PAKISTAN

WATER AND POWER DEVELOPMENT AUTHORITY

METER STANDARDS MANUAL

WAPDA
POWER DISTRIBUTION WING
LAHORE, PAKISTAN
APRIL 1990

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Telephones Off : 213820, 211099, 69911/227
Res : 872075

Water And Power Development Authority
44-G, WAPDA HOUSE,
LAHORE

S.M.Arshad Bokhari
General Manager,
(Operation)

No. 2947-48/PA/GMO

Dated 30-4-1990

Mr. L.A. Rodrigueze
CC Plng, Engg & Opr, PTAT
LDA Plaza - Lahore

Subject: ENERGY METER MANUALS

Reference your IOM No. 11/ 90/013, dated 18.2.1990

The Energy Meter Manuals, as received from you, are hereby approved.

(S.M.Arshad Bokhari)

cc: G.M.(PE&C)WAPDA, LDA Plaza Lahore
with reference to above.

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PREFACE

If there is any piece of equipment which is more talked about by the people producing electric energy and by those using the energy, it must be the measuring instrument - THE ELECTRIC METER.

This device is most important to WAPDA as the source of fair income and to the customer as the source of fair value for payment. Whether this device enjoys a reputation as "righteous" or "condemnable" is dependent on the instrument AND the people who work with it.

Measuring instruments provide a fair value to each person based on the quality of material and workmanship. However, whatever device quality is selected, if the meter is purposely abused, installed incorrectly or suffers from lack of maintenance; the value will decrease.

To achieve an equitable value for all persons involved with this crucial device, this manual has been prepared. If it is used with dedication and consistency and its contents open to anyone who wishes to know, the repute and value of the electric meter will increase.

ACKNOWLEDGEMENTS

The contributions of the XEN M&Es from Faisalabad, Lahore and Multan are acknowledged and gratefully appreciated in the preparation and revision of this Meter Standards Manual.

I. LABORATORY

1. Testing Meters in Laboratory

Before any tests are made, all meters shall be given a thorough visual inspection. New meters should be checked for any apparent defects in material or construction. The manufacturer's seal on any new single phase or polyphase meter shall not be broken in the laboratory during initial testing. Old meters should be inspected for any evidence of tampering or deterioration that might make an electrical test unsafe.

New single phase meters will not be given a dielectric test; all other meters tested in the laboratory shall be given a dielectric test and an accuracy test. New polyphase watthour meters and new demand meters shall be given a dielectric test at 2,000 volts AC for one minute with a current limited test device. Used watthour meters and demand meters shall be given a dielectric test at 1,000 volts AC for one minute. The test voltage shall be applied (1) between the assembly of current-voltage windings, which in normal service are connected together and the frame, with the cover and terminal cover removed; (2) between the current and voltage circuits connected together with the frame. The test shall be carried out with the cover and terminal cover in place.

The test voltage shall be substantially sinusoidal, having a frequency between 45 Hz and 65 Hz. The power source shall be capable of supplying at least 500 VA.

After the dielectric test is completed, an 'as found' accuracy test shall be made before making any adjustments. The testing procedures and allowable limits of error for watthour meters, and demand meters are stated later in the article on Service Testing.

All test results (as found and as left) shall be recorded on the meter test card in addition to other data pertaining to the meter, such as register ratio, meter type and disk constant. (See the Records Section of this Manual).

2. Repairing Meters

Before starting to repair a meter, a thorough inspection should be made to determine the repair parts needed. If the estimated cost of the repairs including labor exceeds 50% of the cost of the meter, the meter should not be repaired but retired and usable parts salvaged.

No repair parts shall be purchased for obsolete types of meters. When possible, meters should be repaired with parts salvaged from retired meters.

3. Testing Watthour Standards

Each watthour standard used for either laboratory or field service testing shall be tested and inspected at intervals not greater than 180 days (6 months). If field test standards are exposed to severe and rough transport during this period, they should be tested more often. Any evidence of damage to a standard should be immediately checked to determine if accuracy has been impaired.

No meter test standard should be used that has not been tested within the above period.

Corrections for all watthour standards, whether they be the induction rotation types or the solid state type, should be determined for each test point at which the standard may be used and at the voltage at which they may be used.

Watthour standards should be adjusted to as close to 100% accuracy as practical and should not have correction greater than +/- 0.3% at any test point.

When watthour standards are tested, the accompanying tests leads should be carefully inspected and maintained in good condition. For rotating type standards special attention must be given to the potential switch. Switch contact resistance should not exceed 0.3 ohms, since the resistance in the switch will slow the standard, especially on the 50% power factor tests.

4. Testing Watthour Field Standards

Annually, WAPDA will use the AEB Reference Standard to calibrate all field Standards. The five test points shall be:

1. Two times full load	-	400% basic current at unity and 0.5 power factor.
2. Full Load	-	200% basic current at unity and 0.5 power factor.
3. Half Load	-	100% basic current at unity and 0.5 power factor.
4. Light Load	-	5% basic current at unity power factor.
5. Starting Current	-	0.5% basic current at unity power factor.

The accuracy of each standard, after corrections have been applied, shall be within +/- 0.1% at all 5 points.

The purpose of these field standard calibrations is to check the accuracy of the field standards against the AEB reference standard. The traceability of each AEB's reference standard must be maintained with some international standard.

5. Auxiliary Resistor for Determining 50% Lagging Power Factor on Electromechanical Rotating Watthour Standards

Each induction type rotating watthour standard used for polyphase meter testing should come with a resistor for determining that the test is being made at 50% lagging power factor. (This does not apply to electronic watthour standards).

A fixed ceramic resistor of 2,000 ohms, rated 25 watts, is satisfactory for this purpose. Depending on the specific test connections, if the test current for a watthour meter is taken from a phase of a three phase supply other than the phase from which the potential is supplied to the meter under test, a 50% power factor condition will be obtained which will be a leading or lagging power factor. For lagging power factor, if the 2,000 ohm resistor were connected in series with the potential coil of the rotating standard, the standard will either slow, stop or reverse. For leading power factor with the 2,000 ohm resistor and potential coil in series, the rotating standard would speed up.

For laboratory testing, where a phase shifter or a predetermined marked supply of voltage is used, it is not necessary to make the identifying test.

6. Testing Phantom Load Devices

Portable phantom load devices used for field testing meters should be tested and inspected at intervals not greater than 180 days and more often if subject to rough transport and severe field conditions.

The device shall be tested with the leads with which it is used. The load circuit impedance should be approximately the value of impedance of the metering circuits to be tested. The input voltage to the phantom loading device should be very near the rated input so that the output current values will be within 5% of the marked values.

Under ideal conditions of loading the input voltage of the phantom loading device and the output current are very nearly in phase. Due to the inductance of the meter current coils, particularly in 2 1/2 ampere rated multi-stator meters, certain conditions of load may give load power factors widely different from the expected value. The best way around this situation is to test the meters separately. In meters of higher current rating the impedance effect is negligible.

Permanently installed watthour meter test boards should be checked every six months for current output and potential circuit resistance and for phase angle.

7. Testing Instrument Transformers

The dielectric, accuracy and polarity tests shall be made on each new instrument transformer before it is placed in service. Instrument transformers returned from service shall be dielectric and accuracy tested before being reinstalled.

8. Dielectric Test - 50 Hertz

High Voltage Winding to Low Voltage Winding and Core

The test voltage for the primary winding of current, potential and auxiliary transformers for use on secondary voltages of 600 volts or less shall be 2,000 volts AC.

The test voltage for the primary winding of current potential and auxiliary transformers for use on secondary voltages of 600 volts or less shall be 3000 volts AC.

The test voltage for the primary winding of current and potential transformers rated 600 volts to 11,000 volts, inclusive, shall be as follows:

kV Rating	New	Used
0.6	3.0 kV	3.0 kV
12.0	34.0 kV	15.0 kV
36.0	70.0 kV	35.0 kV

The used test values given above are lower than the present required initial factory tests in order not to overstress the transformer.

The primary winding test voltage for current and potential transformers above 12 kV should, in general, be two times the rated voltage.

Secondary Winding to Core and Base

The secondary dielectric test voltage for current and potential transformers shall 3,000 volts AC.

Duration of Test. The full test voltage shall be applied continuously for one minute.

Method of Controlling Test Voltage. The method of controlling the test voltage shall be of such a nature that the test may be started at a voltage not exceeding the normal voltage of the circuit for which the transformer is designed and raised gradually and smoothly until the proper test voltage is obtained. The length of time required to bring the test voltage up to its proper value should not be less than 15 seconds nor more than one minute. At the conclusion of the test, the voltage should be reduced gradually and the test circuit opened.

Points of Application of Test Voltage. The test voltage should be applied successfully between each electric circuit and all other circuits and metal parts grounded. For proper dielectric test connections see the diagram "connections for making dielectric tests instrument transformers" at the end of this section.

9. Accuracy Test - Instrument Transformers

The accuracy test for ratio and phase angle on instrument transformers shall be made with an instrument transformer test set.

Current transformers with less than 400 ampere turns shall be tested at 100% rated current first and then at 10% rated current.

10. Current Transformer Phase Angle

Definition

The phase angle of a current transformer is the angle between the current leaving the identified secondary terminal and the current entering the identified primary terminal.

Sign Convention

Phase angle of a current transformer is considered positive when the secondary current leads the primary current.

11. Potential Transformer Phase Angle

Definition

The phase angle of a potential transformer is the angle between the secondary voltage from the identified to the unidentified terminal and the corresponding primary voltage.

Sign Convention

Phase angle of a potential transformer is considered positive when the secondary voltage leads the primary voltage.

12. Present and Old Sign Convention for Phase Angle

Some time between 1940 and 1950 the sign that applies to phase angle (±) of a potential transformer was changed.

Special attention is called to the sign of the phase angle of certified calibration data used with standard instrument potential transformers to be sure which convention is followed in the signs given in the correction data and that no arbitrary changes have been made. The same applies to test sets. In each case it is necessary to have a clear knowledge of the basis of assigring the sign to the phase angle in view of the possibility of changes in signs in all cases when recording data or making reports, that is, leading angles should be considered positive.

Anyone requiring additional data on the application of phase angle and ratio errors should use the latest editions of the Handbook for Electricity Metering or ANSI C12.1 - Code for Electricity Metering.

Definition of Ratio Error

A positive ratio error on either current or potential transformers will decrease the readings of a wattmeter or watthour meter on any load regardless of power factor.

13. Limits of Error for Current Transformers

Current transformers shall be tested at 100% and 10% of rated primary current at the maximum burden specified for the accuracy class of the transformer. Used transformers (rated for 600 volts) having more than one accuracy class or burden designation, may be tested only for the 0.5% at a burden of 10.0 VA. The current error and phase displacement at 50 Hz shall not exceed the following values when the secondary burden is any value from 25% to 100% of rated burden.

0.5 Accuracy Class

Percent Current Error at Percentage of Rated Current				Phase Displacement at Percentage of Rated Rated Current.							
				Minutes				Centiradians			
10	20	100	120	10	20	100	120	10	20	100	120
1.0	0.75	0.5	0.5	60	45	30	30	1.8	1.35	0.9	0.9

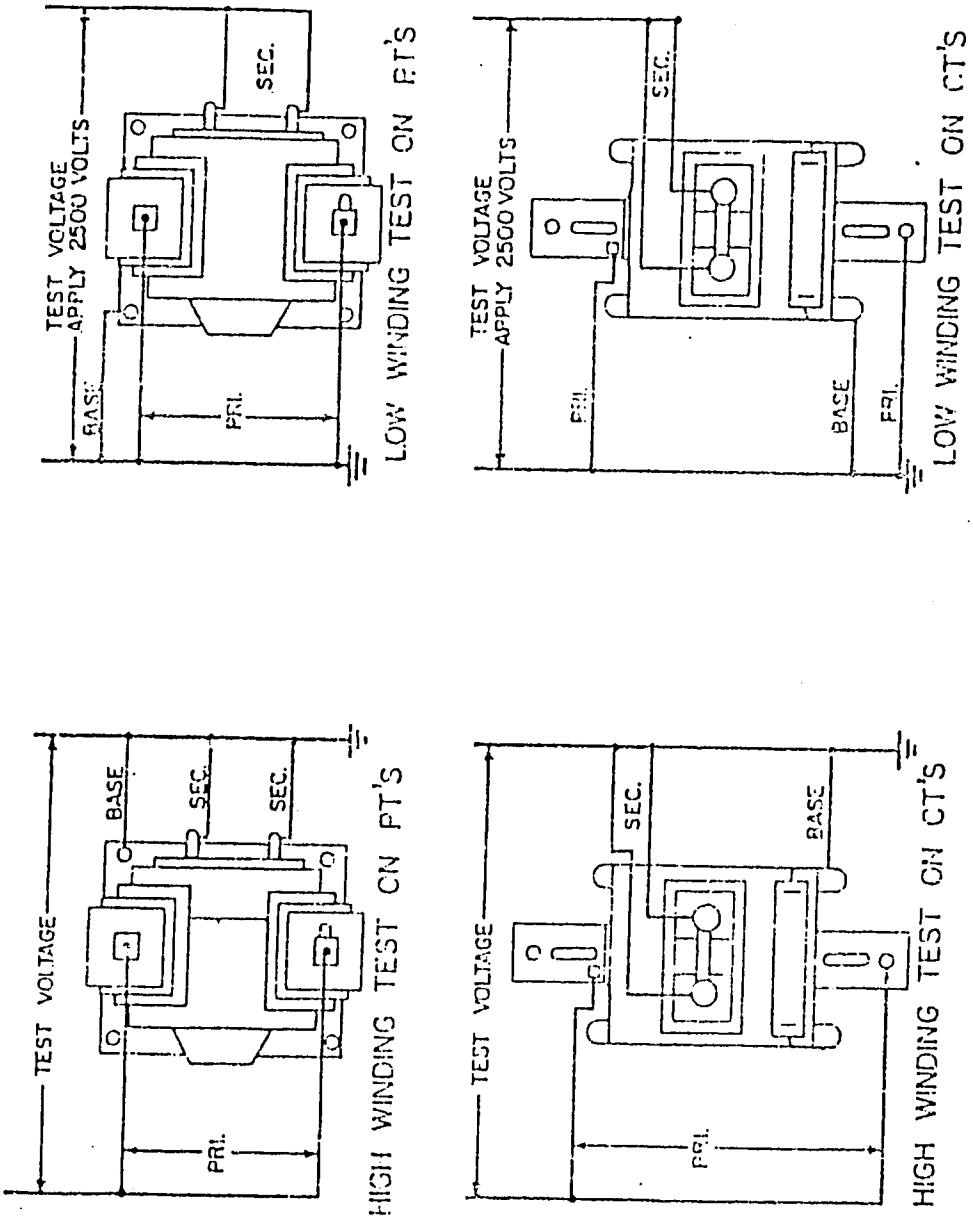
14. Limits of Error for Potential Transformers

Potential transformers shall be tested at zero burden and at the maximum specified burden for the rated accuracy class of the transformer. Used transformers having more than one accuracy class or burden designation shall in general, be tested only for the 0.5% accuracy class at 75 VA, .85 power factor burden. Transformers not meeting the 0.5% accuracy class specifications shall not be used for billing metering.

The voltage error and phase displacement at rated frequency shall not exceed the values given below at any voltage between 80% and 120% of rated voltage and with burdens of between 25% and 100% of rated burden, at a power factor of 0.8 lagging.

The errors shall be determined at the terminals of the transformer and shall include the effects of any fuses or resistors supplied as an integral part of the transformer.

Percentage Ratio Error	Phase Displacement	
	Minutes	Centiradians
0.5	20	0.6



CONNECTIONS FOR MAKING DIELECTRIC TEST ON INSTRUMENT TRANSFORMERS.

