DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
CECW-E Washington, DC 20314-1000

Regulation
No. 1110-2-109 1 November 2001

Engineering and Design
HYDROELECTRIC DESIGN CENTER

1. Purpose. This regulation designates the U.S. Army Corps of Engineers District, Portland, Hydroelectric Design Center (HDC), as the Mandatory Center of Expertise (MCX) for hydroelectric power engineering and design and a Directory of Expertise (DX) for flood control pumping plant engineering and design. It also prescribes the requirements for use of HDC by the U.S. Army Corps of Engineers (USACE) commands and establishes policy and provides guidance for interfacing the resources of HDC with those of the requesting USACE command.

2. Applicability. The regulation is applicable to all HQUSACE elements, major subordinate commands (MSC), districts, laboratories, and field operating activities having civil works operation and maintenance (O&M), construction, and planning and/or design responsibility for hydroelectric and/or flood control pumping plants.

3. References.

a. ER 5-1-10, Corps-wide Areas of Work Responsibility

b. ER 1105-2-100, Planning Guidance Notebook

c. ER 1110-1-12, Quality Management

d. ER 1110-1-8158, Corps-wide Centers of Expertise Program

e. ER 1110-2-1150, Engineering and Design for Civil Works Projects

f. ER 1110-2-1200, Plans and Specifications for Civil Works Projects

g. ER 1110-2-1454, Corps Responsibilities for Non-Federal Hydroelectric Power Development under the Federal Power Act

h. ER 1130-2-500, Partners and Support (Work Management Policies)

i. ER 1130-2-510, Hydroelectric Power Operations and Maintenance Policies

____

This regulation supercedes ER 1110-2-109, 15 April 1993 and ER 1110-2-4402, 14 January 1994.

4. Distribution. This document is approved for public release; distribution is unlimited.

5. Policy. The current hydroelectric power workload within the Corps and the need to preserve the Corps hydroelectric engineering expertise make it necessary to consolidate that workload at a centralized office. In accordance with the requirements of ER 1110-1-8158, HDC has been established as an MCX responsible for hydroelectric power plant engineering and design and a DX for flood control pumping plant engineering and design. All work identified hereinafter shall be executed, reviewed or otherwise controlled in accordance with ER 1110-1-8158 and ER 5-1-10. The planning, engineering and design of hydroelectric power and flood control pumping plants require highly specialized expertise. The capability and expertise to execute this highly specialized work now exist within HDC. HDC will maintain, within the Corps, the capability and proficiency required for the planning, engineering, design, and criteria development for all existing and new hydroelectric power and flood control pumping plants. HDC will keep abreast of emerging technologies for hydroelectric power and flood control pumping plants. This regulation applies to Corps projects and when the Corps is requested by others to provide such services regardless of the source of funds. Professional engineer registration at HDC is required for the positions that have direct oversight of the technical engineering design functions at the branch level.

6. Responsibilities.

a. HQUSACE. The Chief of Engineering and Construction Division, Civil Works Directorate (CECW-E) is assigned oversight responsibility of HDC. CECW-E will coordinate all actions that involve operation and maintenance issues with the Chief of Operations Division (CECW-O) and all actions that involve planning and policy issues with the Chief of Planning and Policy Division (CECW-P). The HQUSACE proponent responsible for the duties identified in ER 1110-1-8158 is CECW-E.

b. MSC. In accordance with ER 1110-1-8158, each MSC is responsible to monitor and to ensure that HDC has been used for the design activities of their districts as required by this regulation. The MSC is also responsible to review any proposed exceptions to the use of HDC services prior to submitting to HQUSACE (CECW-E) for approval.

c. USACE Command.

(1) The USACE command responsible for managing the work will:

(a) Obtain the services of HDC for the work listed in paragraph 7.

(b) In accordance with ER 1110-1-8158, include a statement in their project documentation that HDC has been appropriately used in the planning, design, and execution of the project; and document any HQUSACE approved exceptions to its use.

(c) Retain overall responsibility including funding, scheduling, contracting and construction management and oversight.

