PD-ABN-222

UNITED STATES AGENCY for INTERNATIONAL DEVELOPMENT

CAIRO, EGYPT

ACTION MEMORANDUM FOR THE ASSOCIATE DIRECTOR, DR

FROM : John P. Hunt, OD/~~PT~~

SUBJECT: High Dam Rehabilitation/Modernization Project
USAID Grant No. 263-0160

ISSUE:

Your Approval is required to formally conclude the High Dam Rehabilitation/Modernization Project, which was authorized in March 1982.

AUTHORITY:

Mission Order 5-4, dated March 29, 1993 delegates to the Associate Director the authority to formally close a project.

RECOMMENDATION:

That the High Dam Rehabilitation/Modernization Project (No. 263-0160) status be changed from "active" to "completed".

APPROVED: _____

DISAPPROVED: _____

DATE: 9/22/96

Clearance: PDS/PS:ERauch _____ Date: 8/14/96

106 Kasr El Aini Street
Garden City
Cairo, Egypt

PD-ABN-222

PROJECT ASSISTANCE COMPLETION REPORT

HIGH DAM REHABILITATION/MODERNIZATION

USAID GRANT NO. 263-0160

TABLE OF CONTENTS

PROJECT ASSISTANCE COMPLETION REPORT

HIGH DAM REHABILITATION/MODERNIZATION PROJECT GRANT NO. 263-0160

This Project Assistance Completion Report (PACR) has been prepared in accordance with the requirements of AID Handbook 3, Appendix 14 A, and Mission Order 3-17, dated September 17, 1992

1. PROJECT PURPOSE AND DESCRIPTION:
The project goal was to assist the Government of Egypt (GOE) in the rehabilitation and modernization of the High Dam Hydroelectric Power Station at Aswan consisting primarily of replacement of twelve (12) Francis turbine runners along with ten (10) 500KV power circuit breakers, transmission substation protective relaying and turbine/generator control instrumentation and refurbishment of the in-take and discharge structures and hydraulic barriers (gates).

The project formed part of the U.S. assistance for the strengthening of the electric power infrastructure in Egypt. The replacement of the turbine runners at the High Dam corrected a major design deficiency which required repeated and lengthy outages of the generating units for repairs to the runners and which, if not corrected, would have jeopardized the continued operation of the generating units.

The Project was authorized on March 29, 1982 and the $100 million Grant Agreement was signed on April 12, 1982. The Egyptian Electricity Authority (EEA) was the GOE Implementing Agency and operator of the High Dam Hydroelectric Power Station. EEA, assisted by technical staff from the U.S. Department of Interior, Bureau of Reclamation (BUREC), negotiated the runner replacement contract with Allis Chalmers. The contract was signed on June 3, 1982. EEA utilized the technical assistance of the BUREC throughout the project.

While the initial emphasis and concern was with the replacement of the 12-135 ton Francis type hydraulic runners (the rotating portion of the hydraulic turbine), investigations during the project design revealed deficiencies in the 14-500KV circuit breakers in the substation and protective relaying devices on the 500KV transmission lines between the High Dam and Cairo, due to obsolescence, that would negate reliability improvements with the runners and EEA subsequently requested that their replacement be included in the project design. During the runner replacement phase of the project, EEA established a spare parts supply for the 132KV circuit breakers and their replacement was therefore avoided. The four 500KV circuit breakers on the transmission line to Nag Hammadi were replaced with circuit breakers financed from another lending agency who had financed the circuit breaker replacement at Nag Hammadi, Sammalut and Cairo 500 thereby reducing the quantity

of 500 KW circuit breaker to be replaced to 100.

The generator circuit breakers were found to be defective and subject to failure, and the upstream and downstream gates used to close the water intake and discharge tunnels were found to be badly corroded and had lost their sealing capability necessary to seal the water tunnels thereby greatly complicating the dewatering of the tunnel and turbine when preparing to perform normal maintenance work on the turbines and associated equipment.

The replacement of the generator 15KV circuit breakers and rehabilitation of the gates and associated mechanical equipment was incorporated into the project in a $40 Million Project Amendment in 1987, and the PACD was extended by USAID/WASH to April 12, 1995. The PACD and PASA were extended from April 12, 1995 to June 12, 1995 to allow sufficient time for the BUREC project close out activities and for the orderly demobilization of the BUREC team at Aswan. All work was completed prior to June 12, 1995.