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II. RECORDS

1. Manual Record System

The means of accounting for WAPDA's meters is through a manual record system. This system is used to produce and maintain meter history records and to prepare various reports and summaries that are required.

The identifying chain of each meter in the meter records system consists of the following :

1. The AEB Sub Division Code
2. Manufacturer's Serial Number
3. Manufacturer's Code
4. Six Digit Meter Code

The AEB code consists of 2 digits as follows :

1. 01 Faisalabad
2. 02 Gujranwala
3. 03 Hyderabad
4. 04 Islamabad
5. 05 Lahore
6. 06 Multan
7. 07 Peshawar
8. 08 Quetta

The manufacturer's serial number is assigned by the manufacturer and appears on the meter name plate.

The manufacturer code is a two digit code. A list of the manufacturers code is listed below:

01	General Electric	12	China National Machinery
02	Westinghouse	13	Isotimpex
03	Landis & Gyr	14	Enertec
04	AEG	15	Toyoda
05	Siemens	16	Power
06	GEC		
07	Ferranti		
08	Mitsubishi		
09	Syed Bhais		
10	Climax		
11	Escorts		

Each meter is badged with a six digit meter code which identifies the meter in terms of its function (digits 1 and 2) its base, volts, phase, wire, Amps (digits 3,4,5 and 6). A partial list of the six digit meter code is as follows :

Function (Digits 1 and 2)

00 - Self contained watt hour meter - surge proof.
01 - Self contained watt hour meter - nonsurge proof
02 - Transformer rated watt hour meter with secondary rated meter.
03 - Transformer rated watt hour meter with secondary rated register.
04 - Transformer rated watt hour meter with secondary rated register, and single range mechanical demand register - 30 min.
05 - Transformer rated watt hour meter, with varhour meter, secondary rated register and single range mechanical demand register - 30 minute.

Base, volts, phase, wire, Amps. (Digits 3, 4, 5 and 6)

DIGIT # 3 BASE	DIGIT # 4 VOLTS, PHASE, WIRE	DIGITS # 5 & 6 AMPERES
0 - "A Base	0 - 230V, 1Ø, 2W	00 - 5/10 Amp
1 - Socket	1 - 400V, 3Ø, 3W	01 - 10/30 Amp
2 - Switchboard	2 - 230/400V, 3Ø, 4W	02 - 10/40 Amp
		03 - 15/40 Amp
		04 - 15/90 Amp
		05 - 15/120 Amp
		06 - 20/80 Amp
		07 - 15 Amp
		08 - 40 Amp
		09 - 50 Amp
		10 - 60 Amp
		11 - 80 Amp
		12 - 100 Amp

All the above codes will be expanded as new and different types of meters are purchased.

2. Forms

There are four forms used in the Manual Meter Record System to produce and maintain the meter history record. Samples of these documents will be found at the end of this Section.

A. Meter History Card

The key entries to be made on the meter history card are as follows :

1. Six digit meter code
2. Manufacturer's serial number
3. Manufacturer's name
4. Manufacturer's type
5. Ampere rating
6. Voltage rating
7. Wire, phase, frequency
8. Dial constant
9. Watthour constant
10. Register Ratio
11. Date received
12. Purchase order number
13. Invoice price
14. Date installed
15. Reading when installed
16. Billing constant
17. Name and address of the customer
18. Reading when removed
19. Date removed
20. CT and PT ratio

The meter history card is completed when new meters are received from the supplier. The meter history card travels with the meter and is filed in the division office of the division where the meter is installed. Whenever the meter is removed for test or transfer to another location the meter history card is transferred with the meter. The division office maintains two files of meter history cards for rapid reference. One file contains meter history cards for meters in stock. This file may be sub-divided into two sections; meters tested and meters untested. Another file of meter history cards is maintained for meters in service. The meter history card will be used for establishing a sample meter test program.

B. Symbol Sheet

The symbol sheet is completed at the same time the meter history card is complete. The symbol sheets are numbered consecutively and filed in loose leaf note books which are maintained in the AEB M&T meter laboratory. The key entries on the symbol sheet are:

1. Manufacturer's name
2. Ampere rating
3. Voltage rating
4. Wire, phase, element
5. Manufacturer's serial number
6. Meter type
7. Date received
8. Meter cost.

The symbol sheet is used to account for meters that are retired, lost, stolen or reinstated and provides a useful tool for meter inventory. Whenever a meter is retired, lost, stolen, reinstated or unaccounted for for any reason, the date and manner of disposition are entered. The symbol sheet will be used to establish a sample test program.

C. Meter Test Card

A meter test card is completed for every kwH, kvarH and kw meter tested and kept on file for reference. It contains the information needed to calculate statistical quantities such as Bar X and Sigma, and provides the history record of the meter's accuracy. The meter test card is also useful to gather statistics on defective meters, stopped meters, meters that creep and for comparing a present meter test record with a previous meter test record. It can be used for supporting information when customer complaints are received, for determining the useful life of types of meters, for establishing a sample meter test program, for developing special reports and summaries, for determining energy diversion, and for recommending the types of meters to be purchased on the next order.

The key elements of the meter test card are as follows :

1. Manufacturer's serial number
2. Manufacturer's name
3. Meter type
4. KH (watthours per revolution)
5. Register ratio
6. AEB, Division, Area
7. Test Description
8. KwH as found accuracy (FL, LAG, LL)
9. KwH as left accuracy (FL, LAG, LL)
10. Kw as found upscale accuracy
11. Kw as left upscale accuracy
12. Kw as found zero reading
13. Kw as left zero reading
14. Kw as found timing accuracy
15. Kw as left timing accuracy
16. Demand interval
17. Full scale demand value
18. Kw reading as found
19. Kw reading as left
20. Test date
21. Defect code
22. Retired
23. Tester initials
24. Stopped
25. Creep
26. Seal as found
27. Seal as left
28. KwH reading as found
29. KwH reading as left
30. Average accuracy
31. As found balance test
32. As left balance test
33. Remarks.

DEFECT CODE	TEST DESCRIPTION
1. External Damage	1. Shop New
2. Foreign Matter in Meter	2. Shop Sample
3. Bearings	3. Shop Periodic
4. Pointer Friction	4. Shop Non periodic
5. Register	5. Field Installation
6. Weak Magnet	6. Field Sample
7. Current Element	7. Field Periodic
8. Potential Element	8. All other
9. Demand Rotor	
10. All Other	

D. Meter Transfer Record

The meter transfer record is used to account for the location of each meter when it is transferred from division to division. The division who is sending meters to another division completes the meter transfer record and files the original in the originating office and sends a copy to the division where the meters are being transferred. This is a useful record for keeping track of inventory.

The key entries of the meter transfer record are as follows :

1. Date
2. Manufacturer's serial number
3. From (AEB, Division, Area)
4. To (AEB, Division, Area)

SAMPLE

WAPDA
Meter Standards
Meter History Card

1 2 3 4 5 6 7 8 9 10 11 12

FORM 74 11-84

METER HISTORY CARD

EE.31

CARD NO._____ TEST CLASS_____

TOTAL INST'D COST_____

OUR NUMBER	M'F'R'S NUMBER	MAKE	TYPE	FORM	DISCARDED

AMPERES	VOLTS	WIRE	PHASE	CYCLES	DIAL K	DISK K	REV. PER CONT.	REG. RATIO	GEAR RATIO

DATE REC'D	P. O. NO.	INV. PRICE	EQUIPMENT COST	STORES EXP.	TEST COST	INST'N COST

DATE IN	AUTH.	READING	BILL-K	NAME	ADDRESS	READING	AUTH.	DATE
RATIO	C.T. .1	P.T. .1		TOWN	LOCATION BUSINESS			DISCONNECT REMOVED
RATIO	C.T. .1	P.T. .1		TOWN	LOCATION BUSINESS			DISCONNECT REMOVED
RATIO	C.T. .1	P.T. .1		TOWN	LOCATION BUSINESS			DISCONNECT REMOVED
RATIO	C.T. .1	P.T. .1		TOWN	LOCATION BUSINESS			DISCONNECT REMOVED
RATIO	C.T. .1	P.T. .1		TOWN	LOCATION BUSINESS			DISCONNECT REMOVED
RATIO	C.T. .1	P.T. .1		TOWN	LOCATION BUSINESS			DISCONNECT REMOVED
RATIO	C.T. .1	P.T. .1		TOWN	LOCATION BUSINESS			DISCONNECT REMOVED
RATIO	C.T. .1	P.T. .1		TOWN	LOCATION BUSINESS			DISCONNECT REMOVED
RATIO	C.T. .1	P.T. .1		TOWN	LOCATION BUSINESS			DISCONNECT REMOVED

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SAMPLE

WAPDA
Meter Standards
Sample
Meter Test Card

	TRAN 42		OFF	TYPE	VMGGA
	PH 2.4		RR 33 1/3		
CO-DV-AREA 5510	SER.#			T.D. 4	

	AF ACC.	AL ACC		AF ACC.	AL ACC.
SERIES FULL LOAD	100.0	99.3	DEM. UPSCALE	101.0	LAF
SERIES LAG LOAD	100	99.4	DEPC	E	LAF
SERIES LIGHT LOAD	100.1	99.5	TIMING	100.0	LAF

DEMAND INTERVAL 15 FULL SCALE DEMAND 4KW
KW READING AS FOUND KW READING AS LEFT
DATE 07-07-88 DEFECT REL. TESTER JWS
STOPPED CREEP STD # L-11 SEAL AF OK
SEAL AL OPEN KWH READING AF 0001
KWH READING AL 0001 AVERAGE ACCURACY 100.1
AF BAL TEST OK AL BAL. TEST OK
REMARKS REPLACED PCT. LIGHT ON 240 PICS

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WAPDA Meter Standards

SYMBOL SHEET

MAKE_____ AMP._____ VOLTS_____ WIRE_____ PHASE_____ ELEMENT_____

COMPANY NUMBER	MANUFACTURERS SERIAL NUMBER	TYPE	DATE RECEIVED	MATERIAL VALUE		DISPOSITION		
						DATE	MANNER	ORDER NO.

OBSERVATIONS

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FORM 11.110

PAGE ___ OF ___

METER TRANSFER RECORD

COMPANY _____

FROM _____

TO _____ DATE _____

	DATE MO. (1–2)	DAY (3–4)	YR. (5–6)	TRAN CODE (13–14)	METER CODE NUMBER (40–44)	TO: Tax District No. (45–50)	MANUFACTURER'S S/N OR INTERIM CO. S/N (55–62)	FROM: Co. Div. Area (66–69)	TO: Co. Div. Area (77–80)
1				3 7					
2				3 7					
3				3 7					
4				3 7					
5				3 7					
6				3 7					
7				3 7					
8				3 7					
9				3 7					
10				3 7					
11				3 7					
12				3 7					
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34				3 7					
35				3 7					

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III INSTALLATION

1. General Procedure for Meter Installation

WAPDA meter installations should be in conformance with the following objectives:

1. The meter should be installed outdoors on the customer's building.

2. The meter location should present the minimum hazards to physical damage and electrical shock.

3. The meter location should be readily accessible for reading, security, and servicing.

4. The meter location should present the best appearance possible.

5. The meter installation should be properly secured to prevent tampering.

All meters should be securely fastened to their mounting in a true plumb position. They should be installed so that no wiring is left exposed. Care should be taken to see that the connections are clean and tight to avoid heating and arcing. Where meter connections are made with aluminum conductor, the conductor should be treated with aluminum electrical joint compound (such as Penetrox 'A') before being clamped in the terminal facilities.

Before installing a meter the installer shall insure that the meter is the correct type for the load and that security box (if required) is proper for the type of service. If the meter or security box is inadequate, the installation should be completed and the condition reported to the supervisor.

After installation of the meter, a thorough inspection shall be made to insure the meter is wired properly, no hazards are present to either the meter reader or tester, and the meter is located in an environment free from abnormal deterioration effects. The customer's service entrance equipment shall be checked to insure its installation is in accordance with WAPDA standards and the meter and security box are properly grounded. Any condition found that would prohibit or make the installation undesirable must be reported to the Meter Supervisor. Before leaving the customer's premises, the installer shall determine that the customer has service and that the meter runs in the correct direction. All data pertaining to the meter shall be carefully recorded on the service order. Extreme care must be taken to accurately record the billing constant and the meter register multiplier. If the meter is mounted in a security box (type A or B), the installer shall check that the box is locked and the installation is secure.

2. Current Rating Limit

The current rating of single phase meters is 40 amperes. Self contained polyphase AC meters shall be limited to a maximum ampere rating of 90 amperes. Loads of up to 90 amperes can be metered with modern self-contained bottom connected meters. Current transformers shall be used on all loads that are of such size that cannot be metered with a self-contained meter. Loads that are under 90 amperes may also be metered using current transformers if the load is expected to increase above this value.

3. Voltage Rating Limit

Self-contained meters shall be limited to amaximum rating of 240 volts. This rating shall reduce the likelihood of severe personal injury and/or property damage in the event of accident during meter installation, testing and maintenance. For installation of 3 phase, 4 wire service, extreme care must be taken to assure proper connection since 400 volts potential exists between phases. Instrument transformers shall be used for meter potentials at any voltage above 240 volts.

Single phase Meter - 2 wire

Single phase service of 2 wires (one phase and neutral) shall be metered with a single stator, 240 volt meter.

Three phase Service - 4 Wire

Three stator meters of the correct current range and 240 volt rated shall be used on three phase, four wire services where phase loads are not balanced to the extent of 1% or less. If the service is confined to fixed balanced loads not exceeding 1%, a two stator, four wire meter should be used.

4. Watthour Meters in CT Circuit

Watthour meters shall have dedicated current transformers. No other devices shall be connected to the metering current transformers.

5. Installation of Self-Contained Meters

Before any meter is placed in service, the installation and the meter must be inspected for proper conditions. The potential link in the meter must be closed. To be properly installed the source wiring must be connected correctly, undamaged, and meter, and security box, if required, solidly grounded. If any of the preceding conditions are not satisfied, correction must be made before customer load is connected. Record all meter name plate information, and customer account number. Check and record the voltage.

After the installer has confirmed proper installation, source connection, voltage checks and meter adequacy, the customer load switch must be placed in the 'off' position. The identity of the customer's phase and neutral wires must be marked or made known to the installer. Using

leather gloves, the installer will then connect load wires to the meter terminals in the manner prescribed by the standards. Notice to the customer must be given that electric service is available and meter operating checks performed.

Polyphase self contained meters shall be installed ahead of the service entrance switch. All wire and live parts shall be completely enclosed and secured. The bases of bottom connected meters will be grounded.

Arrangements should always be made with the customers as far in advance as possible, to provide space and mounting facilities for meters.

6. Installation of Meters with Instrument Transformers

Where meters are installed outdoors, they shall be installed in weatherproof outdoor meter enclosures or cabinets. Suggested arrangements are shown by drawings and other arrangements for different kinds of metering equipment may be used as tariffs require.

Where meters are installed indoors, they should be installed in metal meter boxes and should always be installed so as to be readily accessible.

For either indoor or outdoor installations, wire size of not less then No. 12 AWG copper shall be used for connecting meters to the instrument transformers. Conductors shall be coded as in the chart showing "Standard Color Code for Meter Wire and Cable" and may be in conduit or part of a cable from the instrument transformers to the connected terminal block or test switch. Single conductor color coded wires shall be used for wiring from the test switch to the meter.

Meters, whether installed indoors or outdoors, should be mounted as near as practicable to the instrument transformers, but not more than 15.27 m for a burden of 10.0 VA. In designing longer cable runs between meters and current transformers, care shall be taken that the burden of the cable plus the burden of the current coils of the meters shall not exceed the burden rating of the current transformers. Such longer cable runs between meters and potential transformers shall be checked for voltage drop and phase angle shift due to the impedance of the cable. In either case, if lower cable impedance is required to keep the overall meter error within 0.5%, the number of conductors per phase or conductor size shall be increased.