(d) Coordinate all scheduling with that of HDC at the earliest practical date. This date will be 3 to 6 months prior to budgeting line items for which HDC's services will be required, unless other arrangements are made. The development of any schedule must take into account prior commitments of HDC.

(e) Coordinate with HDC, at the time of initial scheduling, the development of a scope of work in sufficient detail to permit HDC to prepare a preliminary cost estimate of the required engineering services and to update the schedule and cost estimate prior to commencement of the work. Funds will be provided to HDC for its participation in this development phase of the work.

(f) Fund HDC for the services to be performed and furnish necessary project information in time to permit HDC to complete the design on schedule.

(g) Execute the construction or repair of the powerhouse and pumping plant, and procure and install the equipment.

(h) Keep HDC informed of all anticipated changes to the completed hydropower design and flood control pumping plant designs done by HDC. Changes will be made only if jointly agreed to by HDC and the requesting USACE command.

(2) The USACE command shall notify HDC of required emergency services needed as a result of the failure of equipment or systems that HDC has mission responsibility, as identified in Appendix A. The command shall also coordinate its in-house resources with that of HDC. Emergency services are defined as design, preparation of contract documents, or consultation services necessary to restore or replace failed power plant equipment to initially an interim functional state then through major repair or replacement to full operational capability.

(3) Routine maintenance and repair shall remain the responsibility of the requesting USACE command. Routine testing and evaluation of major equipment, except for turbine performance testing, will remain with the requesting USACE command.

(4) When the work done by HDC becomes part of a larger contract or design document, the USACE command will furnish HDC the completed contract or design document for review to ensure proper coordination of HDC's work.

(5) All engineering and design functions not listed in paragraph 7, e.g., hydraulic and hydrologic, structural (except as herein identified), geotechnical, and cost engineering will remain the responsibility of the USACE command.

(6) USACE commands planning the installation of a new hydroelectric unit to furnish station service power at existing or new flood control, navigation and other non-hydropower facilities will follow the requirements established in Appendix B.

d. Hydroelectric Design Center.

(1) HDC has been assigned mission responsibility for providing engineering services to the requesting USACE command for hydroelectric power and flood control pumping plants. To accomplish the work of the requesting USACE command, HDC has the option to use A-E services or, with the concurrence of the requesting USACE command, use the resources of another available and capable USACE command. HDC can also use resident expertise at Corps laboratories to perform physical or numerical model studies. When HDC decides that the use of A-E services is required for the mandatory work identified in this document, the USACE command can either have HDC contract for the A-E services or directly contract for the A-E services.

(a) When HDC contracts for the A-E services, the requesting USACE command can provide a direct fund cite to HDC, which will assure that the A-E services are counted towards the requesting USACE command's private sector contracting goal.

(b) If the USACE command decides to contract directly for the A-E services, or use an indefinite delivery A-E contract awarded after the publication date of this document, HDC must be involved in setting the scope, included in the A-E selection process as a voting member in assessing the A-Es technical competency, and have technical oversight and technical approval authority for the mandatory work identified in this document.

(c) If the USACE command decides to use an ongoing indefinite delivery contract to produce mandatory work identified by this document, HDC must review the A-E technical qualifications and the contract scope. If found not qualified or not within scope, the command can either restart the process to select another A-E or contract an A-E firm through HDC.

(2) HDC will furnish to the requesting USACE command the best possible cost estimate for its services commensurate with the scope of work provided and the best possible technical design consistent with the stated requirements. HDC will coordinate its design efforts with the requesting USACE command and will keep that command fully informed regarding the pertinent features and status of the design through monthly progress reports. Any HDC coordination that may be required with the USACE command's local sponsor will be done through the USACE command.