2. CONTRIBUTIONS BY HOST COUNTRY:
Throughout the life of the project, the GOE provided Local Currency and In-Kind Contributions to support the project. These GOE contributions are summarized below:

SUMMARY OF HOST COUNTRY CONTRIBUTIONS
(L.E. Million)

	PLANNED	ACTUAL	EXCESS CONTRIBUTIONS
LOCAL CURRENCY	20.2	37.7	17.5
IN-KIND	2.2	14.7	12.5
TOTAL	**22.4**	**52.4**	**30.0**

* In-kind costs included beginning in 1986 PROAG.

In November 1994, the Financial Management Office performed a financial review of the Government of Egypt project Cash and In-Kind contributions. FM physically reviewed EEA files and were assured from the documents reviewed that both the In-kind and Cash contribution reports were supported by documentation and evidence examined at the EEA/High Dam Power Station accounting offices.

3. PROJECT HISTORY AND BACKGROUND:
The High Dam and Hydroelectric Power Station at Aswan and the 500 KV transmission system that delivers energy generated at the High Dam to Cairo were constructed during the 1960's using low interest loans provided by the Soviet Union. The High Dam was designed to

provide for the over year storage of the annual floods of the Nile River in a man made lake, Lake Nasser, behind the dam that extends 500 km. south into Sudan with a surface area of 5,000 square kilometers. The power station, located at the east side of the dam consists of 12-175 MW hydro-turbine generating units that were designed to deliver full output at hydraulic heads of 57 meters. The generating units are used for a combination of base load and peaking operation. The first three hydro-turbines were placed in operation in 1967 and subsequent groups of three hydro turbines were placed in service in 1968, 1969 and 1970. The transmission system, constructed between 1964 and 1970, integrated the numerous independently operated power systems into a unified power system covering all of Egypt.

During the initial inspection of the first two units in 1969, after two years of operation, cracks were found on the 135 ton hydro-turbine runners where the blades are attached and welded to the crown and base of the runner. The USSR technical staff advised EEA that these cracks were normal and should be corrected through welding. EEA made the necessary welding repairs and when cracks were found on all other turbine runners, as they were inspected after their initial two years of operation, similar welding repairs were also performed. In 1971, during the second maintenance inspection of the initial runners, addition cracking was found and EEA was advised by the USSR that EEA had improperly operated the units at low heads and therefore the USSR technical staff was not responsible for the "cracking".

Over the next nine years EEA consulted with numerous metallurgists, welding specialists and consultant engineers in an effort to determine the cause of the cracking and identify structural modifications to the runners that would eliminate the cracking. All consultants concluded that the runners were improperly designed and the design shortcomings were resulting in vibration of the runner blades that produced fatigue cracks and the welding repairs had only exacerbated the vibration problem. EEA's two primary consultants concluded that the only sure way to eliminate the cracking was to replace the runners with runners of proper design.

The GOE initially sought US assistance in replacing the worst of the runners Units 7 through 12, beginning in 1980 and, following discovery of huge cracks in Units 3 and 4 in April 1981, the GOE sought additional US assistance in the summer of 1981 during President Sadat's visit to Washington. USAID financed a fact finding inspection by senior level technical experts from the BUREC who reviewed the scope of findings of previous studies of the cracking problem, observed first hand the extensive cracking on Units 3 and 4 and reviewed the history of cracking on all twelve generating units. The BUREC concluded that: the runner design was faulty; the runner casting was of poor quality; the structural integrity of the runner was questionable and a catastrophic failure was possible, justifying the urgency to replace all 12 runners. A

Sole Source Procurement Waiver for the runner replacement was approved by the USAID Administrator in October 1981 and EEA was authorized to negotiate a runner replacement contract with the Allis Chalmers Manufacturing Company.

EEA utilized technical assistance provided by the BUREC throughout the project due to their unique qualification as major hydro power plant operators familiar with runner performance problems and the operation of transmission systems similar to EEA's.

The BUREC services were provided through a Participating Agency Service Agreement.

The BUREC staff arrived in Egypt in mid 1985, took up residence in Cairo and Aswan in late 1985 and remained on-site until the completion of the project in mid 1995.