Always ground the base of the meters when they are fastened to electrically insulated mountings.

7. Installation of Instrument Transformers

When instrument transformers are installed outdoors, they shall be outdoor type. In the case of those rated 600 volts or below indoor types may be used if installed in weatherproof outdoor enclosures. Where instrument transformers are mounted on electrically insulating material, their cases or metallic mounting feet shall be grounded. All instrument transformer secondaries shall be grounded. Varying conditions may change the details of metering installations above 11 kV rating and each particular installation should be engineered individually.

Use of indoor-type instrument transformers for customer metering is generally restricted to circuit voltages of 11 kV or less. When such transformers are used they shall be installed in a metal enclosure.

8. General

The phase identity need not be determined in a customer's isolated installation; the numbering may be arbitrarily assumed. The 'identity' as shown by the chart "Standard Color Code for Meter Wire and Cable" applies to three phase four wire installations only. For special installations the color coding will be shown on the wiring diagrams. The wiring diagrams as shown in these standards apply to metering installations using front-connected apparatus.

9. Special Design Considerations

In an effort to reduce peak splitting by the customer, end of demand interval time pulses will not be accessible to the customer.

10. General Precautions for Installing all Meters

1. The meter must be handled very carefully.
2. It must be installed in a vertical position.
3. Meter and meter board should be securely fixed.
4. The insulation of the connecting leads should be removed only upto the extent required and the bare ends of the leads should be tightened firmly in the terminal block.
5. It must be ensured that the meter terminal cover is tight and fits without damaging the insulation of the connecting leads.

6. The meter body must be securely earthed at the earthing screw marked as such.

7. After connecting the meter in the circuit :

   (a) Check that the line and load leads are connected to the proper terminals of the meter.
   (b) Then turn on some load and see that the disc rotates in the correct direction.
   (c) Check if it creeps on no load in either direction, if so the meter is to be replaced.

   Whenever instrument transformers (current transformers and potential transformers) are used, there are more changes for errors and greater care must be exercised.

8. Current transformers with ratios selected to match the customer's load, are to be connected in series with each phase. Thimbles of proper material and capacity should be used at both ends of each lead and the same should be tightened properly with the nuts an bolts provided on both main and load side of the current transformers (primary side).

9. On the primary as well as secondary side of the current transformers the main and load terminals should be verified before connecting the same. The main side of the current transformer is marked M or K and the load side is always marked as L.

10. Each voltage coil is to be energised by the voltage of the phase in which the associated current coil is connected.

11. There must be no joint in the leads from secondary side of the current transformer to meter terminals.

12. The phase sequence at the meter terminal block should be checked by means of phase sequence indicator.

13. When any work is to be done, secondary terminals of current transformer should be short circuited before opening any part of the secondary circuit to avoid damage to the CT.

14. When the actual CT ratio used differs from the marked on the meter the multiplying factor must be prominently indicated on the meter.

15. The working of the MDI (maximum demand indicator) mechanism, if any, should be checked.

11. Special Precautions for Installing Various Types of Meters

1. Single phase meter

Check the potential link and verify that the connection is correct. This link is provided on the terminal block as shown in the drawing EW/DM-1. With the new supply of single phase meters another link is provided inside the meter in addition to and in parallel with the existing one.

2. 3-Phase, 4-Wire, 230/400 volts Meter, Drawing EW/DM-4

Check the potential links and verify that the connections are correct. The internal links have not been shown in this case.

As this is a 4-wire meter, it can be used to record the consumption of combined loads.

3. 3-Phase, 4-Wire, 230/400 Volts CT Operated Meter Without MDI

Connect the red, yellow and blue potential leads to the first three terminals from the left respectively as shown in the drawing EW/DM-5.

Connect the secondaries of the CTs of red, yellow and blue phase to the three current coils as shown.

The neutral lead should be connected to the last terminal which is the star point of the three potential coils.

Note that there are no potential links as in the case of direct meters.

This type of meter can record the consumption of combined load (3-phase and single phase load).

4. 3-phase, 4-wire, 230/400 volts CT operated kWh meter with MDI.

As this is a 4-wire meter there are three current coils and three potential coils, the connections have been shown in the drawing EW/DM-9.

Connect red, yellow and blue phase potential leads to the terminals 2, 5 and 8 respectively as shown.

The neutral is to be connected to the last terminal which is the star point of the three potential coils.

Connect the secondaries of the CTs of the red, yellow and blue phases as shown in the drawing.

This type of meter records the consumption of combined loads, (3-phase and single phase). In addition, it also indicates the maximum demand.

Turn on some appreciable load at least for one hour to check the working of the MDI mechanism.

5. 3-phase, 4-wire, 230/400 volts CT operated kWh meter with MDI and kvarh

kWh meter with MDI and kvarh meter are two independent units. These are installed side by side.

kWh meter records the energy consumption and also indicates the maximum demand, while the kvarh meter records the reactive energy. The power factor is calculated from these readings is already explained.

As this is a 3-phase, 4-wire meter, three CTs one in each phase are used to feed the three current coils of the kWh as well as kvarh meter.

Connect the secondaries of the CTs as shown in the drawing EM/DM-10. Connect the red, yellow and blue phase potential leads to the respective terminals as shown in the drawings.

The neutral is to be connected to the last terminals of both the meters

Turn on some appreciable load at least for one hour to check the working of MDI mechanism.

6. 3-phase, 4-wire, 230/400 volts CT operated
Trivector meter with kWh MDI, kVAh and kvarh

In this type of meter, all units are built in the same case with full glass cover. The kWh and MDI part records energy consumption and indicates the maximum demand. The kVAh part records the kilovolt-ampere-hours and the kvarh part registers the reactive energy.

This meter is similar to the meter discussed in paragraph 11 except that this is a 4-wire meter and three current transformers are used one in each phase to feed the current coils.

Connect the secondaries of the current transformers to the meter terminals as shown in drawing EW/DM-13. Connect red, yellow and blue potential to the first, fourth and seventh terminals from left these terminals feed the potential coils of kWh part. Similarly connect red, yellow and blue potential to the eleventh, thirteenth and fifteenth terminals from the left, these terminals feed the potential coils of kvarh part. Connect the neutral to the tenth, twelfth, fourteenth and sixteenth terminals from the left. Short circuit the two terminals on the extreme right as shown in the drawing EW/DM-13.

Turn on some appreciable load at least for one hour to check the working of all the three parts including MDI. The disc of kWh and kvarh should rotate in correct direction marked on the meter and kVAh disc will rotate in the opposite direction.

STANDARD COLOR CODE FOR METER WIRE AND CABLE

Type	Color	Identity	Meter Connections
Conductors with synthetic (PVC) insulation	Red	Phase No. 1 Cur.	Top Line Cur.
	Green	Phase No. 2 Cur.	Mid. Line Cur.
	Blue	Phase No. 3 Cur.	Bot. Line Cur.
	Yellow	Phase No. 1 Pot.	Top Line Pot.
	Brown	Phase No. 2 Pot.	Mid. Line Pot.
	White	Phase No. 3 Pot.	Bot. Line Pot.
	Black or Bare	Common & Ground Current & Potential	Common Load Cur. & Pot.
Conductors with rubber insulation and braid*	Red	Phase No. 1 Cur.	Top Line Cur.
	Green	Phase No. 2 Cur.	Mid. Line Cur.
	Blue	Phase No. 3 Cur.	Bot. Line Cur.
	Black	Comm. & Grnd. Cur.	Comm. Load Cur.
	Red-White	Phase No. 1 Pot.	Top Line Pot.
	Green-White	Phase No. 2 Pot.	Mid. Line Pot.
	Blue-White	Phase No. 3 Pot.	Bot. Line Pot.
	Black-White	Comm. & Grnd. Cur.	Comm. Load Pot.

The abbreviations used in this chart and on the wiring diagram are as follows :

Cur.	- Current	Top	- Top	GN	- Green
Pot.	- Potential	Mid.	- Middle	BL	- Blue
Comm.	- Common	Bot.	- Bottom	BK	- Black
Grnd.	- Ground	R	- Red	RW	- Red-White

W	- White	BW	- Blue-White
YL	- Yellow	BkW	- Black-White
BR	- Brown	Ba	- Bare
GW	- Green-White		

*Conductors with rubber insulation and braid should not be used for new installations. This chart is shown for reference purposes only to assist in identifying meter connections and wiring identity in existing installations.

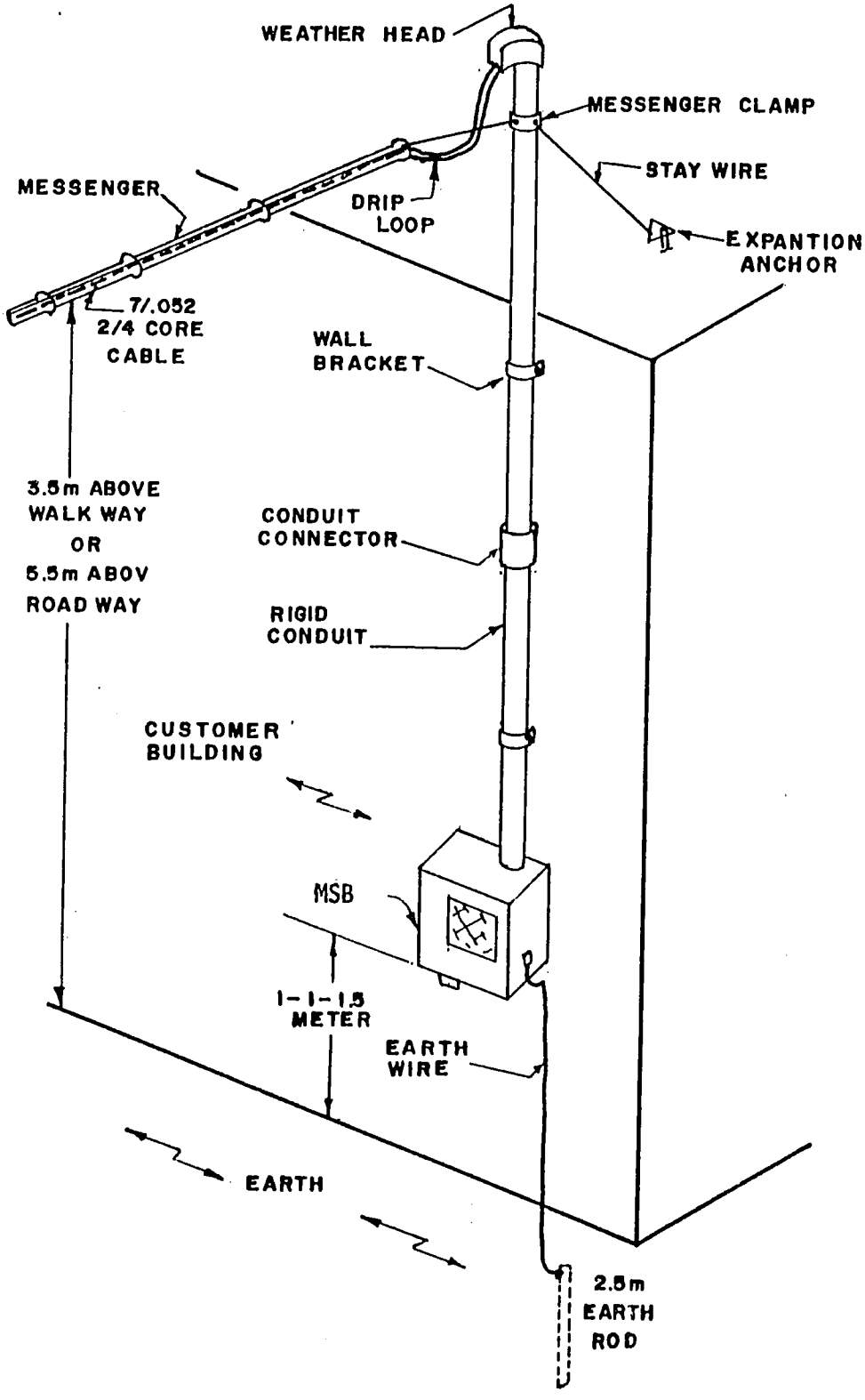
WAPDA

METER STANDARD

INSTALLATION - LOW BUILDING ENTRANCE DE-1

NOTES:

1. Cover of MSB to be sealed.
2. MSB to be painted white to reflect heat.
3. Metal of all boxes to be cleaned of paint for earth connections.
4. MSB and meter to be mounted in a vertical position.
5. Customerservice entrance box as close to meter as possible.
7. Entire length of service drop wire without splices.
8. Earth connections to be welded.



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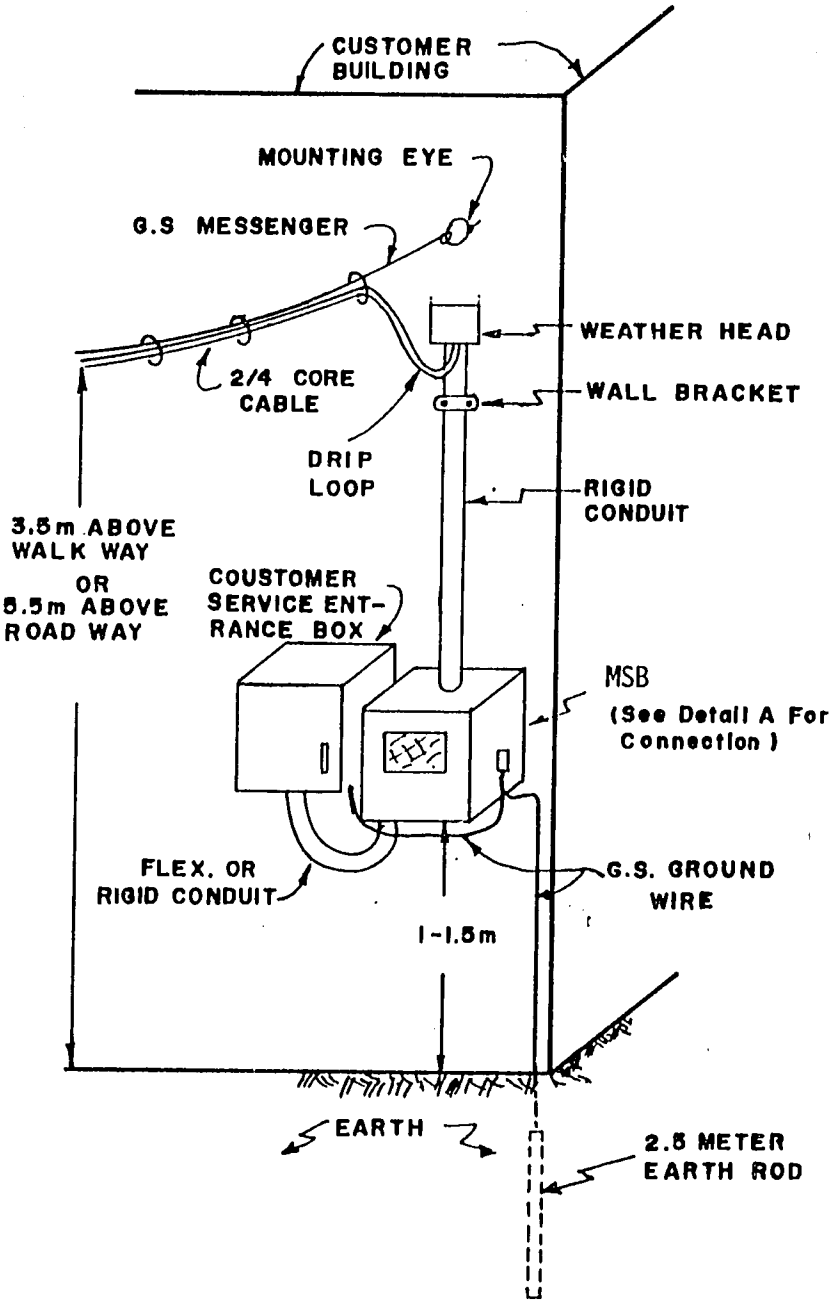
METER STADARD

INSTALLATION- HIGH BUILDING ENTRANCE DE-2

NOTES:

1. Cover of MSB to be sealed.
2. MSB to be painted white to reflect heat.
3. Metal of all boxes to be cleaned of paint for earth connections.
4. MSB and meter to be mounted in a vertical position.
5. Customer service entrance box as close to meter as possible.
6. Entire length of service drop wire clear of obstructions.
7. Entire length of service drop wire without splices.
8. Earth connections to be welded.