(3) Prior to commencing work, HDC will review the latest scope of work with the requesting USACE command to ensure that there is agreement and understanding on content, schedule, and cost. A written agreement will then be prepared by HDC confirming: the work to be accomplished, the schedule, and the cost. Both the requesting command and HDC must agree in writing to any revision, requested by either party, to the original schedule or design cost for proposed work and for work in progress. This includes

schedules and design costs for work to be done by in-house HDC resources, A-E or another USACE command. HDC will keep the requesting USACE command informed about problems which could delay completion of the design or impact other aspects of the project or work item and potential design cost overruns. If needed and after consultation with the requesting USACE command, HDC may establish priorities based on workload and project or work item requirements. However, emergency services as defined above will always have high priority. HDC will also provide a list of technical data needed to perform its work and a schedule of when the data is required.

(4) HDC is responsible for performing an independent review and approval of all its work. HDC will develop a Quality Control Plan (QCP) in accordance with ER 1110-1-12 for the services that it provides. The plan will be submitted with the preliminary cost estimate for the engineering and design services to be provided.

(5) HDC will report the quarterly status of the work being performed and the anticipated future workload to the assigned HQUSACE proponent. HDC will also provide the proponent with updated electronic data for posting on the HQUSACE homepage as needed. The data will include information identified in ER 1110-1-8158.

(6) HDC will submit a biennial report of the status of its program to the HQ proponent. Submission of the report can coincide with submission of the recertification document identified in paragraph 11. The report will provide a description if its organization, an overview of its program, a summary of its performance and accomplishments, and near term and long term outlook of its anticipated workload. The report will analyze HDCs staff with respect to size and content for its current and anticipated programs, and will include copies of the quarterly status reports and copies of evaluations provided by its customers and any subsequent actions resulting from the evaluations. The report will identify the percentage of work contracted to the private sector, and will identify work done for other organizations. Funding sources and all recommended alternatives to its current method of conducting business will be identified. The report will identify how the center maintains capability and proficiency, how it kept abreast of emerging technologies and how well its quality control program is working. All the information will be appropriately supplemented with charts, tables and graphs.

e. Portland District. HDC is a Corps-wide resource and is attached to the U.S. Army Corps of Engineers Portland District for day-to-day administrative oversight and administrative support. The Director of HDC will report to the district commander.

7. Work to be Performed by HDC. This paragraph describes both the mandatory services that must be performed by HDC and optional services that will be performed by the HDC if requested by HQUSACE or a USACE command.

a. Mandatory services. Except for the USACE command responsibilities identified in paragraph 6, HDC has mission responsibility to provide engineering and design services for hydroelectric power plant equipment and/or systems identified in Appendix A. HDC must do the following:

(1) Provide input to the electrical and mechanical portions of reconnaissance reports and other preauthorization studies; prepare design reports; prepare studies for uprating, rehabilitation, or replacement of equipment or systems and provide input for preliminary cost estimates.

(2) Perform the electrical and mechanical engineering and design.

(3) In addition to the requirements of subparagraph (7), provide structural engineering services to coordinate the plant layout, foundation support for mechanical and electrical equipment, structural modifications and/or additions, and crane requirements with other technical disciplines.

(4) Prepare contract plans and technical specifications. Assist the requesting command in preparing the non-technical portions of the contract documents and provide input to the construction cost estimate.

(5) Provide the technical review of shop drawings that include engineering or design work completed by the contractor.

(6) Provide technical assistance to the Contracting Officer's Representative during contract period and at all shop and field tests, including model tests. Analyze results, make recommendations, and provide engineering services during construction.

(7) In accordance with ER 1110-2-1454, review the following structural and mechanical features that could affect the integrity and safety of Corps projects; penstocks, vents, bifurcations, gates, valves and hydraulic transient analyses.

(8) HDC will provide engineering and design services for the planning and installation of station service hydroelectric units in accordance with Appendix B.

(9) Conduct failure analyses for major equipment.

(10) Perform turbine performance testing.

b. Optional services. At the request of a USACE command or HQUSACE, HDC will perform the following services:

(1) Prepare or assist in preparation of O&M manuals.

(2) Provide support for hydroelectric and pumping plant training programs involving engineering and design.

(3) Provide support to HQUSACE or USACE commands on hydroelectric and pumping plant matters. This includes preparation of new criteria, update/revision of existing criteria, and execution of special studies to determine equipment condition indicators and/or reliability projections.

