets. Dilution water for the chlorinator shall be from the facility's water supply system. Delivery shall be by erosion feed technology to control accurate and consistent concentration limits in the chlorine treatment solution. The chlorine solution is to be returned to the potable water tank via a gravity return system. All components of the system shall be designed to be unaffected by the harsh chemical environment. Construction shall be as simple as practicable to provide reliable service and to be readily accessible for inspection, cleaning, adjustment, repairs, and replacements.

2.2.1 Capacity

The chlorinator shall be capable of delivering chlorine at a maximum rate of 5.5 kg in 24 hours and shall be capable of continuous operation at rated capacity. The water supply to the unit at this maximum rate shall be 38 lpm.

2.2.2 Chlorinator Stand

The chlorinator is to be supported on a stand that raises the bottom of the chlorinator 1 meter off the equipment pad. This is to provide sufficient head to allow the chlorine solution to flow by gravity to the water tank. The stand is to be constructed of aluminum or stainless steel, meet all applicable seismic codes, and have base plates suitable for bolting to the equipment pad.

2.3 OTHER SYSTEM COMPONENTS

2.3.1 Inlet Solenoid Valve

The solenoid valve opens and closes on command from the well pump control panel. The valve is to be rated for 1,000 KPa. Solenoid valve is to be brass construction.

2.3.2 Pressure Reducing Valve

The pressure reducing valve (PRV) is to be sized for a flow rate of 0.2 - 0.7 lps, with an upstream pressure of approximately 480 KPa. Pressure reducing valve is to be brass construction.

2.3.3 Rotameter

Rotameter is to be machined from solid cast acrylic rod. Float and guide rod to be stainless steel. Sized for the flow range stated. End connections are to be PVC.

2.3.4 Flow Control Valve

Flow control valve is to be a PVC diaphragm valve with an EPDM diaphragm.

2.4 PIPING

All piping up to the PRV is to be Schedule 40 black steel. All piping downstream of the PRV is to be Schedule 80 PVC.

2.5 ELECTRICAL WORK

Electric motor-driven equipment, and wiring shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Ratings shall be as indicated.

2.6 FACTORY PAINTING

Factory painting shall conform to manufacturer's standard factory finish.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of work, verify all dimensions in the field, and advise the USAID Implementing Partner of any discrepancy before performing the work.

3.2 INSTALLATION

3.2.1 Chlorine-Feeding Equipment

All chlorination equipment, including the dilution system components, is to be installed in accordance with the manufacturer's instructions.

3.2.2 Pipe, Tubing, Hangers, and Supports

The installation of pipes and tubes shall be in accordance with the manufacturer's recommendations. Installation of hangers and supports shall conform to MSS SP-58 and MSS SP-69.

3.3 MANUFACTURER'S FIELD SERVICE

3.3.1 Field Training

Conduct a field training course for designated operating staff members. Training shall be provided for a total period of 8 hours of normal working time and shall start after the system is functionally complete but prior to final acceptance tests. Field training shall cover all of the items contained in the operating and maintenance instructions.

3.4 FRAMED INSTRUCTIONS

Post framed operating instructions under glass or in laminated plastic,

including wiring and control diagrams showing the complete layout of the entire system, where directed. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified and posted beside the diagrams. The framed instructions shall be posted before acceptance testing of the systems.

3.5 TESTING

After installation of the chlorine-feeding machine is complete, operating tests shall be carried out to assure that the chlorine-feeding installation operates properly. All piping shall be tested hydrostatically and for leaks. If any deficiencies are revealed during any tests, such deficiencies shall be corrected and the tests shall be reconducted.

3.6 FIELD PAINTING

Equipment which did not receive a factory finish shall be painted as specified in Section 09 90 00 PAINTS AND COATINGS. Factory painted items requiring touching up in the field, shall be thoroughly cleaned of all foreign material and shall be primed and topcoated with the manufacturer's standard factory finish provided it does not discolor in the presence of hydrogen sulfide fumes, high water vapor atmosphere, alkaline water vapor, and concentrated chlorine (oxidizing) conditions. Coating shall be not less than 0.05 mm thick.