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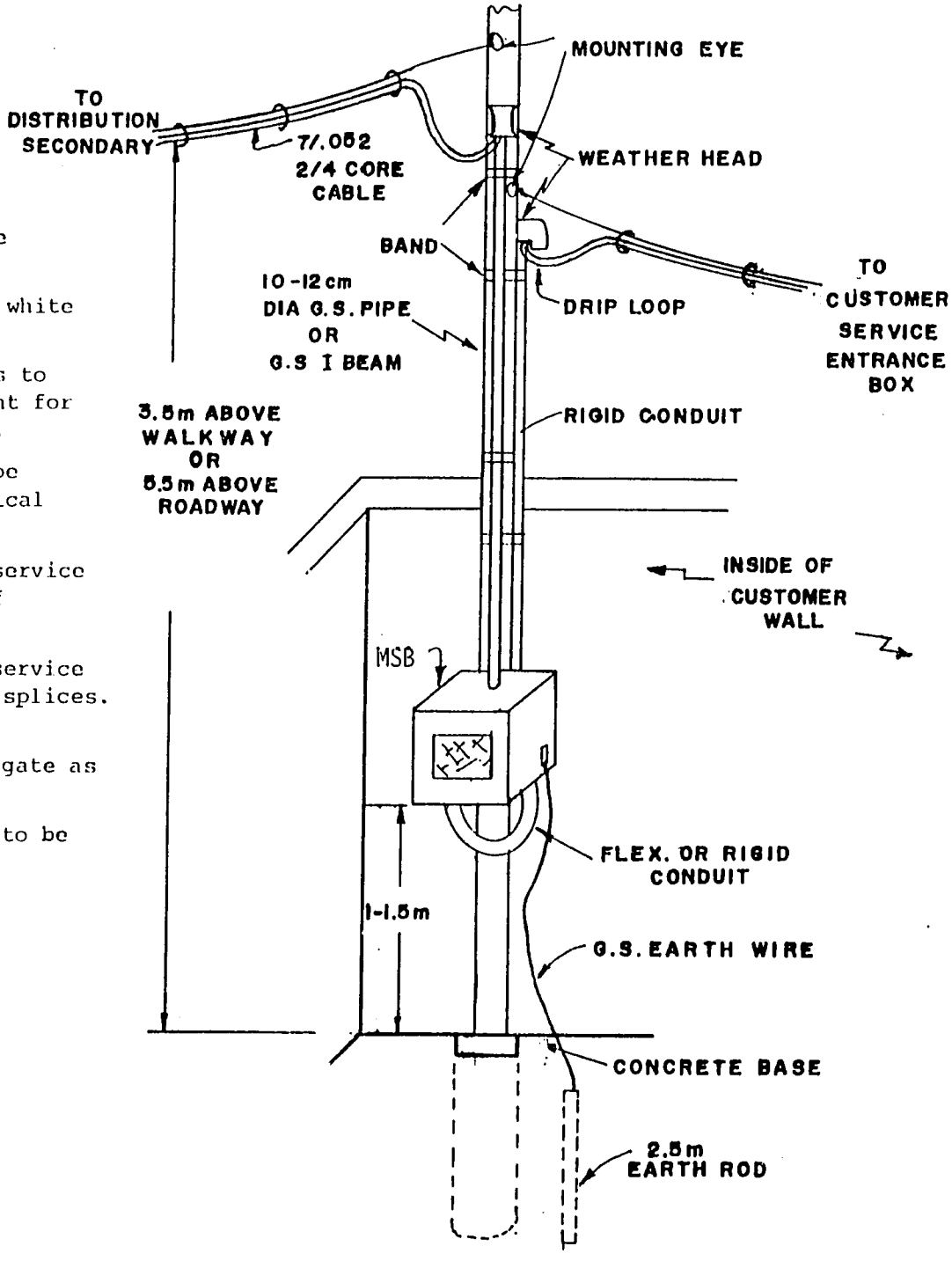
METER STANDARD

INSTALLATION - WALL SERVICE ENTRANCE DE-3

NOTES:

1. Cover of MSB to be sealed.
2. MSB to be painted white to reflect heat.
3. Metal of all boxes to be cleaned of paint for earth connections.
4. MSB and meter to be mounted in a vertical position.
5. Entire length of service drop wire clear of observations.
6. Entire length of service drop wire without splices.
7. Meter box as near customer entrance gate as possible.
8. Earth connections to be welded.



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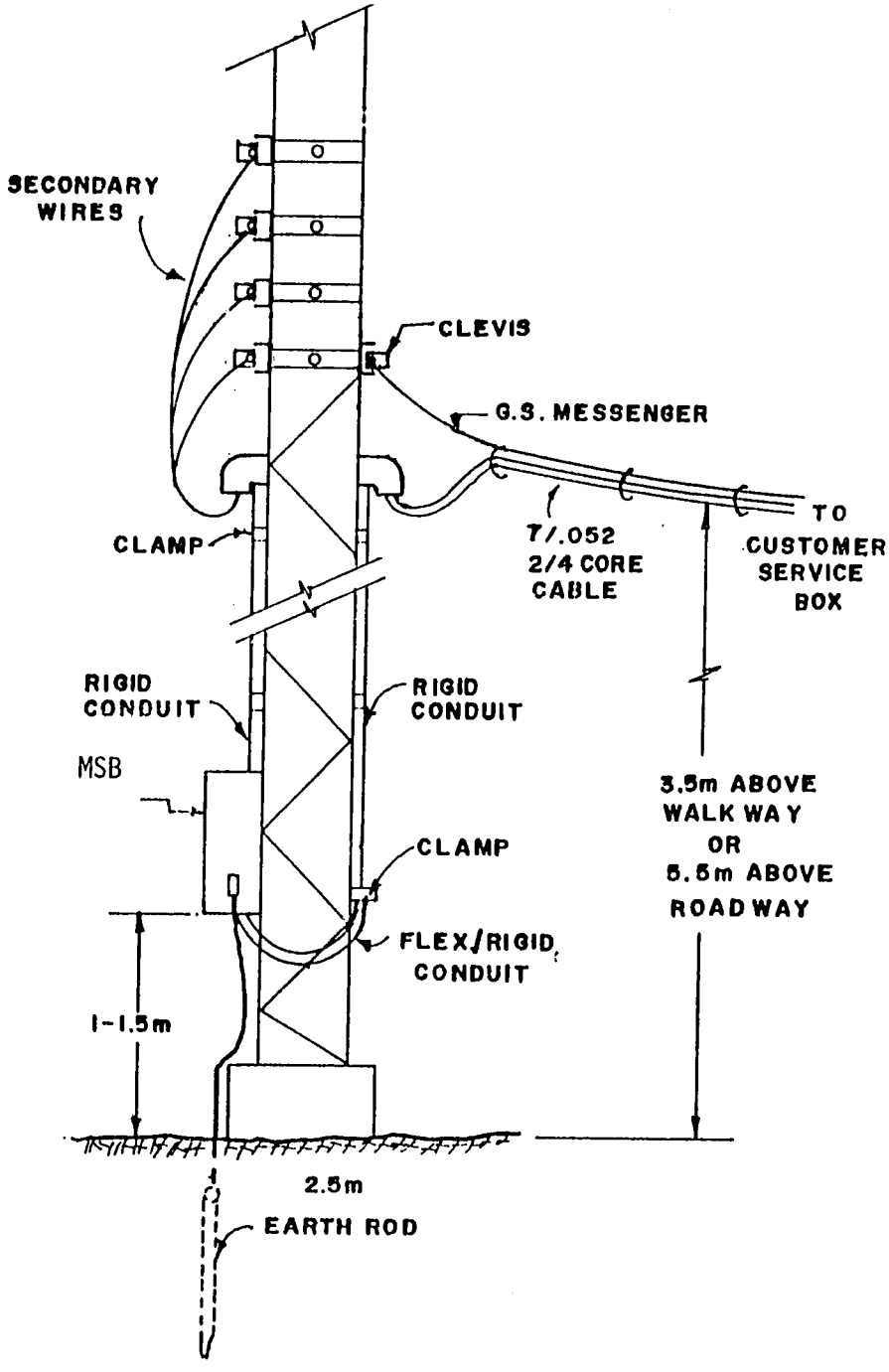
METER STANDARD

INSTALLATION - TOWER SERVICE ENTRANCE DE-4

NOTES:

1. Cover of MSB to be sealed.
2. MSB to be painted white to reflect heat.
3. Metal to be cleaned of paint for all earth connections.
4. MSB and meter to be mounted in a vertical position.
5. Entire length of service drop wire clear of obstructions.
6. Entire length of service drop wire without splices.
7. Form service drop wire - do not leave excess wire.
8. All towers with service drop to earthed.
9. Earth connections to be welded.



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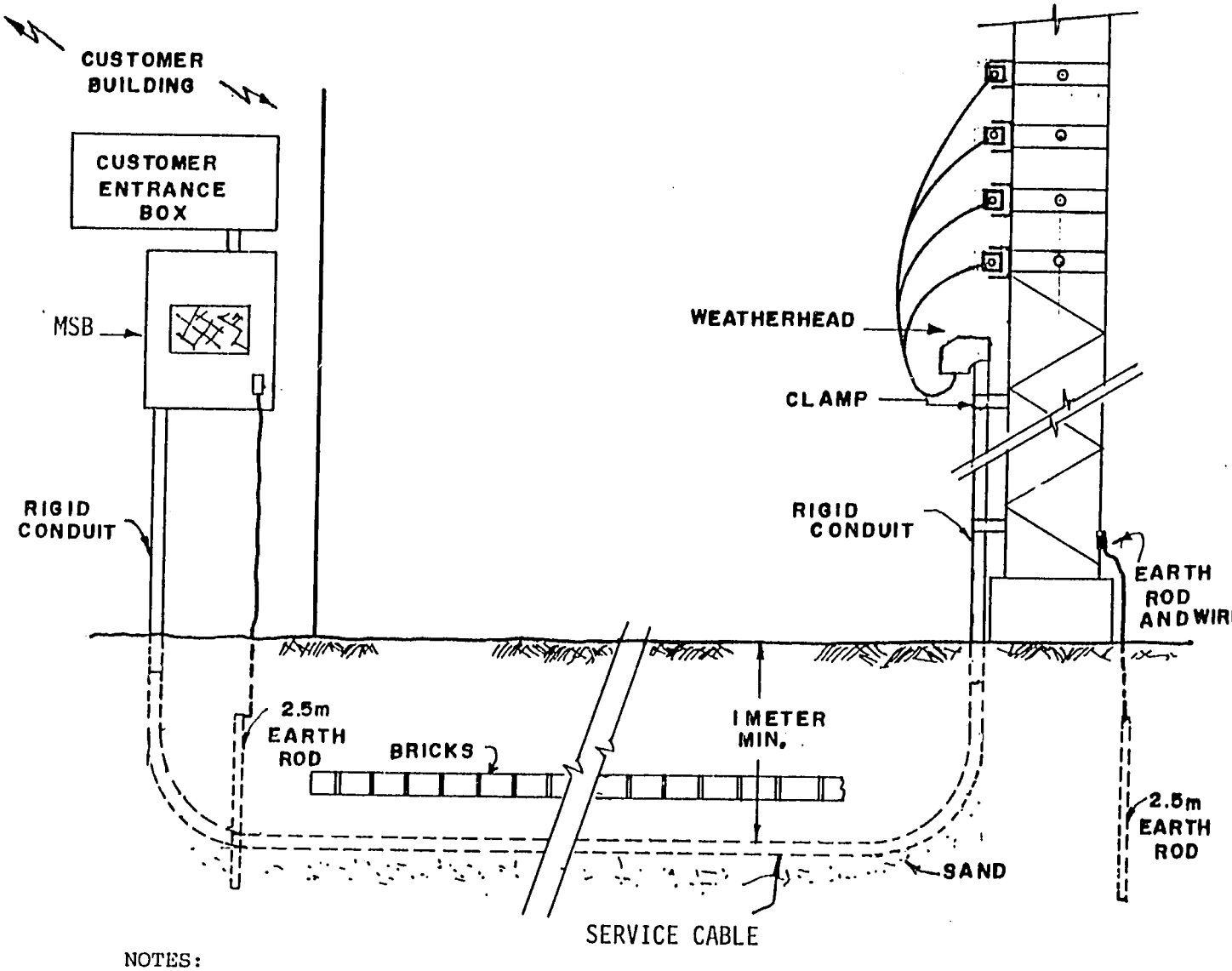
METER STANDARD

INSTALLATION - UNDERGROUND ENTRANCE DE-5



NOTES:

1. Cover of MSB to be sealed.
2. MSB to be painted white to reflect heat.
3. Metal to be cleaned of paint for all earth connections.
4. MSB and meter to be mounted in a vertical position.
5. Entire length of service drop wire eithout splices.
6. Form service drop wire - do not leave excess wire.
7. All towers with service drop to be earthed.
8. Cable trench clear of rock and debris.
9. Earth connections to be welded.