(4) Assist in periodic inspections.

(5) Test and evaluate the performance and condition of existing major equipment.

(6) USACE commands can assign COR authority to HDC for approving technical submittals, model tests, and field performance tests of major equipment.

(7) For flood control pumping stations:

(a) Perform engineering and design services.

(b) Provide input to the electrical and mechanical portions of reconnaissance reports and other preauthorization studies.

(c) Prepare design reports and prepare studies for rehabilitation, or replacement of equipment or systems.

(d) Provide input for preliminary cost estimates.

(e) Provide technical assistance to the Contracting Officer's Representative during contract period and at all shop and field tests, including model tests. Analyze results, make recommendations, and provide engineering services during construction.

(f) Provide structural engineering services to coordinate the plant layout, foundation support for mechanical and electrical equipment, structural modifications and/or additions, and crane requirements with other technical disciplines.

(g) Prepare contract plans and technical specifications. Assist the requesting command in preparing the non-technical portions of the contract documents and provide input to the construction cost estimate.

(h) Provide the technical review of shop drawings that include engineering or design work completed by the contractor.

(8) Review the testing and evaluation of existing major hydroelectric equipment performance performed by others.

(9) Provide engineering services for hydroelectric equipment not identified in Appendix A.

(10) Revise contract drawings to reflect "as-built" conditions.

(11) Provide assistance to develop, conduct and evaluate value engineering studies.

8. Method of Operation. The following lists HDC's method of operation and specific operational requirements for both HDC and the requesting USACE command.

a. General. HDC will evaluate requests from USACE commands and will assign engineering functions to maximize its resources and maintain its technical capability and expertise.

b. Activity scheduling. Each year in November, HDC will request Commanders of the USACE commands, having responsibility for Civil Works projects, to provide the best estimate of anticipated needs for HDC services in terms of dollar value of design effort or assistance for the ensuing 2- to 5- year period. The USACE commands should respond by January. HDC will then meet with district representatives in February to discuss line items in the budget that could impact HDC's workload.

c. Funding for HDC services. HDC will develop a preliminary cost estimate and a QCP for its services based on the scope and schedule agreed to between HDC and the requesting USACE command. The parties involved must mutually agree to any revisions made to the cost estimate. Each USACE command also has the option to establish a "small-on-call" account with HDC. This account will facilitate a rapid response to emergencies and will provide initial funding for the development of scopes of work, schedules and cost estimates for its services. HDC will charge to this account only when specifically authorized by the requesting USACE command and excess funds will be returned in the fourth quarter of each fiscal year.

d. Review and approval process. The review and approval process will be in accordance with the requirements of ER 1110-2-1150 and ER 1110-2-1200.

e. Quality management. The quality control and quality assurance roles and responsibilities established in ER 1110-1-12 will be followed for the products or services provided by HDC.

f. Interoffice communication and coordination. Direct correspondence and communication between HDC and the requesting USACE command are authorized. This is necessary to define scope(s) of work, determine schedule(s) and funding, coordinate the design, administer contracts, and to keep the respective parties fully informed as to the status of the work.

g. Evaluation. Upon completion of the work provided by HDC, the requesting USACE command and HDC can perform a written evaluation of the services provided. The evaluation will be a check on how well the process worked and where improvements are needed to develop a quality product on time and within budget. HDC and the requesting USACE command will complete its respective part of the evaluation form and it will be forwarded by the USACE command to HDC, the appropriate MSC, and HQUSACE (CECW-E). The blank evaluation form will be provided to the USACE command by HDC.

h. Regional Office. HDC has engineering and design responsibility for an existing regional office established within an MSC for the mandatory services identified by this regulation.

i. Conflict resolution. Conflicts or differences should be resolved between HDC and the USACE command. If a conflict or difference develops that cannot be resolved by mutual agreement between the parties involved, it should then be elevated to the Command's MSC for resolution. Finally because HDC is a Corps-wide asset, HQUSACE (CECW-E), if requested by either HDC or the MSC, will resolve the conflicts or differences.

j. Team approach. HDC and the requesting USACE command will take a team approach to produce the product or work item. The site-specific, resident expertise that exists at the USACE command will participate as a member of the planning and design team assembled by HDC.