-- End of Section --

SECTION 44 41 12

PACKAGED WASTEWATER TREATMENT PLANT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

Recommended Standards for Wastewater Facilities, 2004 Eds, A Report of the Wastewater Committee of the Great Lakes--Upper Mississippi River, Board of State and Provincial Public Health and Environmental Managers, Published by: Health Reasearch, Inc. Health Education Services Divisions, Albany, NY 1224

ASTM INTERNATIONAL (ASTM)

ASTM A 36/A 36M	(2008) Standard Specification for Carbon Structural Steel

1.2 SUBMITTALS

Contractor shall submit the following using submittal procedures as specified in the Contract Documents.

SD-01 Preconstruction Submittals

Submit Material, Equipment, and Fixtures List in accordance with paragraph entitled, "General Requirements," of this section.

SD-02 Shop Drawings

Submit the following in accordance with paragraph entitled, "Design Requirements," of this section.

Fabrication Drawings
Erection/Installation Drawings

Also, submit detailed drawings showing the layout of freeze protection systems for all exposed, normally filled pipes.

SD-03 Product Data

Submit manufacturer's catalog data and equipment and performance data for the following items:

Submit Spare Parts Data also for the following in accordance with paragraph entitled, "General Requirements," of this section.

Surface Preparation and Coating
Inlet Bar Screen
Flow Equalization Chamber
Sludge Holding Chamber
Aeration Chamber

Clarifier Chamber
Sludge Recirculation System
Scum Recirculation System
Chorine Disinfection

SD-05 Design Data

Submit Design Data with Manufacturer part number following:

Surface Preparation and Coating
Inlet Bar Screen
Flow Equalization Chamber
Sludge Holding Chamber
Aeration Chamber
Clarifier Chamber
Sludge Recirculation System
Scum Recirculation System
Chlorine Disinfection

SD-07 Certificates

Submit the following in accordance with paragraph entitled, "General Requirements," of this section.

Listing of Product Installations
Safety Considerations

Submit Certificates for the following items in accordance with the applicable reference standards and description of this section.

Surface Preparation and Coating
Inlet Bar Screen
Flow Equalization Chamber
Sludge Holding Chamber
Aeration Chamber
Clarifier Chamber
Sludge Recirculation System
Scum Recirculation System
Chlorine Disinfection

SD-08 Manufacturer's Instructions

Submit manufacturer's instructions including special provisions required to install equipment components and system packages for the following items.

Submit operating instructions, including standard operating procedures with startup, shutdown, and emergency operation for Package Wastewater Treatment Plant, and the following:

Surface Preparation and Coating
Inlet Bar Screen
Flow Equalization Chamber
Sludge Holding Chamber
Aeration Chamber
Clarifier Chamber
Sludge Recirculation System
Scum Recirculation System
Chlorine Disinfection

Submit the following in accordance with paragraph entitled, "General," of this section.

Preventative Maintenance and Inspection
Special Tools
Posted Instructions

SD-10 Operation and Maintenance Data

Submit Operation and Maintenance Manuals for package wastewater treatment plant including the following in accordance with paragraph entitled, "Operation and Maintenance," of this section.

Equipment Description
Assembly and Installation Procedures
Adjustment and Alignment
Checkout Procedures
Procedures of Operation
Troubleshooting

SD-11 Warranty

1.3 DESIGN REQUIREMENTS

Actual range in capacities may vary from that stipulated if the minimum and maximum capacities specified are included.

Furnish and install one (1) complete prefabricated carbon steel wastewater treatment plant and related equipment designed and constructed in accordance with the plans and specifications stated herein. The wastewater treatment plant will be the activated sludge type, specifically know as "Extended Aeration" consisting of 2 trains each, designed for each train treating an average day flow of 144 m3/day and 68 kg/d BOD load.