During project design, the 10-500 KV circuit breakers associated with the generating units and protective devices on the 500 KV transmission lines between the High Dam and Cairo were found to be obsolete and subject to failure and their replacement was included in the project design.

During the runner replacement, in-plant switching equipment was found to be defective and subject to failure and the barriers (gates) used to close the water intake and discharge tunnels were found to be badly corroded and could not effectively seal the water passages requiring extraordinary procedures to seal the water passages at anytime the runners required attention. After reviewing the seriousness of the switching and gate deficiencies, EEA requested and USAID concurred in expanding the scope of the project and adding these procurements to the project while deleting the instrumentation modernization and data acquisition procurements. The replacement of the switching equipment and gates was incorporated into the project in a $40 Million Project Amendment in 1987. The Project Assistance Completion date was extended twice by USAID/WASH from April 12, 1992 to April 12, 1995 and then to June 12, 1995.

Allis Chalmers utilized a runner of proven design that was similar to the runners utilized for the 800MW hydro turbines at the Grand Coulee Hydro power station. Runner performance characteristics were verified in model tests performed in York, PA in October 1982. Runner component fabrication and assembly began in early 1983 and the first two runners were delivered to the station in mid to late 1984. Runner installation began in early 1985 and the twelfth runner was returned to operation in December 1991. Near the completion of the replacement of the first pair of runners in September 1986, the Allis Chalmers Hydro Turbine Division was sold to Voith Hydro, Inc. All facilities, employees and contractors continued to perform without adverse effects from this change in ownership. This replacement required the simultaneous complete

disassembly of two units and involved handling individual components of the generator that weighted over 700 tons. Since disassembly facilities were provided for one unit only, innovative storage facilities were required and were developed by the BUREC and were effectively utilized throughout the runner replacement work.

EEA staff seconded to Allis Chalmers were responsible for all disassembly, rigging, lifting, machining, mechanical and electrical work and unit reassembly.

The contract for the replacement of the protective relay systems on the 500 KV transmission systems, involving work at the High Dam, Nag Hammadi, Assuit, Sammalut (Minya) and Cairo 500 was competitively awarded to Gilbert/Commonwealth. The contract was signed on May 27, 1987 with work beginning in June 1987 and all work was completed in November 1991. The installations are state-of-the-art and provide the optimum protection for the 500 KV network.

The contract for the replacement of the 500 KV circuit breakers in the High Dam switchyard was awarded competitively to ABB Power T&D. The contract was signed on November 10, 1990 with replacement work beginning in early 1992 and the replacement of the tenth circuit breaker was completed in January 1993. These circuit breakers when integrated with the protective relaying have greatly enhanced the reliability of the power station and transmission network.

The contract for the replacement of the 15KV unit circuit on the leads of the generating units was competitively awarded to ABB Power T&D. The contract was signed on December 10, 1992 with replacement work beginning in mid April 1993 and all contract work and services was completed prior to April 12, 1995.

The contract for the rehabilitation of the gates, trash racks and mechanical equipment was competitively awarded to Fru-Con Construction Company. The contract was signed on August 25, 1992. Rehabilitation of the first tunnel began on July 31, 1993. This rehabilitation work involved preliminary work performed under water and subsequent rehabilitation work of the large bulky structures that comprise the intake and discharge gates and trash racks. All contract work and services were completed on June 8, 1995.

4. PROJECT ACHIEVEMENTS:

Project Implementation Schedule:

A. Allis Chalmers - Runner Replacement Contract:

The twelve runners, governors and wicket gates were installed and the generator and bearings were completely reconditioned and accepted by EEA over a 52 month period beginning in August 1987 and ending in December 1991. The warranty period for the turbines runs from March 1995 till May 2000. The warranty

period, as defined in this and the following contracts, begins at the time that the Owner formally takes over the replaced or rehabilitated equipment or system, which is shortly after the Owner issues to the contractor the Construction Completion Certificate for the individual piece of equipment or system.

Nine of the twelve runners will remain under warranty after December 1995 and will be covered by the warranty until 2000. Warranty inspections of the runners performed by Voith to date have revealed minor defects caused by inclusion of foreign material from the assembly process. The warranty period for the governors, wicket gates and rewedding of the generator windings has been completed.