9. Research and Development. Upon direction from CERD, HDC will be responsible to participate in, review, or monitor research and development work unit activities for hydroelectric power plants

and flood control pumping plants. HDC will participate with other field users in identifying Civil Works research and development needs. Staff members of HDC will also participate, as members of the Civil Works R&D Field Review Group in their area, in reviewing, advising, and assisting in the technology transfer of research results. HDC may also conduct joint research, development, and demonstration projects with the Corps laboratories as directed by CERD.

10. Exceptions. A request for an exception to the requirements of this regulation will be fully justified and submitted to HQUSACE (CECW-E) in accordance with ER 1110-1-8158.

11. Recertification. HDC will be recertified as an MCX every two years according to the requirements of ER 1110-1-8158 Appendix A. Six months prior to its recertification date, HDC shall provide the HQUSACE proponent a draft copy of the recertification document as outlined in the Appendix.

12. Agency Representation. HDC is authorized to represent the Corps on industry technical committees related to hydroelectric power and flood control pumping plants.

FOR THE COMMANDER:

2 Appendices
APP A – HDC's Engineering and Design Mission Responsibility
APP B – Station Service Power

ROBERT CREAR
Colonel, Corps of Engineers
Chief of Staff

APPENDIX A
HDC'S ENGINEERING AND DESIGN MISSION RESPONSIBILITY

A-1. Purpose. This appendix identifies the technical nature and extent of HDC mission responsible work and the level of HDC's involvement.

A-2. New Projects.

a. Hydroelectric power plants. HDC is fully responsible to provide the planning, engineering and design of all mechanical and electrical equipment and systems in new hydroelectric power plants including equipment arrangement and coordination with structural aspects of the new facility.

b. Flood control pumping plants. When requested by a USACE command, HDC will provide the planning, engineering and design of all mechanical and electrical equipment and systems in new flood control pumping plants including equipment arrangement and coordination with structural aspects of the new facility.

A-3. Existing Projects.

a. Flood control pumping plants. When requested by a USACE command, HDC will provide the planning, engineering and design for the major rehabilitation, major maintenance, major repair work, and system configuration or operational modifications to existing flood control pumping plants. Definitions for major rehabilitation, major maintenance, major repair work, and system configuration or operational modifications are provided below.

b. Hydroelectric power plants. Table A-1 identifies the nature and extent of HDC mission responsible work and the level of HDC's involvement for existing projects.

(1) Definitions.

(a) Level 1 is defined as HDC's mandatory mission work. HDC is fully responsible for all Level 1 work. The design, function and operating criteria of the systems, equipment, and component integration are either so critical or so complex that thorough and specialized knowledge is required to assure the equipment will operate as expected and/or guaranteed and achieve its design life. Design for power generation and transmission equipment involves close coordination among component characteristics and ratings, adjustments and settings, governing standards, established practices, changing technologies, and marketplace conditions including the shifting roles of the relatively few manufacturers available. Inadequate design or coordination among the various components can easily cause failures resulting in long-term outages. A written Memorandum of Understanding (MOU) between the district and HDC will cover all work in this category.

(b) Level 2 is defined as work that has a direct interface with HDC's mission area and can affect powerhouse operations. This work may be performed by a district's engineering staff or optionally may be performed by HDC if the district does not have capability or current expertise. HDC will participate in the formal and informal scope development, participate in the Independent Technical Review, and have technical approval authority for the mandatory work identified in this document. All work in this category will be covered by written MOU between the district and HDC.

(c) Level 3 is defined as routine maintenance and repair engineering and engineering for replacement-in-kind of system components. Prior to performing this type of work, the district needs only to discuss the scope of work with HDC to gain the benefit of HDC's related experiences. This discussion and exchange of knowledge should avoid inadvertent or unanticipated consequences and may reveal better options for the replacement-in-kind work. The district also has the option of having HDC perform this type of work.