Submit Fabrication Drawings after receiving tentative approval of the equipment and the materials list but before installation, Contractor to submit drawings covering necessary or recommended changes to accommodate the equipment offered. Show clearly on the drawings the design of the chamber, with dimensions, types, and thicknesses of materials, and elevation levels with reference to those elevations indicated.

Submit Erection/Installation Drawings for the wastewater treatment plant with the required equipment and accessories that are inclusive. Show clearly on the drawings the design of the wastewater treatment plant, with dimensions, types, and thicknesses of materials, and elevation levels with reference to those elevations indicated.

Provide the following motor/pumps design data provided prior to final turnover - number of motor rotor bars and stator slots; number of cooling fan blades; RPM of motor; bearings, bearing manufacturer, bearing type, bearing style and number of balls/elements; number of commutator bars and commutator brushes; SCR firing frequencies; and number of pump impellers.

Design package wastewater treatment plant in accordance with "Recommended Standards for wastewater facilities," by the Wastewater Committee of the Great Lake-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers, latest edition (2004), commonly known as "Ten States Standards." Design shall be in conformance with relevant

sections of AWWA, ASME, ASTM, AISC, ISO, MSS, NEMA and ICBO. The wastewater treatment plant effluent shall meet 30 mg/L BOD, 30 mg/L TSS and less than 126/100 ML e-Coli based on a 30 day geometric mean of daily samples.

1.4 PROTECTION FROM MOVING PARTS

Locate and guard belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts in accordance with applicable OSHA standards and so that personnel are properly protected from injury.

1.5 NAMEPLATES

Provide the manufacturer's name or trademark on a corrosion-resistant identification plate or cast integrally, on each item of equipment, stamped, or otherwise permanently marked in a conspicuous place. Include on the pump identification plate the pump capacity in liter per minute, pump head in meter, and speed of rotation. Cast on the body of the pump the direction of rotation On the identification plate indicate all necessary information to complete identification such as the manufacturer.

1.6 FIELD REPRESENTATIVE

Contractor shall be required to provide specific instructions on the equipment, processes and systems by a Qualified Representative of the Equipment Supplier during installation, commissioning, and start-up of the wastewater treatment plant.

1.7 GENERAL REQUIREMENTS

Submit Material, Equipment, and Fixtures List of all major components including manufacturer's catalog numbers, specification and drawing reference number, warranty information, and fabrication site.

Submit Safety Considerations including information relating to load limits, speed of operation, environmental criteria (temperature and pressure limitations), and personnel hazards and equipment safety precautions for the wastewater treatment plant.

Supply one year supply of spare parts. An operator's kit with face shield and cleaning solution shall also be provided.

Provide a 30 day supply of chemicals associated with the daily operation of the treatment facility.

1.8 WARRANTY

Provide manufacturer's standard performance guarantees and warranties.

PART 2 PRODUCTS

Verify conformance of materials and equipment for wastewater treatment plant to the referenced publications or as specified Verify manufacturers regularly engaged in the manufacture of such products.

2.1 GENERAL SPECIFICATIONS

Two (2) trains shall be provided with a total of the following minimum criteria:

Minimum Equalization Chamber Volume:	36,000 L (9,500 gal)
Minimum Sludge Holding Chamber Volume:	12,000 L (3,200 gal)
Minimum Aeration Chamber Volume:	203,000 L (75,000 gal)
Minimum Clarifier Surface Area:	3.2 sq.m (34 sq.ft)
Minimum Clarifier Weir Length:	0.36 m (1.18 ft)

2.2 MATERIALS OF CONSTRUCTION

All tank vessels will be fabricated of 7 mm structural grade ASTM A 36/A 36M steel plate joined by arc welding with fillets of adequate section for the joint involved. All walls will be continuous and watertight and will be supported by structural reinforcing members where required. Connections will conform to the requirements of the American Welding Society's Code and will develop the full strength of the member. All piping within the plant will be Schedule 40 steel pipe except as may be noted otherwise in other sections of the specification or called for on the plans.