B. **Gilbert-Commonwealth International - Protective Relay:**
The protective relaying system including voltage and current transformers were installed over a 53 month period beginning in June 1987 and ending in November 1991. The 24 months warranty period for the protective relays has expired. The 500KV current transformers have a 5 year warranty expiring in November 1996. The protective relaying systems have operated properly as designed, installed, tested and placed in service. To date, there have been no mis-operations of the equipment and all faults on the 500KV transmission line have been isolated properly by the new protective relaying systems.

C. **ABB Power T & D - 500KV Circuit Breakers Replacement:**
The 500KV circuit breakers were installed over a one year period beginning January 1992 and ending January 1993. The warranty period of 24 months on the equipment system has been completed, except for the circuit breaker pneumatic and electrical operating mechanism which has a 5 year warranty period ranging from August 1997 to January 1998. Several warranty problems have occurred and the necessary corrective actions have been made by the contractor.

D. **ABB Power T & D - 15KV Circuit Breakers Replacement:**
The 15 KV unit circuit breakers were installed over a two year period beginning in April 1993 and ending April 1995. The warranty period of 24 months on the circuit breaker system has been completed, except for the breaker pneumatic and electrical operating mechanism which has a 5 year warranty period ranging from April 1998 to April 2000. The circuit breakers have operated properly. To date, there has been no mis-operation of these circuit breakers.

E. **Fru-Con Co. - Gates & Mechanical Equipment Rehabilitation:**
Work to rehabilitate the gates, trash racks, draft tubes and gantry cranes occurred over a 33 month period beginning in September 1992 and ending in June 1995. All work performed and equipment rehabilitated has a 5 year warranty from the date of the Construction Completion Certificate for the

specific contract bid item. The rehabilitated gates, gate sealing system and civil and mechanical rehabilitation of the draft tubes, resulted in a tested water leakage rate that has averaged 5% of the maximum allowable leak rate specified in the contract. Dewatering of tunnel No. 3 in September 1995, to allow for the Voith warranty inspection of runners Nos. 5 and 6, took less than 12 hours using a single small capacity pump, as compared to 48 hours to several days using three large capacity pumps on tunnels prior to rehabilitation. To date, there have been no warranty problems.

Project Cost:
The total project obligated cost over the LOP was $140 million. Total disbursements at the Terminal Disbursement Date (TDD) was $139,515,759.

Long Term Achievements:
Allis-Chalmers, utilized modern computer modelling design of the turbine runners and specified state-of-the-art stainless steel metallurgy, casting and machining processes, welding techniques and welding rod alloys, in the fabrication of the turbine runners, all of which were absent in the originally designed and furnished Soviet runners. The Allis Chalmers designed turbine runner produced a 3.7 percent increase in turbine efficiency when compared to the replaced Soviet runners when operated at the historic average water elevations of the reservoir.

The ABB furnished 500KV and 15KV circuit breakers underwent prototype factory tests involving 50,000 operating cycles. The Gilbert Commonwealth 500KV protective relaying system utilized high speed and high reliability solid-state devices.

Fru-Con's rehabilitation of the civil work in the pen stock and draft tube water passages utilized high tech concrete with a compressive strength of over 10,000 pounds per square inch. The Fru-Con rehabilitated gantry cranes utilized modern control circuits and motors with finely controlled variable speed which permit the gates to be lowered and set into place without damage to the seals or concrete embedded gate baseplate.

Based on the estimated life of similar hydroelectric installations would indicate that the project furnished equipment and rehabilitation work has reasonably extended the life of the power station by more than 30 years. The High Dam releases through the turbines approximately 54 billion cubic meters of water per year. The High Dam Power Station annually produces an average of 8 billion KWHr of electrical energy which is equivalent to burning 2 million tons of oil at a fossil fuel power station. The improved efficiency and extension in the life of the power station results in the averted use of 2 million tons/year of mazout oil, which would cost the GOE LE 20 million/year based the cost of oil to produce the same amount of electrical energy. The averted use of

2 million tons/year of mazout oil averts annual emissions of 7.7 million tons of carbon dioxide, 118 thousand tons of sulfur dioxide, 2 thousand tons of nitrous oxides, and 6.7 thousand tons of particulates.

5. TRAINING:

Allis Chalmers - Runner Replacement Contract:
Under the terms and conditions of the contract Allis Chalmers trained 15 EEA engineers and technicians for four weeks at the Woodward Governor Co. factory in Chicago, IL, and at Allis Chalmers plant in York, PA.