(d) Major Rehabilitation and Major Maintenance. Major Rehabilitation is defined in ER 1130-2-500. Major Maintenance is defined as a non-repetitive item of work or aggregate items of related work in which the total estimated cost exceeds $3 million and does not qualify as Major Rehabilitation.

(e) Major Repair, System Configuration or Operational Modifications. Major Repair is defined as work that is beyond routine preventative maintenance requirements. System Configuration or Operational Modifications is defined as work that involves a fundamental change in the way a powerhouse or pumping plant system is configured or operated. Representative examples include:

- Adding a new back-up source of water to the generator cooling water system
- Changing a rotating excitation system to a static excitation system
- Changes to the transformer or switchyard configuration
- Changing bridge crane control systems
- Adding new wall penetrations below pool or tailwater
- Changing pump start/stop elevations.
- Replacing obsolete analog meters and instrumentation with digital devices
- Repairing and/or replacing equipment or systems on an emergency basis due to an in-service failure.

(f) Equipment and System Repairs and Direct Component Replacement is identified as work that is normally the responsibility of project operations.

(2) Matrix. Paragraph (3) provides a detailed description of the equipment and systems identified in Table A-1.

Table A-1

Equipment or System for Hydroelectric Power Plants	Major Rehabilitation and Major Maintenance Engineering and Design (E&D)	E&D for Major Repair, System Configuration or Operational Modifications	E&D for Equipment and System Repairs and Direct Component Replacement
1. Turbines – Group A	Level 1	Level 1	Level 2
2. Turbines – Group B	Level 2	Level 2	Level 3
3. Governors	Level 1	Level 1	Level 3
4. Intake Closure Devices	Level 1	Level 1	Level 3
5. Submerged Mechanical Equipment in or in front of the water passageway.	Level 1	Level 1	Level 3
6. Structural Modifications to the powerhouse and/or structural modifications or additions in or in front of the turbine intakes	Level 2	Level 2	Level 3
7. Main Unit Bridge Cranes	Level 1	Level 1	Level 3
8. Mechanical Peripheral Equipment Group A	Level 1	Level 1	Level 3
9. Mechanical Peripheral Equipment Group B	Level 2	Level 2	Level 3
10. Generation and transmission system and equipment	Level 1	Level 1	Level 3
11. Control systems	Level 1	Level 1	Level 3
12. Station service power system	Level 1	Level 1	Level 3
13. Powerhouse Auxiliary Electrical Equipment – Group A	Level 1	Level 1	Level 3
14. Powerhouse Auxiliary Electrical Equipment – Group B	Level 2	Level 2	Level 3

(3) Equipment or System Description.

(a) Turbines - Group A includes those component parts of the turbine and pump turbine that are considered critical to power production. These components include embedded and formed parts (turbine intakes, spiral cases, spiral case extensions, penstocks including hydraulic transient analysis, stay vanes, discharge rings, draft tubes, piezometer taps). Also included are non-rotating parts (head covers, wicket gates, seals, bearings, bushings, servomotors, wicket gate linkages, oil heads, wearing rings, manual and automatic gate lock system), rotating parts (all), ASME and IEC field performance (Index & Gibson) testing, and design, fabrication, and testing of models.

(b) Turbines - Group B consists of all turbine parts and systems not mentioned above.

(c) Governors are the turbine control unit and as such are critical to power production. The governor opens the gates on unit startup, closes the gates on unit shutdown, prevents the unit from going to overspeed and adjusts the blade angle of the adjustable-blade turbines to optimize efficiency. Governors include oil tanks, piping, pumps, valves, actuator and sump.

(d) Intake/Tailrace Closure Devices are used to shut off water to the unit in the event the governor loses control of the turbine or when flooding of the powerhouse may otherwise occur. This is a highly critical emergency back up system. Intake/tailrace closure devices include gates, gate hoists, gantry cranes, butterfly valves and spherical valves. Intimate knowledge of the power plant operation is required to ensure that the gate closure sequencing, timing and speed will safely close off the water flow when required.