2.3 INLET BAR SCREEN

A bar screen will be provided at the influent port to remove any unusually large solids from the incoming raw sewage. The bar screen will be fabricated from 13 mm diameter bars spaced 25 mm apart and arranged as shown on the drawings. The bars shall be sloped to permit easy cleaning of accumulating debris. A deck will be furnished for drying this debris. The bar screen shall have the same protective coating as specified for the plant.

2.4 FLOW EQUALIZATION CHAMBER

A flow equalization chamber will be supplied with a volume designed to handle 25% to 42% of the daily design flow.

Flow control will be accomplished by pumping the plant influent to a flow control box containing an adjustable overflow broad weir and a v-notch discharge weir. The overflow broad weir will be adjustable so that a measured amount of pumped influent will discharge throughout the v-notch weir to the aeration chamber, while recycling the remaining pumped influent back to the equalization chamber.

A duplex set of equalization pumps will be furnished and installed within each chamber. Each pump will be rated at 1.0 hp 380/220 V; 3 phase; 4 wire; 50 Hz. An emergency overflow will be provided between the equalization and aeration chamber

A blower/motor unit mounted in a fiberglass housing will be supplied to meet the air requirements of the equalization chamber. Each blower unit will be capable of delivering 20 CFM when operating at 4 psi. The motor will be 1 HP, ODP type for operating on 380/220 V; 3 phase; 4 wire; 50 Hz service. Liquid level sensors will regulate the pumps and blower/motor unit. Controls will be provided in the plant control panel.

2.5 SLUDGE HOLDING CHAMBER

The chamber will be of the aerated type. Diffuser air will be supplied by the plant blower system supplying 1.06 CFM of air per cubic meter of volume. The diffusers will be located parallel to and near the bottom of the tank. All piping and valves within the chamber will be factory installed. A fixed supernatant decant pipe will be provided within this

chamber. Air-lift type of sludge removal will not be approved for removal of primary sludges in accordance with 10 State Standards Section 73.24.

2.6 AERATION CHAMBER

The aeration chamber will be sufficient capacity to provide a minimum of 24 hours retention of the average daily flow, and/or maximum loading of 6.8 kg BOD5 per 28.32 cubic meters of aeration tank volume. To insure maximum retention, enhance spiral rotation and eliminate short-circuiting of raw sewage, the aeration chamber will be constructed with fillets top and bottom, air diffusers will be placed longitudinally along one side of the chamber, and flow control baffles will be provided. To insure adequate circulation velocity, the proportion of chamber width to depth, in the direction of rotation will be sufficient to scour the chamber bottom and prevent sludge filleting as well as to prevent the escape to the surface of miniscule air diffusion bubbles, causing their entrapment to provide maximum oxygenation efficiency. All aeration tanks should have a freeboard of not less than 460 mm., in accordance with 10 State Standards Section 92.323.

2.7 CLARIFIER CHAMBER

The clarifier chamber will be sized to provide a minimum of 4 hours retention, based upon the same design flow rates governing the aeration chamber, and will have proper baffling to prevent short circuiting and to provide maximum uniform retention.

The total settling volume will include the volume of the upper one-third of the sludge hopper. The bottom of the chamber will be formed into an inverted pyramidal hopper or hoppers. The flat bottom area of the hopper will in no case be greater than 0.093 square meters. The slope of the hopper walls will not be less than 1.7 vertical to 1.0 horizontal

Settled sludge will be returned from the clarifier sludge hopper to the aeration chamber by the positive sludge return system, consisting of one or more airlift pumps. The clarifier effluent will pass over the edge of the baffled effluent weir into the effluent trough and then out of the chamber. The effluent weir trough will be equipped with an adjustment to permit precise leveling of the serrated weir after plant installation.