Training included hydraulic turbine theory, design, manufacturing, inspection, final machining, quality assurance, maintenance of turbines, and operations and maintenance of turbine hydraulic operated governors.

In addition to the formal training required in the contract, EEA personnel received extensive "on the job training". Allis Chalmers, in the capacity of the prime contractor, negotiated and signed a subcontract with the Egyptian High Dam Electric Co. (HIDELCO) to provide personnel needed in the replacement of the turbine runners and governors. HIDELCO signed a Seconding Agreement with EEA whereby EEA would assign EEA power station engineers and craft personnel to work under the direction of HIDELCO. The work involved the disassembly and removal of the generator, exciter and rotor, turbine shaft and runner, followed by the installation of the new runner, shaft and generator rotor and exciter. Addition work included the machining and replacement of new wicket gates. Approximately 500 EEA personnel participated in this work over a 65 month period beginning in early 1985. The activities performed by EEA personnel enhanced their technical and craft skills and experience in the operation and maintenance of the turbine-generators.

Gilbert-Commonwealth International - Protective Relay Replacement Contract:
Under the terms and conditions of the contract, GCII trained 20 EEA engineers and technicians for a ten week period at their company headquarters in Reading, PA and for three weeks in the ABB training center in Baden, Switzerland. The training consisted of two Phases with Phase I focusing on the philosophy and the basis for the design of protective relays in an integrated system, various relaying schemes designs, interaction and coordination with associated protection equipment, system wide relaying operation, use of schematic and wiring diagrams determining normal operation, and the detection of malfunctions. Phase II training consisted of the operation and maintenance of individual pieces of equipment with instruction provided by experienced manufacturers and technical representatives. The instruction focused on the theory of operation of the relay components, setting requirements,

testing, trouble shooting and repair.

ABB Power T&D Co. - 500KV Power Circuit Breaker Replacement Contract:
Under the terms and conditions of the contract, ABB trained 19 EEA engineers and technician for a period of two weeks at their factory in Greenburg, PA. The training provided instruction on the operation and maintenance of the 500KV circuit breakers. The training included the philosophy and basis for the design of the 500KV circuit breaker, various control system that make up the systems controls, operating mechanism, operation of the circuit breaker, maintenance and servicing requirements, trouble shooting, testing, calibration and installation procedures, and training in the use of schematic and wiring diagrams, interpretation of performance data, and repair procedures on the electrical and pneumatic controls.

ABB Power T&D Co. - 15KV Unit Circuit Breaker Replacement Contract:
Under the terms and conditions of the contract, ABB trained 24 EEA engineers and technicians for a period of two weeks at their factory in North Brunswick, NJ. This training provided instruction on the operation and maintenance of the 15KV unit circuits breakers. The training focused on the design, operation, interaction and coordination with associated generator equipment as well as the theory of operation of the individual components, setting requirements, testing, normal breaker operation and malfunctions, trouble shooting, and equipment repairs, and the use of circuit breaker drawings in determining breaker operation and maintenance.

Bureau of Reclamation - Engineer Advisor PASA Contract:
Under the terms and conditions of the USAID/BUREC PASA agreement, BUREC furnished generator winding index test equipment and on site training to EEA engineers and technicians. This equipment was used to test the electrical generator winding insulation integrity, and is used during the annual generator maintenance program. Annual testing of the windings with this equipment will determine if any deleterious condition, such as overheating, moisture or fault currents, have occurred which would shorten the operating life of generator. During the rehabilitation of several of the hydro turbine generators, inspections had revealed early signs of insulation deterioration. Subsequent use of this test equipment on other units confirmed similar aging which has been corrected during each unit's rehabilitation.

The BUREC also provided EEA with state-of-the-art insulation test equipment specifically designed for the analysis of insulating oil. The equipment included a Gas Chromatograph, Dielectric Power Factor, Flash Point, Interfacial Tension and Moisture Content test equipment.

At the request of EEA, BUREC in cooperation with the Hughes Training Co. Link Division, supplied EEA with computer based training modules which were developed for the BUREC in training their operating staffs at Hoover Dam and other BUREC installations. These training modules included: 1) relaying protection of generator, transformers, bus, transmission lines; 2) excitation theory of transmission line; 3) generator regulation theory; and 4) static voltage regulators.