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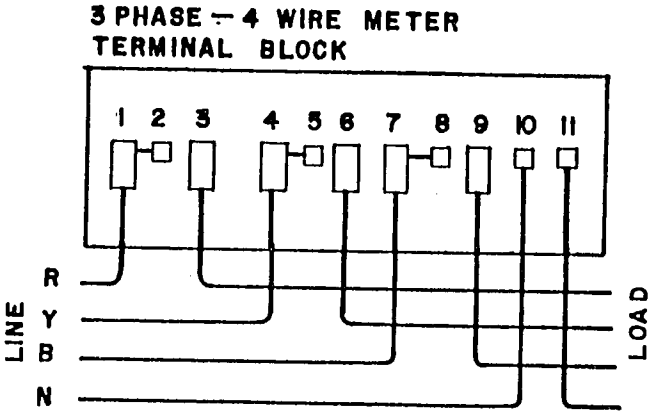
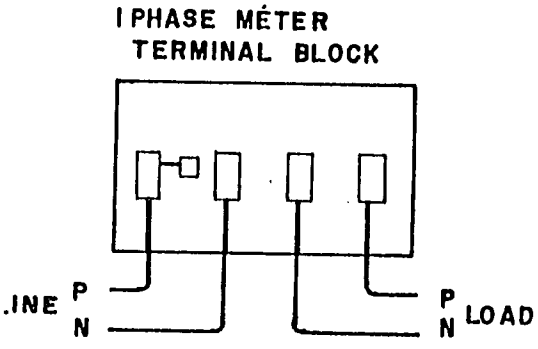
METER STANDARD

INSTALLATION — WIRING DETAIL

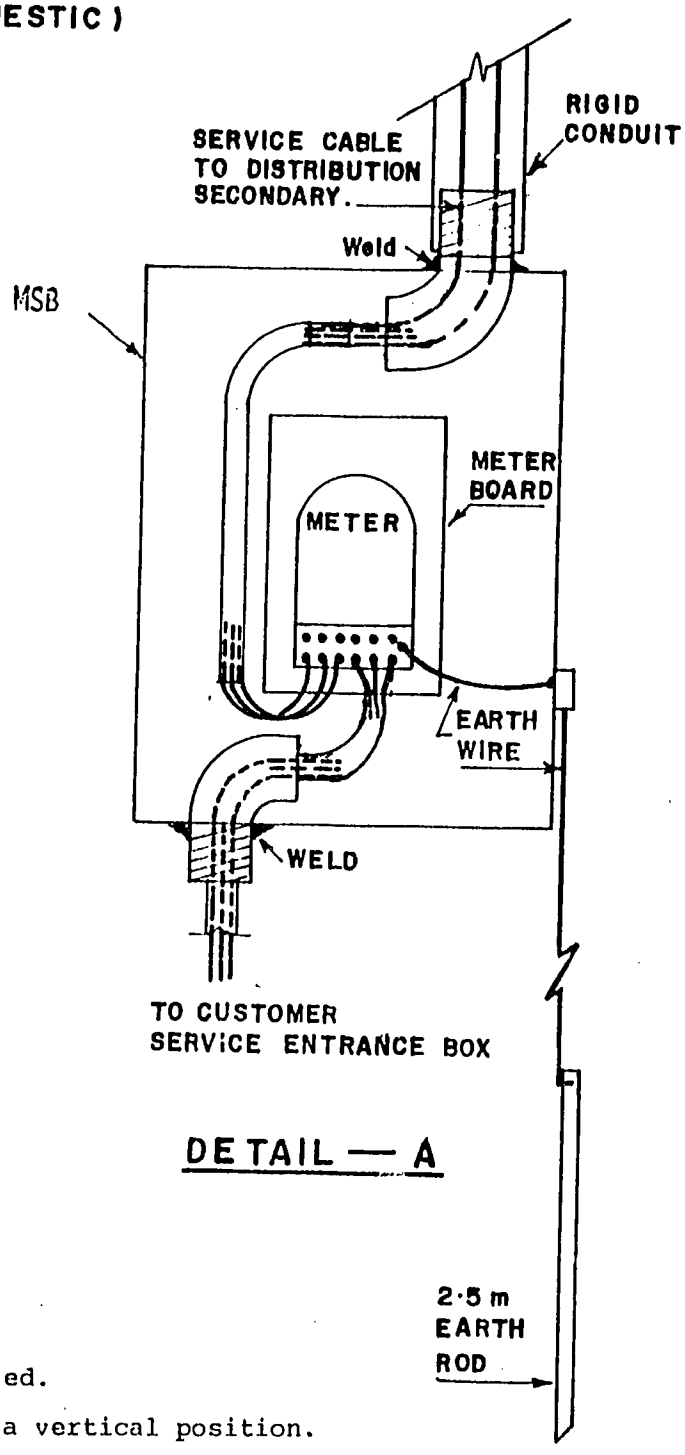
(DOMESTIC)



DETAIL — C



DETAIL — B



DETAIL — A

NOTES:

1. Cover of MSB to be sealed.
2. Mount MSB and meter in a vertical position.
3. Clean all service drop wires before making terminal block connection.
4. Tighten securely all terminal block connections.
5. Install earth rod at meter location.

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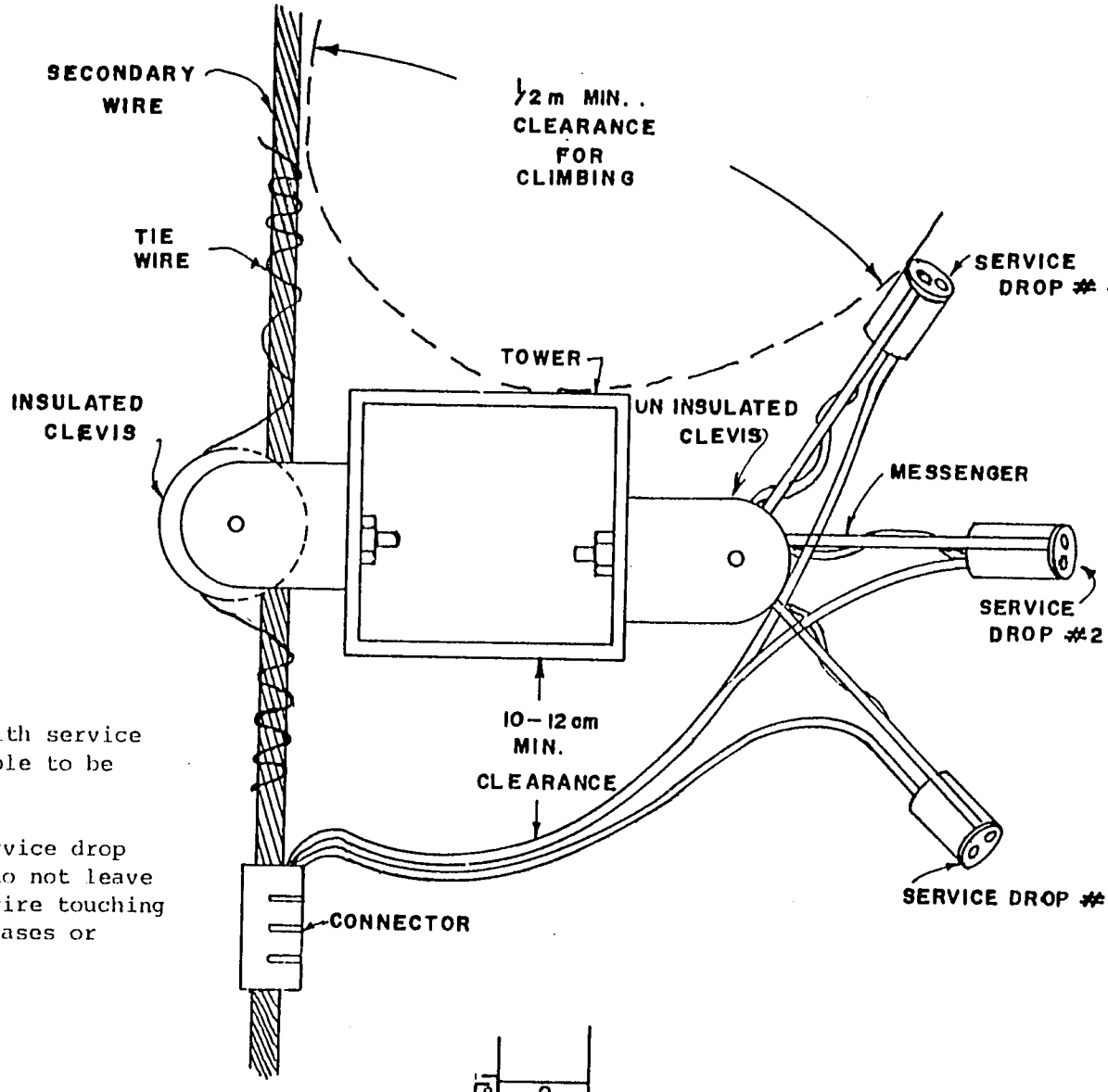
METER STANDARD

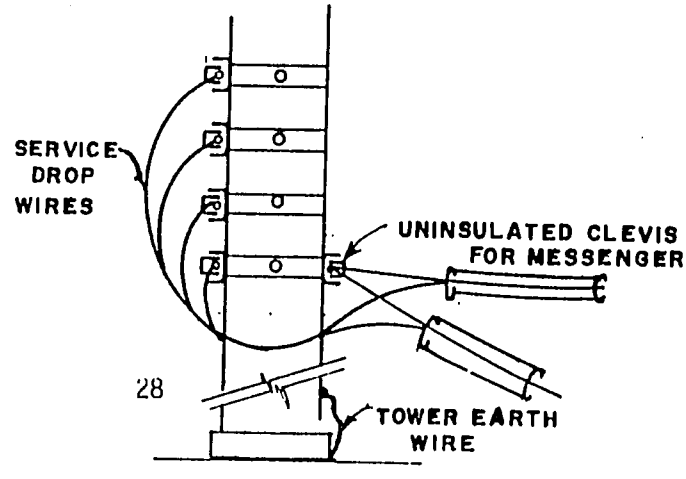
INSULATION – SERVICE DROP CONNECTION DETAIL



NOTES:

1. Tower with service drop cable to be earthed.

2. Form service drop wire - do not leave excess wire touching other phases or neutral.



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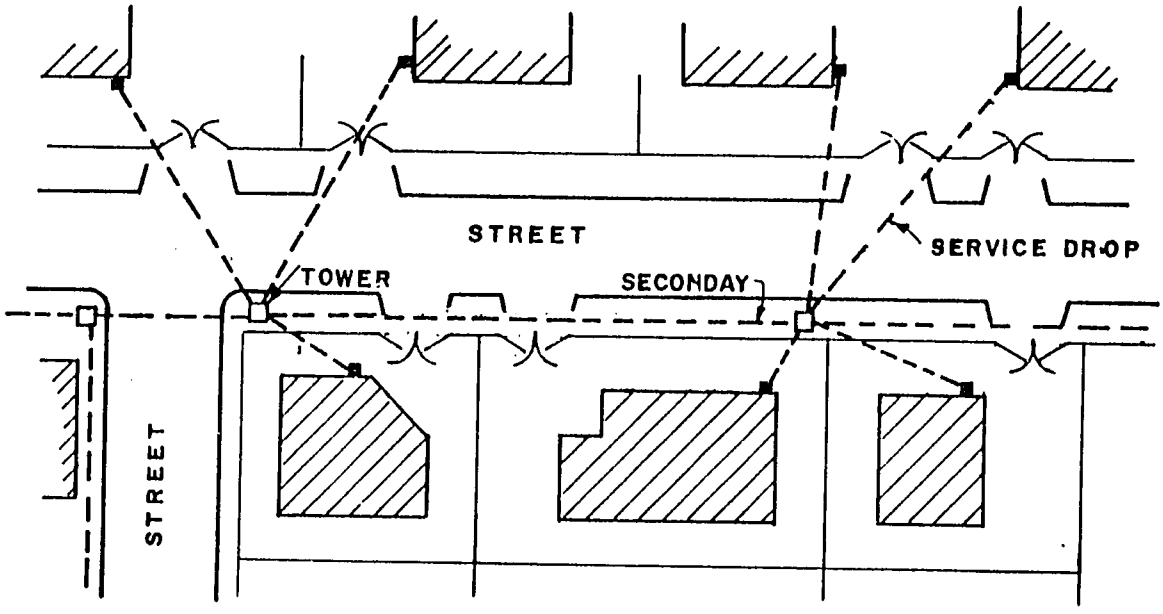
WAPDA
METER STANDARD

INSTALLATION – DOMESTIC SERVICES
(PLAN VIEW)



NOTES:

1. Avoid crossing other property whenever possible.
2. Locate meter as close to secondary line and customer entrance gate as possible.
3. Maintain clearance between service drop cable and other objects.
4. Service drop cable should be without splices.
5. Maintain required height of service drop cable over walkways and roadways.

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12. METER INSTALLATION TYPE

Type or kind of meter to be installed at consumer end is generally governed by the tariff applicable as explained in the table below. Technical instructions and related installation standards of different types of meters are attached.

Sr. No.	Supply	Tariff		Meter
1	General	A-1		
			Energy (kWh) charge Residence, places of worship, hospitals etc.	1-phase or 3-phase 4-wire 230/400V.
2	Commercial	A-2		
			Energy (kWh) charge All government, semi-government offices, institution	1-phase or 3-phase 4 wire 230/400V.
3	Industrial 230/400V	B-1 (0-70kW)		
			Energy (kWh) charge single phase 230V or three-phase 400V.	1-phase 230V or 3-phase 3 wire 400V for balanced load or 3-phase 4-wire 230/400V for mixed load.
4	Industrial 400V.	B-2 (70-500kW) Two part		
			(i) energy (kWh) charge (ii) fixed (kW) charge (iii) penalty for low p.f. (below 80%) (iv) lamps & single phase fans etc consumption in excess of 5% of total motive power consumption shall be charged at Tariff A-2. (v) Attached residential colonies shall be charged at tariff-H Provision of separate circuit shall be responsibility.	(i) 3-phase 4-wire 230/400V C.T. operated. with M.D.I. for kW measurement (ii) kVARh meter in series with same C.Ts for pf. measurement. (iii) 1-phase or 3-phase 4 wire 230/400V meter (iv) 1-phase or 3-phase 4 wire 230/400V for colony

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Sr. No.	Supply	Tariff		Meter
5	Industrial 11 kV, 33kV	B-3 500-5000 kV Two part	(i) Energy (kWh) charge (ii) Fixed (kW) charge (iii) Low p.f. penalty (below 80%) (iv) Residential colonies shall be charged at Tariff-H on separate circuit.	C.T. & P.T. operated kWh meter with M.D.I and kVARh meter. 3-phase 4 wire 230/400V meter for residential colony.
6	Industrial 66 & 132kV	B-4 above 5000 kW Two part	i) Energy (kWh) charge ii) Fixed (kW) charge iii) Low p.f. penalty.	C.T. & P.T. operated kWh meter with M.D.I. and kVARh meter in series with the same C.Ts.
7	Bulk 400V Licensees & Non-Licensees and government depts.	C-1 (0-500kW)	i) Energy (kWh) charge ii) Fixed (kW) charge iii) Low p.f. penalty	C.T. operated 3-phase 4-wire 230/400V kWh, M.D.I meter and kVARh meter in series with the same same C.Ts.
8	Bulk 11&33kV Licensees & Non-Licensees & Govt. depts.	C-2 (500-5000 kW).	i) Energy (kWh) charge ii) Energy (kW) charge iii) Low p.f. penalty.	C.T. & P.T. operated with M.D.I. meter & kVARh meter in the series of same C.Ts.

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Sr. No.	Supply	Tariff		Meter
9	Bulk 66kV & 132kV	C-3 above 5000 kW		
			i) Energy (kWh) charge ii) Fixed (kW) charge iii) Low p.f. penalty. iv) Grid construction at consumer cost.	C.T. & P.T. operated kWh meter with M.D.I. and kVARh meter in series of the same C.Ts.
10	Agricultural & lift Irrigation pumps	D 400V		
			i) Energy (kWh) charge for reclamation & drainage t/wells ii) (a) Energy (kWh) charge. (b) Fixed charges per kW of sanctioned load. For all other t/wells separate light charge for any attached residential quarter.	i) 3-phase 4-wire 230/400V meter ii) Separate light meter if there is attached colony
11	Temporary Domestic & Commercial	E-1 400V		
			Energy (kWh) charge	Single phase 230V or 3-phase 230/400V meter.
12	Temporary Industrial Bulk	E-2 400V 11 or 33kV		
			Energy (kWh) charge	3-phase 4 wire 230/400V C.T. operated kWh meter or C.T. P.T. operated when voltage is 11 or 33 kV.

4-3

Sr. No.	Supply	Tariff		Meter
13	Seasonal	F 400V 11kV		
			125% of the corresponding regular industrial supply except fixed charge (kW) shall be recommended only for season actually runs.	3-phase 4-wire C.T. operated kWh meter with M.D.I.
14	Public Lighting	G 400V		
			i) Energy (kWh) charge ii) Fixed line charge iii) Fixed lamp and fixture charge	3-phase 4-wire 230/400V meter
15	Residential colony attached to premises of industrial consumer who have their own distrib-tion facilities	H 400V		
			i) Energy (kWh) charge	3-phase 4-wire 230/400V meter
16	Railway Traction	I 11kV		
			i) Energy (kWh) charge.	C.T. & P.T. operated kWh meter.

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IV. SERVICE TESTING

1. General Procedure for Service Testing

Upon entering a customer's premises to test or inspect a meter, the tester should first check the address and all other given data on the meter before starting the test.

The wiring and general conditions should next be inspected for incorrect and unauthorized connections, hazardous conditions, etc., and if found, noted on the test card.

An 'as found' test should be made on the meter unless some abnormal condition prohibits it. The 'as found' test shall always be made before the seals are broken and the cover removed.