2.8 SLUDGE RECIRCULATION SYSTEM

There will be installed within the clarifier chamber a positive sludge recirculation system consisting of at least two (2) 80 mm diameter airlift pumps in accordance with 10 State Standards Section 92.42. The airlift pump will have the recirculation capacity ranging from 0% to 150% of the average daily design flow. The airline supplying air to the pump will be equipped with a cock valve to vary the amount of air supplied to each pump, thus varying the capacity of the pump. The airlift pump will be firmly supported and equipped with a clean-out plug to allow for easy cleaning and maintenance. Discharge piping should be a minimum of 100 mm and designed to maintain a velocity of not less than 0.6 m/s when operating at normal sludge rates. Suitable devices for observing, sampling, and controlling return activated sludge flow for each settling tank hopper shall be provided in accordance with 10 State Standards Section 92.43.

2.9 SCUM RECIRCULATION SYSTEM

There will be installed within each clarifier chamber a positive scum and

skimming recirculation system consisting of two (2) 50 mm diameter airlift skimming device(s). Each skimming device will be a positive airlift pump type, located in a position to skim and return floating material to the aeration chamber. The airline supplying air to the skimming device will be equipped with a valve to regulate the rate of return. The scum intake will have an adjustment assembly that will enable exact positioning of the skimmer at water level.

2.10 CHLORINE DISINFECTION

Provide a chlorine contact chamber to disinfect the treated wastewater prior to discharging from the wastewater treatment plant. The chlorine contact chamber will have minimum of 15 minutes of contact time at the design peak hourly flow. Sufficient flow baffles will be supplied to ensure proper mixing of the chlorine solution with the plant effluent. The disinfection method shall be tablet style chlorination.

2.11 AIR DIFFUSION SYSTEM

An air distribution manifold constructed of rectangular hollow steel tubing with diffuser drop assemblies will be installed longitudinally on one side along the entire length of the plant.

Each diffuser drop assembly will be equipped with an air regulation and/or shut-off cock valve, a disconnecting union and a diffuser bar with air diffuser nozzles mounted thereon. The diffusers will be parallel to and near the base of the vessel sidewall and at the proper elevation providing optimum diffusion and mixing of the vessel contents.

Each air diffuser will be constructed with an integral air check diaphragm constructed of oxidation resistant material designed to handle a wide range of airflow. The oxygen transfer capacity of each diffuser will be such that an adequate supply of oxygen will be maintained in the aeration chamber to deliver 200% of the oxygen demand to meet treatment requirements of the design sewage load specified in Part 2.7 in accordance with 10 State Standards Section 92.332. Air piping headloss from blower outlet to diffuser shall not exceed 3.4 kPa (0.5 psi) at average operating conditions in accordance with 10 State Standards Section 92.332.

2.12 AERATION TANK BLOWER/MOTOR UNITS

To meet the air requirements of this wastewater treatment system, 2 positive displacement blower/motor unit(s) will be supplied. The blower/motor unit(s) shall be mounted on the plant or at a remote location as indicated on the plans. The blower/motor unit(s) will be capable of providing a minimum of 128 cubic meters of air per kg of BOD5 plant loading taking into account that the air temperature may reach 46 degrees C or higher and the pressure may be less than normal.

Each blower unit will be capable of delivering 156 CFM when operating at 27.58 kPa. The motor will be 5 HP, ODP type, for operation of 380/220 volt; 3 phase; 4 wire; 50 Hz service.

The blower/motor unit assembly will be mounted on a molded fiberglass base. The base structure will be adequately reinforced to support the blower/motor unit.

The blower/motor will be enclosed within a molded fiberglass weatherproof hood mounted to the base. The fiberglass-locking hood is designed for easy

access to service the unit.