Overview of Project Training:
Both the contract required formal training provided by Allis Chalmers, Gilbert-Commonwealth and ABB, and the informal experience gained by EEA in the Allis Chalmers contract, greatly enhanced the capabilities of the High Dam Power Station staff to both operate and maintain the equipment which was furnished. Subsequent to the PACD, EEA implemented a computer based maintenance scheduling program at the High Dam which should compliment the training received during the project.

6. POST PACD ACTION:
The project is complete and post PACD action is not required. All Contractors continue to perform warranty inspection and testing work under the terms of the contracts.

7. PROJECT STATUS:
The project is complete. All funds have been disbursed. All residual funds have been Decommitted and Deobligated. Some equipment and rehabilitation work performed remains under warranty. The power station is operating normally. The Runners remain under warranty. The replacement circuit breakers and relaying protection is operating normally. The rehabilitated gate leakage rates on average are less than 5% of contract allowed maximum allowable tolerance which mean more water to generate and reduced unit down time to perform maintenance work.

8. OUTSTANDING PROBLEMS:
There are no remaining problems with this project. All covenants were met, and all outputs were achieved. There is no recommendation for follow-on action.

9. LESSONS LEARNED:

General Analysis:
When ever possible, the Project Contractor and Subcontractors should consider utilization of the GOE Implementing Agency staff and manpower in performing work associated with a rehabilitation or modernization project at existing facilities, as was the case for the runner replacement project. For this project the direct benefits included: the contractor having ready access to a pool of skilled labor directly from the Implementing Agency at the project site; in the course of performing the project work, the contracted work crews enhance their Operation & Maintenance (O&M) skills from

the "hands on" experience gained during the project work which they will utilize during future O/M periods.

In the course of performing rehabilitation work on older power stations, unforeseen conditions are frequently encountered which demand flexibility on the part of all parties to identify and determine the merit of performing additional work or the justification to cancel work found to be unnecessary. The ultimate objective of rehabilitating the power station was met by USAID when additional problems were discovered in the hydraulic gates, 15KV circuit breakers and other system which required additional funding. Conversely, original components of the project were deleted when it was found that spare parts could be acquired thus eliminating replacement of the 132KV circuit breakers. In the Fru-Con contract, it was discovered that the 150 ton gantry crane main drive reducer had pre-existing damage due to a faulty design, and it was discovered that the intake gate lifting mechanism wire rope had been previously damaged, and in both case the equipment or parts were replaced. In the Fru-Con contract, removal of rock and concrete in order to place the temporary sealing bulkhead was not permitted by the Ministry of Irrigation who is responsible for the dam structure, and the Contractor was required to initiate a design change which allowed the work to continue.

Specific Analysis:
Replacement of the first 6 units occurred during a drought period that resulted in inordinately low water levels in Lake Nasser. These low water levels reduced the operating hydraulic head on the runners to unforeseen levels that threatened the safe operation of the new runners. At the request of EEA, Voith Hydro performed additional tests over the full range of conceivable hydraulic heads to determine the threshold of cavitation and damage to the runner. At the request of EEA the BUREC modeled the water intake structure and inlet canal and conducted hydraulic studies to determine at what lake level and discharge rates vortices would form at the entrances to intake tunnels and to identify operating interventions that would prevent their formation. Both studies provided EEA with operating procedures that would extend the range of operation under the most adverse head conditions.

The replacement of the turbine runners, and associated terms of the warranty, mandated exhaustive testing of the welding which included Cobalt-60 x-ray, ultrasonic and dye penetrate testing, as well as laboratory testing and analysis of the molecular composition of the welds. The BUREC is not aware of any testing program in the world that is as rigorous. The BUREC have revised many of their testing and inspection procedures based on the experience gained at the High Dam. The comprehensive testing program has been the subject of several technical papers presented at technical association meetings.

The Fru-Con contract required that all concrete used in the rehabilitation of the draft tubes have a compressive strength of 9,800 pounds per square inch (PSI). This required the utilization of modern additive materials used in the mixing, or batching, of the concrete and high quality assurance procedures throughout the entire batching, placement and curing of the concrete. In addition, it was discovered that there was only one location where the optimum quality of sand was located in Egypt and that the cement had to be imported from the U.S. since the local cement could not be used to reach the compressive strength requirements. In addition, Fru-Con developed techniques to use liquid nitrogen to cool the aggregate rock in the batching operation needed to meet the compressive strength.