(e) Submerged Mechanical Equipment in or in front of the water passageway includes the fish guidance systems and other components that are in or in front of the turbine intakes. This equipment directly effects the operation of the turbine and can increase hydraulic losses across it. Hydraulic losses affect turbine performance. Risk analysis has shown that a failure of these components will result in damages to the turbine, wicket gates, head cover, or the discharge ring. The potential for a turbine runaway is highest from a failed fish screen. Knowledge of turbine operation and powerhouse systems is essential to assure that these components are safely integrated into the powerhouse.

(f) Structural Modifications to the powerhouse and/or structural modifications or additions in or in front of the turbine intakes can directly impact the structural integrity and operational adequacy of the powerhouse. Such modifications may be to satisfy major rehabilitation, seismic retrofit, and environmental enhancements or improvements for fish passage requirements. Special knowledge and experience in powerhouse structural design for hydroelectric systems are essential to understand the effects of structural modifications on the various electrical and mechanical features. A faulty design could cause powerhouse flooding and major damage to the operating equipment. Structural modifications include headwall penetrations, non-floating juvenile fish screen skimmers, juvenile bypass systems built into the powerhouse, and trash racks which can directly and indirectly effect the operation of the turbine.

(g) Main Unit Cranes, 50 tons capacity and larger, are used for the assembly and disassembly of the main unit generators and turbines. They have a direct impact on the ability to return a generating unit to service after a major failure or being able to perform unit maintenance. Problems with these cranes can also have a direct affect on the length of time that generating units are out of service during a major rehabilitation project. Each crane is custom designed for the specific powerhouse application and many operation factors are taken into consideration during design. The larger cranes, up to 600 tons capacity, are not normally found at Corps of Engineers or Army facilities other than powerhouses. Cranes includes the power supply and crane rails.

(h) Mechanical Peripheral Equipment – Group A directly affects the ability of a powerhouse to successfully produce power on a reliable basis. A description of each system follows.

- Generator Cooling Water system provides cooling water to the generators for the removal of waste heat. System malfunction will lead to generator overheating and will either shorten the life of the generator or cause immediate unit shutdown.

- Bearing Cooling Water system provides cooling water to the turbine and generator guide bearings and the generator thrust bearing coolers to remove excess heat. System malfunction will lead to bearing overheating and could cause bearing failure.

- Turbine Gland Water system provides clean water to the turbine shaft packing to cool the packing and to prevent damage from silt laden river water. System malfunction will lead to packing overheating and failure and could cause turbine pit flooding and unit outages.

- Powerhouse Fire systems that directly effect the ability of a powerhouse to successfully produce power on a reliable basis include the generator CO_2 system and the transformer deluge system. Generator CO_2 system malfunctions can cause inadvertent unit outages or failure to extinguish a generator fire. A malfunction of the transformer deluge system can cause damage to adjacent transformers and structures resulting in extended generating unit outages.

- Brake Air system supplies a reliable source of compressed air and controls for operating the generator brakes during unit shutdown. The generator brakes are required to release on unit start up and actuate on unit shutdown. Failure of this system has the potential to cause damage to the generating unit and injury to personnel.

- Piezometers, Flow Meters, and Level Gauges provide critical feed back systems for unit condition and operation. Failure or miscalibration of these components can have a significant impact on unit performance.

- Draft Tube Water Depression system injects a large quantity of compressed air into the turbine draft tube so that the unit can be used for condensing. This system is critical to proper powerhouse operation and is only used at a small percentage of the Corps' facilities.

(i) Mechanical Peripheral Equipment – Group B are systems that are not considered critical to power generation and include the following.

- Powerhouse HVAC systems provide for ventilation and temperature control including control room and office air quality. This system is indirectly related to power generation as insufficient cooling and ventilation can affect reliability of solid-state control equipment. Also, some systems utilize generator cooling water as a heat source for heat pumps which has a potential to impact power generation.

- Service Water system normally feeds multiple systems not directly related to power production such as deck wash and air compressor cooling. The system is often tied together with the generator and turbine cooling water and/or transformer deluge as a backup source of water.