To help reduce blower vibration and noise, the blower/motor base will be mounted on vibration dampeners.

For easy adjustment of the V-belt drive connection between the blower and motor, the motor will be mounted on an adjustable motor mounting base. The blower will be fitted with a dry type filter/silencer at the air intake. Each blower discharge will be fitted with a check valve, and a flexible rubber discharge coupling.

For purposes of determining the blower performance and/or diffuser condition, a pressure relief valve and pressure gauge will be mounted in the air manifold. The blowers shall be provided in multiple units, so arranged in such capacities as to meet the maximum air demand with the single largest unit out of service. The design shall also provide for varying the volume of air delivered in proportion to the demand of the plant. Aeration equipment shall be easily adjustable in increments and shall maintain solids suspension with these limits in accordance with 10 State Standards Section 92.332.

Air filters shall be provided in numbers, arrangements, and capacities to furnish at all times an air supply sufficiently free from dust to prevent damage to blowers and clogging of the diffuser system used in accordance with 10 State Standards Section 92.332.

2.13 CENTRAL CONTROL PANEL

A central control system installed within the weatherproof enclosure will be provided. The enclosure will be rated NEMA 4X-F Fiberglass. The electrical controls will consist of magnetic starters, program timers and switches necessary to automatically control all electrical devices and/or motors on the sewage treatment system.

M-O-A selector switches and magnetic starters in conjunction with the program timer will control the blower/motor. The program timers will have the capability to operate the treatment system when required as determined by the variation in the daily flow rate. Properly sized circuit breakers and fuses will protect all electrical equipment and circuitry. The control system will be designed to operate all duplex or standby equipment. The enclosure will be wired for 380/220 volt; 3 phase; 4 wire; 50 Hz incoming power.

2.14 SERVICE WALKWAYS

A service walkway will be provided to service the plant equipment. Grating panels will each consist of one-piece skid resistant steel plank. All grating panels will be constructed of 18 gauge, galvanized steel sheet. Each grating panel has a standard of 230 mm surface width and a 63.5 mm rib depth. Each panel will be supported to insure a safe uniform load carrying capacity of 390 kg/m2. On doublewide plants, the service walkways are shipped loose for field mounting by the field contractor.

2.15 SERVICE HANDRAILS

Service handrails will be provided for all doublewide tanks. Service handrails are supplied with mounting flanges for bolting into place. The rails and posts are fabricated from 38.1 mm diameter Schedule 40 steel pipe. Longer sections of hand railing are spliced to allow for easier

handling and installation. Steel handrails are painted with enamel paint, black or safety yellow. Due to shipping limitations, handrails are shipped loose for field mounting by the field contractor.

2.16 GUARANTEE

Vendor will guarantee for one (1) year from the date of commissioning that the vessel and all equipment components will be free from defective materials and workmanship. Vendor will furnish replacement parts for any component considered in the opinion of vendor to be defective, whether of his or other manufacturer during the guarantee period.

PART 3 EXECUTION

Installation of the packaged wastewater treatment facility will be in accordance with the manufacturers installation requirements.

3.1 GENERAL

Submit Preventative Maintenance and Inspection procedure for package lift stations. Procedures should include frequency of preventative maintenance, inspection, adjustment, lubrication, and cleaning necessary to minimize corrective maintenance and repair.

Submit Special Tools that are required for maintenance and testing of the wastewater treatment plant.

Submit Posted Instructions to be posted consisting of labels, signs, and templates of operating instructions that are required to be mounted or installed on or near the wastewater treatment plant.

3.2 TESTS

Perform Tests, including hydrostatic leak checking of piping and operation of equipment.

3.3 OPERATION AND MAINTENANCE

Submit Operation and Maintenance Manuals for wastewater treatment plant, including Equipment Description, Assembly and Installation Procedures, Adjustment and Alignment, Checkout Procedures, Procedures of Operation and Troubleshooting.

-- End of Section --