After the meter has been thoroughly inspected, a complete 'as left' test shall be made with the cover in place. The cover should not be removed and the meter seal should be checked and replaced, if necessary.

An exception to this Procedure is that the AEB field test team who is responsible for testing, calibration, and installation of MDI meters between 70-500 KW are authorized to carry out testing and field calibration of MDI meters.

Before leaving the customer's premises the tester should always see that the customer has service and that the meter runs in the correct direction on the customer's load, and all litter resulting from the test shall be picked up. If the meter needs to be returned to the shop for repair, a note should be sent back with the meter outlining the problem. This note should always be dated and signed and a reference should be made to the defective meter on the test card. If possible, the note should be so written that it can be read through the meter cover. All of the test cards should be signed and dated and submitted the same day the work is done.

To maintain proper supervision over inspection, repairing and testing, it is essential that some routine procedure for checking such work be maintained. Approximately 1% of all meters tested should be re-checked by a supervisor or other qualified person.

2. Test Revolutions and Limit of Errors

The minimum number of test revolutions for the testing of watthour meters is given below :

	Test Revolutions	
	Single Phase	Polyphase
Full Load	20	10
Lagging PF	10	5
Light Load	2	2

These test revolutions apply to the meter under test and not to the rotating standard. However, a greater number of revolutions may be necessary in order to get a minimum of 5 revolutions on the standard. If automatic counting equipment is used, the number of meter revolutions should be such as to provide a minimum of 5 revolutions on the rotating standard or the equivalent on a solid state standard. One revolution may be used for all loads if an automatic one-revolution test board is being used.

The lag test should be made at 50% lagging power factor. Lag tests should be made on both laboratory and field tests of polyphase meters, and on laboratory tests of single phase meters. For a method of obtaining and determining 50% power factor condition, see "Auxiliary Resistor for Determining 50% Lagging power Factor on Electromechanical Rotating Watthour Standards".

3. Test Loads

For self contained meters, the test current for the full load and lag tests shall be approximately 100% of the base amperes. For the light load test, the test current shall be approximately 10% of the base amperes. The base ampere rating is shown on the meter name plate. For meters used with current transformers, the current at full load and lag tests shall be approximately 100% of the secondary rating of the current transformer, and at light load approximately 10% of that rating. The secondary rating of the current transformer is the nominal 5 ampere value and not the maximum current obtained by the use of the rating factor.

4. Limits of Accuracy

A. Single Phase Class 2 Kilowatthour meters.

Value of Current	Power Factor	Percentage Error Limits
0.05 Ib	1.0	+/- 2.5
From 0.1 Ib to Imax	1.0	+/- 2.0
.1 Ib	0.5 lagging	+/- 2.5
From 0.2 Ib to Imax	0.5 lagging	+/- 2.0

B. Three Phase, 4 Wire, 3 Element Class 2 Kilowatthour Meters

Value of Current	Power Factor	Percentage Error Limits
0.05 Ib	1.0	+/- 2.5
From 0.1 Ib to Imax	1.0	+/- 2.0
0.1 Ib	0.5 lagging	+/- 2.5
From 0.2 Ib to Imax	0.5 lagging	+/- 2.0

The percentage error limits of 3-phase meters carrying a single phase load but with balanced three phase voltages applied to the voltage circuit are as follows :

Value of Current	Power Factor	Percentage Error Limits
From 0.2 Ib to Ib	1	+/- 3.0
Ib	0.5 lagging	+/- 3.0
From Ib to I max	1	+/- 4.0

C. 3 Phase, 4-Wire, 3 Element 400 Volt and 3 Phase, 3 Wire 2 Element 110 Volt Kilovar meters

Value of Current	Sin ϕ (Inductive or Capacitive)	Percentage Error Limits
0.1 Ib	1	+/- 4
From 0.2 Ib to Imax	1	+/- 3
From 0.5 Ib to Imax	0.5	+/- 3

D. Maximum Demand Indicators, Class 1.0

The error of the maximum demand indicator itself over the effective range (which is additional to any error of the supporting meter) shall be within +/- 1.0% of the rating.

5. Meter Testing

Meters tested in service or in the laboratory should be left within these limits on all points. If the 'as found' test shows the meter to be outside these limits, the meter should be adjusted and brought within the values. It is not necessary to make a lag test on single phase meters in service.

6. General

The sequence in which test loads should be applied to the meter under test is as follows :

1. Full Load
2. Lagging Power Factor
3. Light Load

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One test run each, at full load and lag, may be relied upon to establish accuracies for these two test points. However, at least two (2) successive test runs should be taken at light load. If the first run and the second run check are within 0.2%, the meter apparently does not have excessive varying friction. If accuracies are found within the Limit of Error, the meter may be left 'as found'.

The 'as found' and 'as left' accuracy of polyphase meters should be determined with a full three phase test. Each individual stator test should be checked on the 'as found' and 'as left' test in order to determine the balance between stators and when necessary should be balanced to conform to the Limits of Error. All potential coils shall be energized during a balance check.

In the preceding and following paragraphs the working "base amperes" shown on the meter nameplate is used. This will apply to new types of meters. On older types of meters the nameplate current rating should be used instead.

Since laboratory and service equipment for testing watthour meters are usually limited in capacity, some deviation in load current may be necessary due to the limitation.

7. Single Phase Service

Two wire meters - single phase 240 volt shall be tested with full load and lag test made with load currents equal to 100% of base amperes shown on the meter nameplate; and the light load test made with 10% base amperes shown on the nameplate. The Lag test shall be made in the laboratory but not in the field.

8. Multi-Stator Meters

It is very important that each individual stator exhibit accurate performance by itself as well as having good accuracy with all stators combined. The balance test is made by connecting all potential coils in parallel and applying the base current of the meter to each current circuit first at unity power factor and then at 50% power factor, lagging current. Calibration of each stator is checked for both currents. When the accuracies are not within the required limits, adjustments are made. After the balance adjustments are made, the "as left" calibration is made by testing the meter in the full three phase configuration and making tests at the usual full load, light load, and lagging power factor loads and making the required accuracy adjustments.

9. Reactive Metering

When testing installations on which reactive meters are installed, the reactive test switch shall always be placed in the 'test' position before any test connections are made.

10. Meter Adjustments

When testing the meter, the tester must attempt to adjust the meter as close as possible to 100%.

11. Testing Demand Meters

Demand meters are an important part of the meter installation and shall be tested and inspected regularly. Demand meters shall always be tested and adjusted in the laboratory before installation and shall be tested periodically on the same schedules as the watthour meters with which they are used.

Mechanical demand meters should be replaced at least once in every 3 years and brought into the laboratory for a thorough overall examination and adjustment. Mechanical demand registers shall be brought into the laboratory at least once in every 8 years for maintenance.

Demand meters shall be tested for time interval as well as KW indication since the accuracy is equally dependent on the time. The time interval shall be checked with a stop watch or a reliable timer from 'start' to 'set back'. Checking the time driving element does not give a check on the interval and this means of checking should not be used to obtain accuracy.

12. Demand Meters

Demand meters directly connected to watthour meters of the type that are incorporated in the register, or geared directly to the watthour meter, may be conveniently tested for indication by counting the total number of disk revolutions of the watthour meter in a demand interval. It is not necessary to run the watthour meter for the full interval. The time check may be made at the same time by use of a stop watch or equivalent timer. The time should begin when the demand mechanism cuts in. Then the watthour meter may be started and the revolutions counted. The watthour meter should be run enough to get about 50% scale indication on the demand meter and should be stopped before the demand sets back. The timer must be stopped when the demand sets back. In the case of a time-lagged demand meter it is, of course, necessary to run the meter continually for the full time interval.

The indication accuracy referred to full scale of the demand register using the above method would be as follows :

$$\frac{\text{Revolutions} \times 3600}{\text{Meter Disk K} \times \text{Nominal Demand Interval in seconds}} = \text{Required Indication (R'qd)}$$

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$$\text{Req'd} - \frac{\text{(Full Scale Obtained)}}{\text{Full Scale}} \times 100 = \text{Indication \% Accuracy}$$

The time interval accuracy will be :

$$\frac{\text{Seconds Obtained}}{\text{Seconds Required}} \times 100 = \text{\% True Time Interval}$$

The overall accuracy of the demand meter will be :

$$\frac{\text{Indication \% Acc'y} \times \text{Time \% Acc'y}}{100} = \text{Overall \% Accuracy}$$

13. Checking Meter Installations

Every meter installation should be checked for correct connections when the installation is made. On most self-contained installations, the wiring can be visually checked to be sure that line and load wires, and potential tap, when required, are connected to the proper points. A ready check of the operation is obtained by noting the direction of rotation and approximate speed after the load is turned on.

With installations requiring current and potential transformers there exists a greater likelihood for incorrect meter registration due to wiring errors, incorrectly marked instrument transformer polarity, a reversed coil inside the meter, or an incorrectly marked transformer ratio.

It is not always possible to determine if the installation is correct by visual inspection, however, a properly conducted check in accordance with the following procedures will insure the correctness of the installation.

The following checks, using customer's load, shall be made on all meter installations with instrument transformers. These checks shall also be applied whenever changes subsequent to initial installations are made in the meters, instrument transformers, or wiring, and whenever the meters are tested on a routine test schedule.

It is to be understood that the following checks are not a substitute for the usual watthour meter installation test in which the meter accuracy is determined by using a portable watthour meter and a phantom loading device, but rather as a supplement to such tests to further insure correct metering.

It is advisable to indicate on the initial test card that the following checks were made and what the results were.

14. General

A. Determine the phase sequence in order to check for correct connections between the phase shifting autotransformer.

B. Measure the voltage and current of each phase.

C. Report for investigation voltage unbalance of more than 3% and current unbalance of more than 10%.

D. Use Eastern Speciality (TESCO) # 1042 current transformer field test set or similar device in the secondary circuit of each current transformer to find defects in current transformer secondary, meter control cable, test switch, panel wiring and meter current circuits.

15. Testing Schedule

Watthour meters shall be tested regularly, except self-contained single phase meters which may be tested according to an approved sampling plan. The following schedule sets forth the maximum periodic test schedule recommended.

Periodic Test Schedule for Alternating Current Watthour Meters

A. Meters with instrument transformers

(a) polyphase meters - at least once in three years

B. Self-contained polyphase meters - at least once in four years.

C. Self-contained, single phase meters - at least once in four years.

16. Investigations

Investigation requests will be prepared by Customer Service Representative in the revenue Office. The Meter Engineer or Meter Electrician will call on the customer, make a stop watch check on the meter, examine the wiring and advise the customer of the conditions. If the cause of the complaint appears to be an incorrect meter registration, a meter field test should be made and the test data recorded on the Investigation Request.

Any test on an installed meter that requires entrance into the security box (AIB) shall be done by an authorized representative of the Meter Section. If an investigation is made by any other person, no entry shall be made, but the meter section shall be advised.

When a meter field test accuracy check is made the results shall be filed with the concerned Engineer.

The meter shall be replaced if it exceeds the accuracy limits. (See Limit of Error).

17. Bearing Practice

No attempts should be made to repair jewel-type bearing meters in the field. Reusable type jewel bearings removed from meters may be inspected in the laboratory with a microscope or sent to one of the jewel service companies for inspection. In no case should needles or sharp instruments be used on jewel bearings. Good bearings should be thoroughly cleaned and packed in dust-tight containers for re-use. Ball-type bearings should not be oiled.

On some types of meters difficulty has been experienced with "shallow cup" jewels. Such jewels should be discarded and only deep cup jewels for these type meters should be recleaned or used for replacement.

Ball bearings should be carried in suitable dust-proof containers. Balls should be handled in a ball dropper and not by the hands.

No attempt should be made to salvage used ball bearings. Replacement ball bearings should be of the lubricated type, such as lithium stearate or molycote.

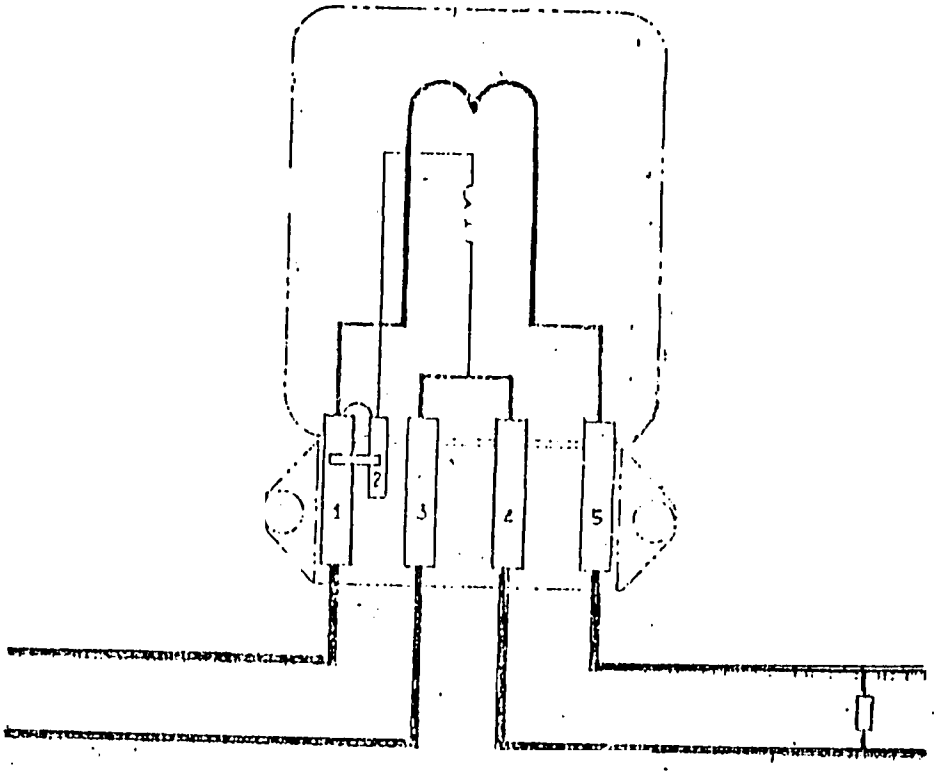
V. CONNECTIONS

1. Meter Connection Diagram

This Section contains the connection diagrams for all of the meters used on the WAPDA System. These diagrams were taken from the Technical Instruction No. 0-7 Installation of Energy Meters. The installation notes contained in Sections 3 and 4 of the Technical Instruction No. 0-7 have been incorporated in the Installation Section of this Manual.