The rehabilitation of gates and mechanical equipment contract required the removal of eroded and damaged concrete, and the repair of the gate horizontal metal baseplate and gate vertical metal guideways. The contract also specified that only two of the twelve generators could be removed from service at any one time in order to meet water release irrigation and generation schedules. To perform this work, it was necessary to install a temporary sealing type barrier, or bulkhead, at the outer entrance of the draft tubes, to allow the tunnel to be dewatered and the gates removed in order to create a dry working environment and provide access to the concrete and metal work to be repaired. The opening of an individual draft tube is approximately 11 meters by 28 meters. For openings this size, industry practices would dictate the installation of a temporary metal sheeting and/or earth filled coffer dam to provide the dry conditions necessary to remove the gates and perform the work. A more sophisticated and technically advanced approach was used for this project. The BUREC provided the design for a bulkhead device complete with sealing material, control valves and internal ballast chambers which in the buoyant mode was floated to the site and air was vented to atmosphere as water was admitted to the chambers permitting the bulkhead to be sunk in place, and secured and sealed to the outer surface of the draft tube. The tunnel, and associated draft tube passage, was dewatered and the gates removed allowing the work to be performed. Upon completion and acceptance of the work, the bulkhead chambers were pressurized with compressed air, discharging the chamber water, to the point of buoyancy, and then floated to the next draft tube where the process was repeated. Fru-Con prepared a technical paper on the use of large bulkheads and submitted it to the Engineering News Report for publication. The use of this large bulkhead at the High Dam will reshape industry practices for similar projects in the future.

10. AUDITS:

The Office of the Inspector General for Audit, RIG/A/Cairo, performed two functional audits of the Project in 1989 and 1995 as part of larger audits of a number of projects. The objectives of the audits was to:

a. evaluate the Mission's procedures in monitoring the GOE's local currency and in-kind contributions and assess the adequacy of controls for the accounting of local currency and in-kind contributions,

b. determine how effectively project financed machinery and equipment are being utilized.

The first audit of this Project in 1989 revealed that while the High Dam Power Station staff had established detailed accounting records for project expenditures involving AID funds as well as local currency, there was no monitoring system to ensure that the GOE's local currency and in-kind contributions were being made. A monitoring system was established that met all requirements to RIG/A/Cairo.

The second audit of the project in 1995 showed that equipment and machinery financed by AID was being used effectively and identified significant improvements in the operation, maintenance and efficiency, as result of the USAID funded project. The report also noted that since the replacement of the new turbine runners, no stress cracking in the turbine blades had occurred to date.

11. RECOMMENDATION:
That the Associate Director, DR, approve the High Dam Rehabilitation & Modernization Project Assistance Completion Report and approve the change in project status from "Active" to "Completed".

APPROVED: _____

DISAPPROVED: _____

DATE: 9/22/96

Information:
AID/W/POL/CDIE

TABLE 1

FINAL PROJECT FINANCIAL REPORT				
ELEMENT	**PROJECT**	**OBLIGATED**	**EARMARKED**	**DISBURSED**
1	PROFESSIONAL SERVICES	10,800,000	10,799,966	10,742,427
3	TURBINE REPLACEMENT	81,573,628	81,573,628	81,573,628
4	500KV RELAY REPLACEMENT	13,999,307	13,999,307	13,999,307
5	500KV CIRCUIT BREAKER REPLACEMENT	9,375,935	9,375,935	9,375,935
8	GATE AND MECHNICAL REHABILITATION	19,771,000	19,731,266	19,344,341
11	15KV CIRCUIT BREAKER REPLACEMENT	4,480,130	4,480,121	4,480,121
	TOTALS	**140,000,000**	**139,960,223**	**139,515,795**

TOTAL FUNDS TO BE DE-OBLIGATED - $484,205[1]

NOTES:

* Total Life of Project Obligated funds was $140,000,000. Prior to the issuance of this report, $39,777 was De-Obligated.

Doc. ID "PACRFIN":DRPTM\DOCS **(Updated: 09/04/96)**