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
ENGINEERING DEPARTMENT

NO EW/DM-1



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METER CONNECTIONS ARRANGEMENT
SINGLE PHASE METER

DWN	ASSTT: ENGR:	DATE 13 - 5 - 66
CKD	ASSTT: DIRECTOR	APPVD: DIRECTOR

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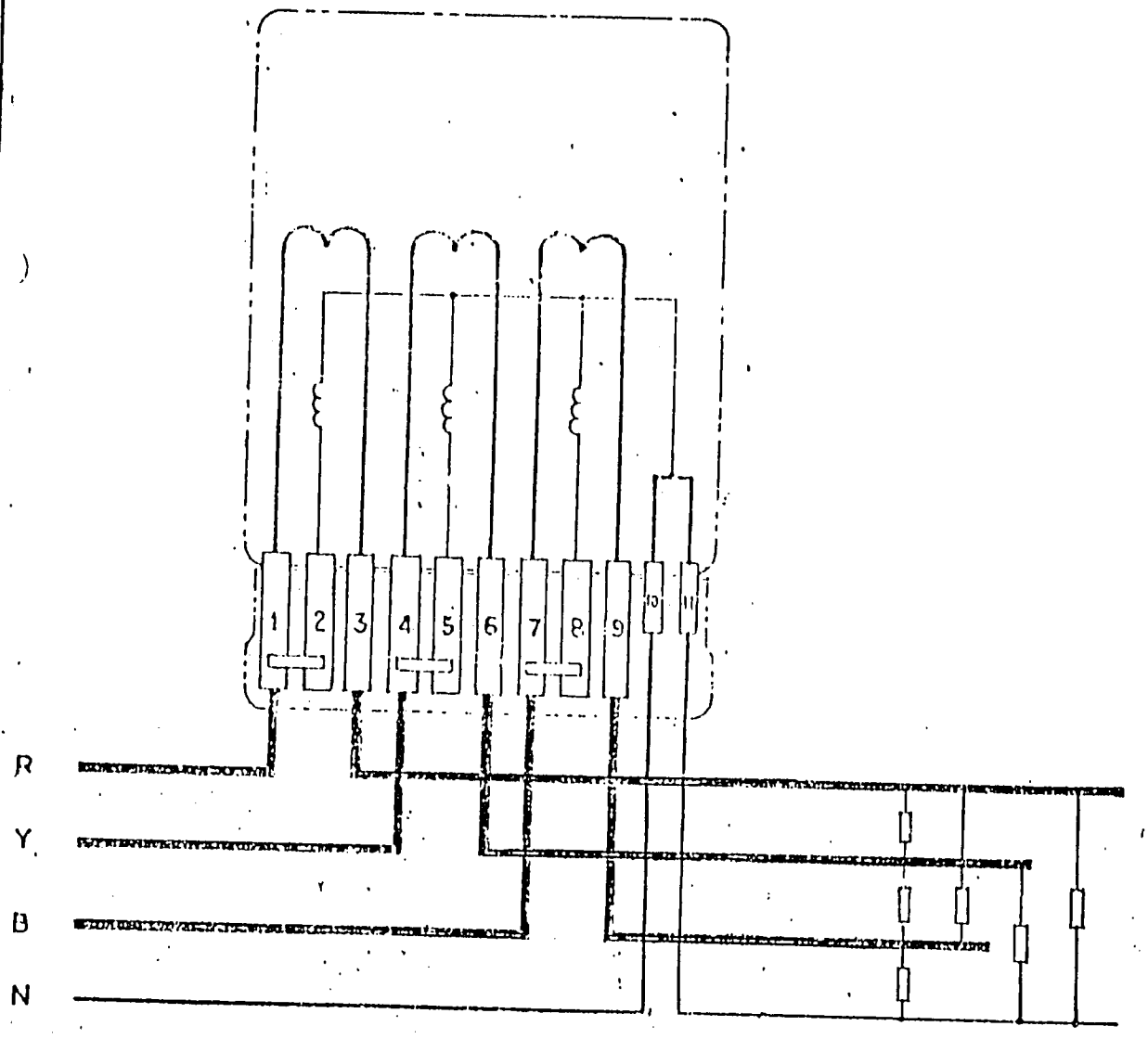
PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
ENGINEERING DEPARTMENT

NO
EW/DM-4



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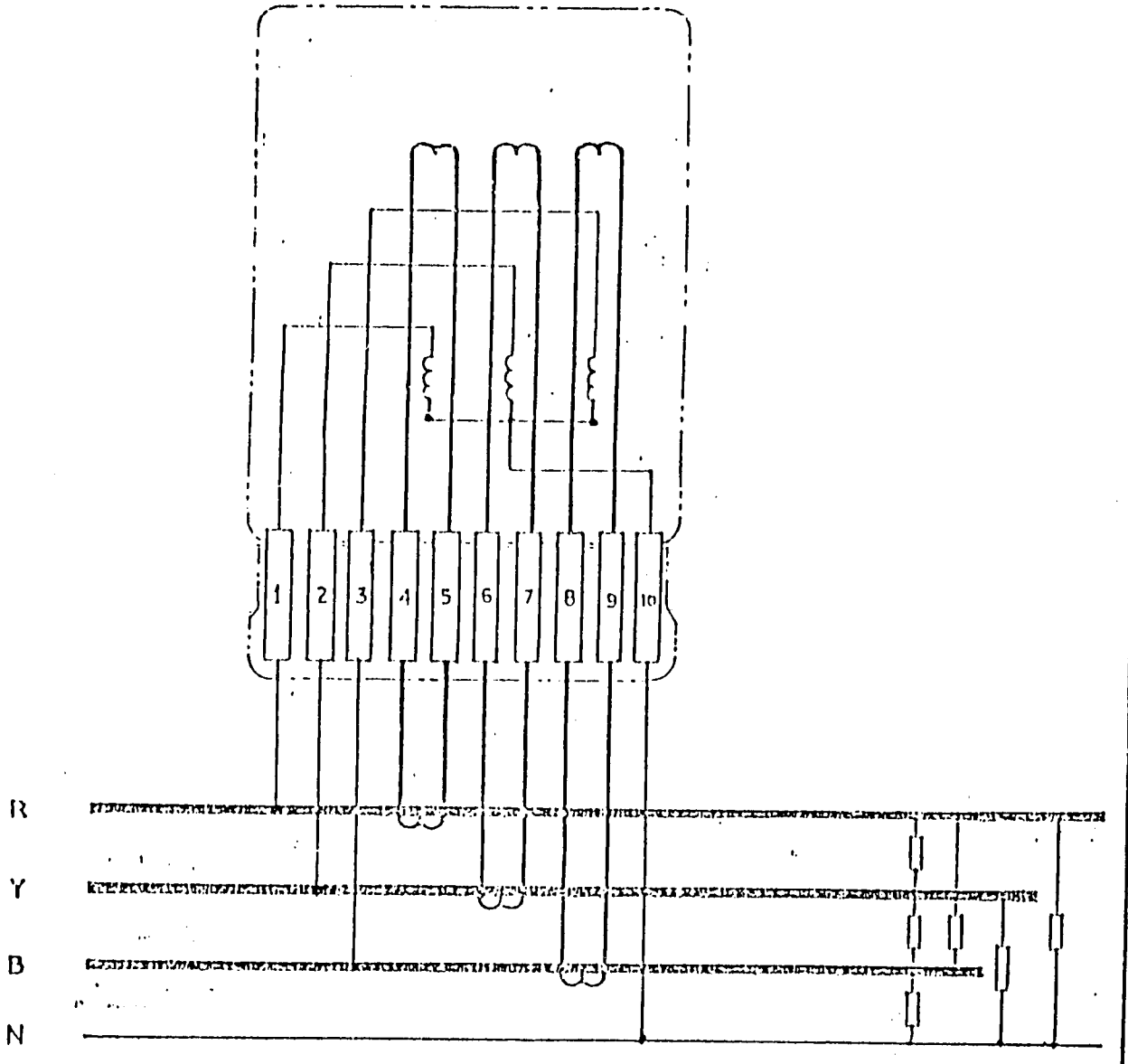
METER CONNECTIONS ARRANGEMENT
3 PHASE 4 WIRE, 230/400 VOLTS (DIRECT) METER

DWN	ASSTT: ENGR:	DATE: 24 – 6 – 66.
CKD	ASSTT: DIRECTOR	APPVD: DIRECTOR

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY ENGINEERING DEPARTMENT	NO EW/DM-5



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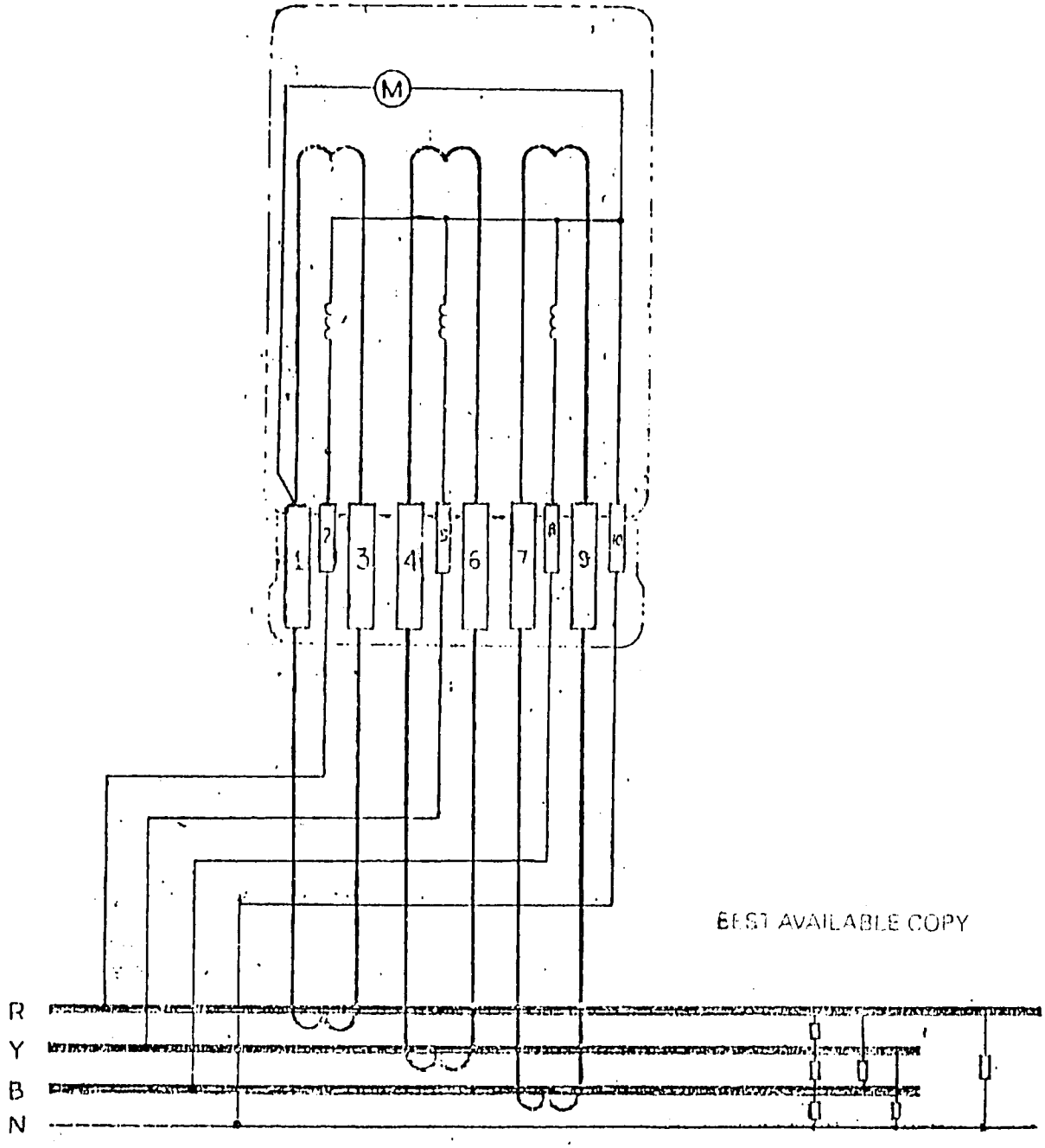
METER CONNECTIONS ARRANGEMENT
L & K, 3 PHASE 4 WIRE 230/400 VOLTS, KWH C.T.
OPERATED METER, WITHOUT MDI.

DWN	ASSTT: ENGINEER	DATE 25 - 6 - 66
CKD	ASSTT: DIRECTOR	APPVD: DIRECTOR

PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
ENGINEERING DEPARTMENT

NO
EW/DM-9



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METER CONNECTIONS ARRANGEMENT
L & G 3 PHASE 4 WIRE 230/400 VOLTS C.T. OPERATED
METER WITH KWH AND MDI (KW).

DWN:	ASSTT ENGINEER	DATE 4-7-66.
CKD.	ASST. ENGINEER	APPVD. DIRECTOR

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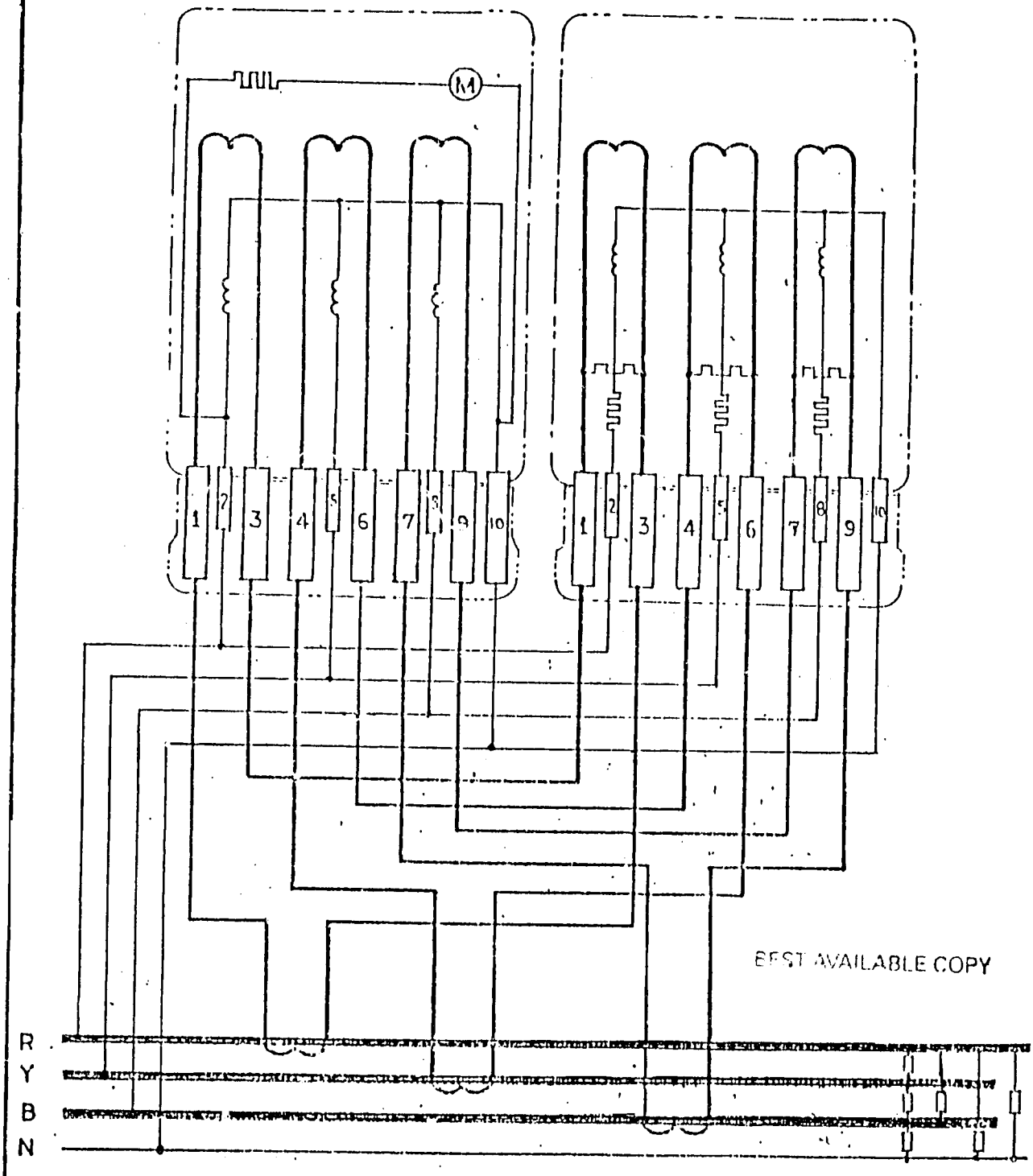
WATER AND POWER DEVELOPMENT AUTHORITY
ENGINEERING DEPARTMENT

NO
EW/DM-10



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METER CONNECTIONS ARRANGEMENT
AEG 3 PHASE 4 WIRE 230/400 VOLTS C.T. OPERATED
METER WITH KWH KVAh & MDI (KW).

DWN	ASSTT. ENGINEER	DATE 5-7-66.
CKD	ASSTT. DIRECTOR	APPVD: DIRECTOR

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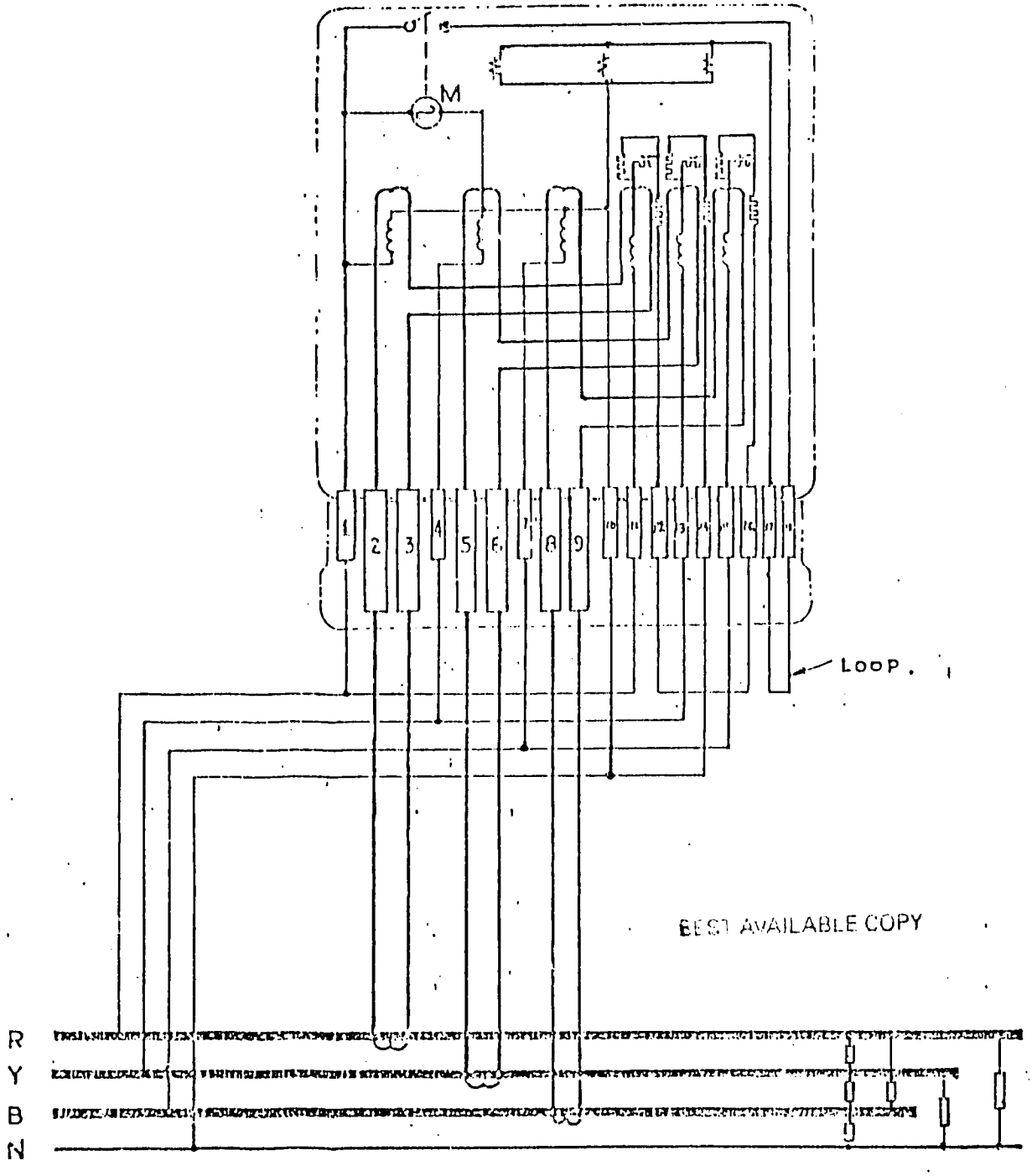
PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
ENGINEERING DEPARTMENT

NO
EW/DM-13



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METER CONNECTIONS ARRANGEMENT
3 PHASE 4 WIRE C.T. OPERATED TRIVECTOR METER

DWN	ASSTT. ENGINEER	DATE 14 – 7 – 66
CKD	ASSTT. DIRECTOR	APPVD. DIRECTOR

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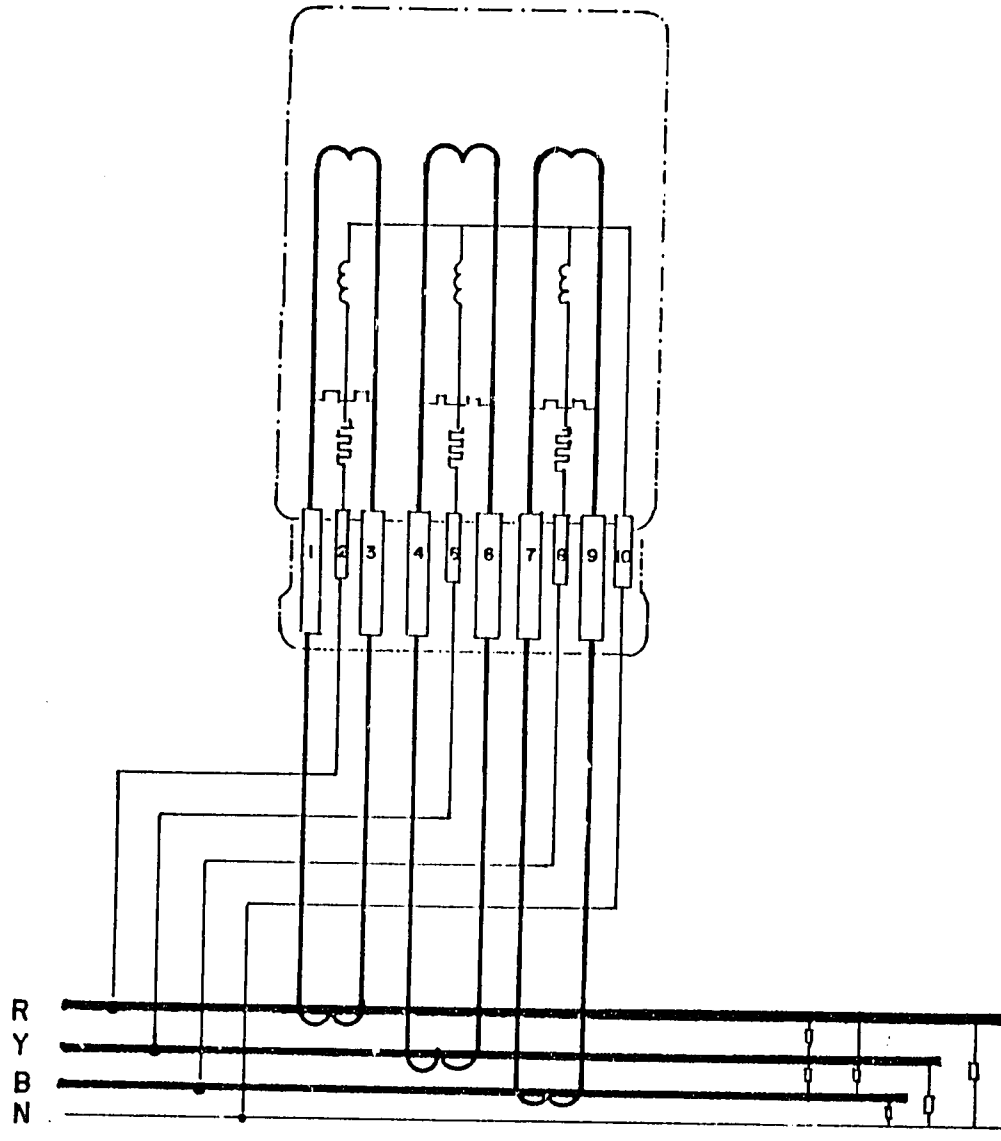

TERMINAL MARKING AND CONNECTION DIAGRAM OF THREE PHASE, THREE ELEMENT, C.T OPERATED L.V. KVAR – HOUR METER.

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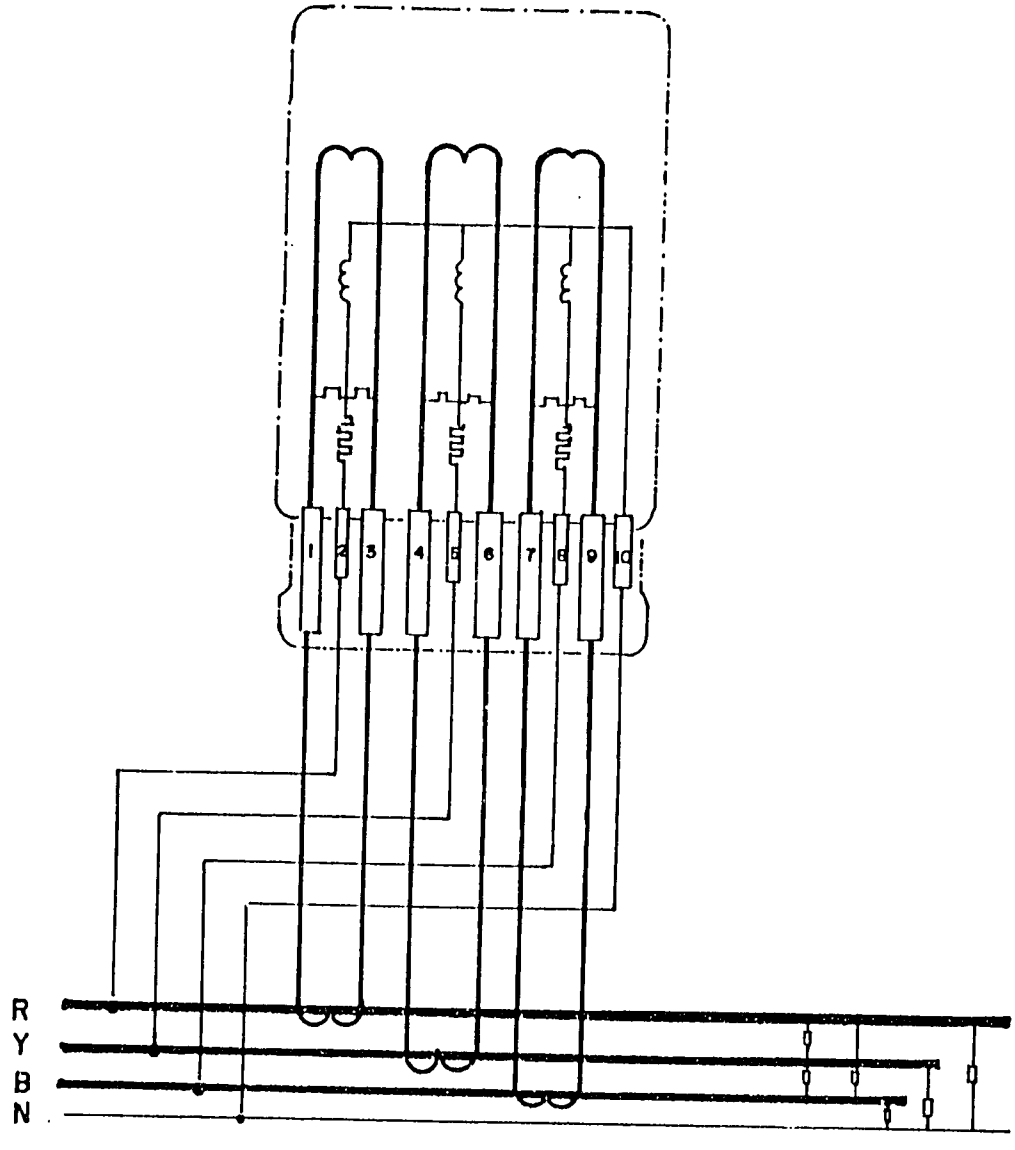

TERMINAL MARKING AND CONNECTION DIAGRAM OF THREE PHASE, THREE ELEMENT, C.T OPERATED L.V. KVAR – HOUR METER.

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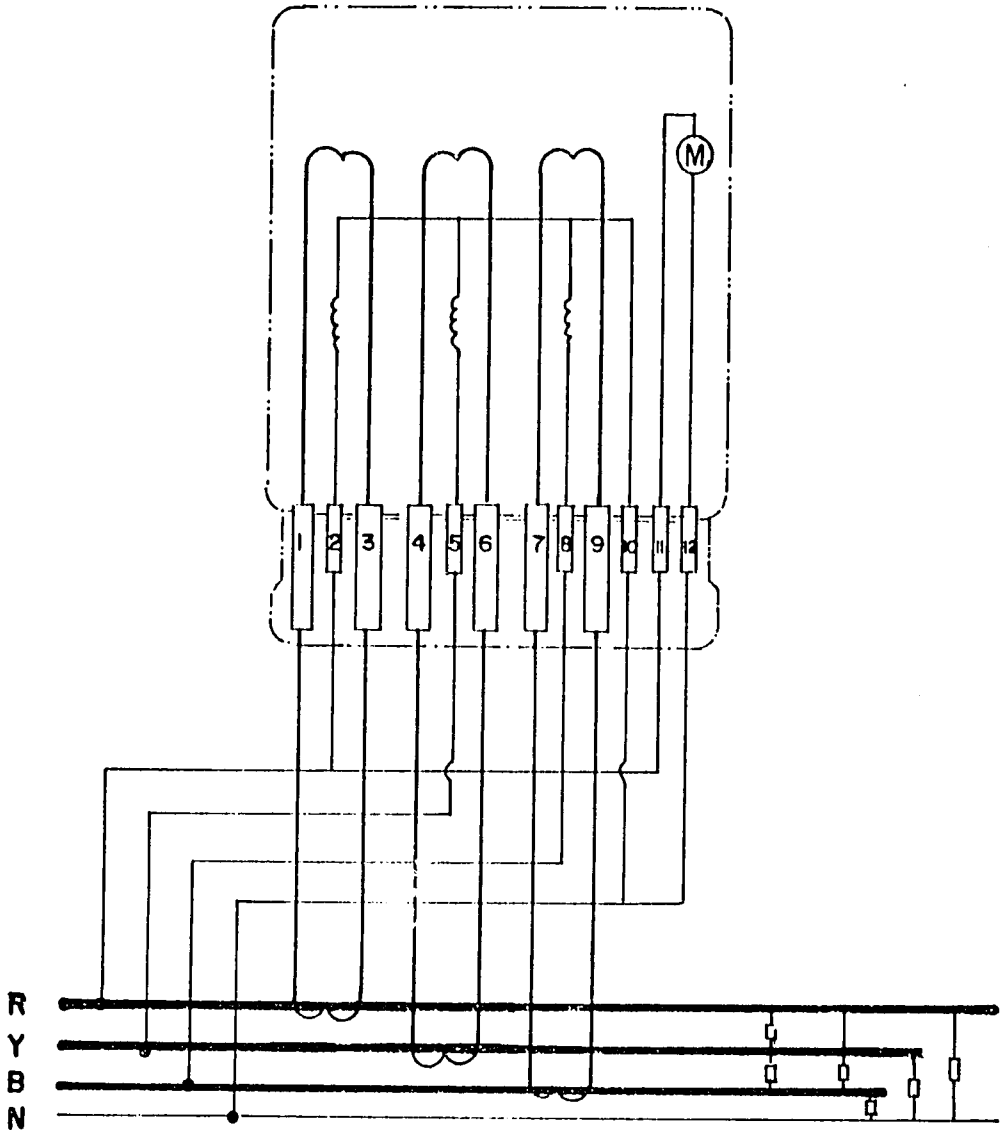

CONNECTION DIAGRAM AND TERMINAL MARKING FOR 3 Ø 3 ELEMENT, C.T OPERATED L.V. ENERGY METER.

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