- Service Air system provides compressed air for maintenance purposes, trash rack bubblers and float well bubblers. This system is indirectly related to power generation, as it is the source of compressed air for the generator brake system.

- Governor Air system provides high-pressure compressed air to the governor tank to form the air blanket on top of the governor oil.

- Engine-Generator Sets are diesel engine-driven and provide emergency backup power to the powerhouse for black-start operation.

- Drainage system collects and removes water that leaks into the powerhouse. Power for the drainage pumps is normally on the station service power system. The system is indirectly related to power generation since a failure could lead to powerhouse flooding.

- Unwatering and Fill system provides for the removal of water from the turbine water passages for maintenance access, and refilling of the turbine prior to unit operation. This system is indirectly tied to power generation as a system failure or improper-operation can cause powerhouse flooding.

- Oil system incorporated in powerhouses provides for the storage and purifying of lubrication, governor and transformer insulating oil.

- Powerhouse Fire Protection systems that are not considered critical to power generation include the oil storage room CO_2 system, storage area sprinkler systems, fire extinguishers and hose stations, and smoke detection and ventilation.

(j) Generation and transmission system and equipment includes systems and components that are custom designed and rated for the specific site needs to function as a coordinated power conversion and transmission chain. The equipment chain starts by receiving mechanical power from the turbine shaft and ends by delivering electrical power, usually at high voltage, at the powerhouse transmission line terminals, or the line terminals of an integral switchyard. The items in this category are discussed below.

- Generators are the primary electrical component in the power generation chain. Generator failure is one of the most common causes for long duration outages. Generator protective relaying is also critical to power generation. Improper application of settings or equipment failure can result in extensive generator damage. Generator equipment typically includes everything located above the turbine shaft coupling, e.g., thrust and guide bearings, stator frame, laminated core, rotor, stator and amortisseur windings, partial discharge coupling capacitors, wedges, field poles, and cooling system.

- Excitation Systems are critical for power system stability and need to be properly applied and tuned for unit voltage control during synchronizing. Coordination with power system planners is critical during the exciter procurement phase to ensure that proposed exciter performance is adequate for system needs and that the necessary auxiliary devices are supplied. Tuning studies and further coordination with system planners are needed during the equipment-commissioning phase to ensure the correct voltage regulator settings are made for proper exciter performance within the power system. Excitation system equipment typically includes shaft driven pilot exciters, amplidynes, field rheostats and breakers, voltage regulators, power potential transformers, static excitation devices, power system, and stabilizers.

- Transmission, switching, and monitoring equipment includes main unit bus and circuit breakers, neutral grounding equipment, transformer low-voltage bus, high voltage bus and switching equipment, grounding and surge protection, metering and relaying instrument transformers, and line coupling devices. This specialized equipment is required to transmit power at high voltages and currents, safely and reliably, under extreme conditions and must be designed for low maintenance. Circuit breakers can vary in duty from infrequent operation at well below maximum ratings, to several operations daily, with occasional full-load interruptions and rarely fault interruptions. Instrument transformers and other coupling devices must be coordinated with the needs of the secondary circuits they serve, to assure accurate metering and coordinated relaying.

- Power Transformers are a critical link in the power generation chain of equipment. Generator “step-up” power transformers are used to raise the generator voltage (typically 13.8kV) to transmission voltage (normally 115, 230 or 500 kV). Equipment of the size and ratings used at a hydropower facility are normally used only at a power generation facility. They differ substantially from equipment used in power distribution substations.

Intimate knowledge of the powerhouse operation is required to ensure that the power transformer is properly selected and installed to assure reliable and safe operation. Power transformer equipment includes the transformer, tap changers, high and low side bushings, insulating oil, and all associated protective devices.

- Switchyard equipment includes the connections between transformers, buses, and lines by various combinations of switches and circuit breakers, with associated metering, relaying, protection, control and communication devices, all coordinated intimately with powerhouse operation. Switchyard equipment and systems are usually no different than in any other switchyard with station-class equipment, but their functions are so closely tied to powerhouse operation that design for such a facility can not be separated from powerhouse design. The switchyard functions mainly to serve the local PMA or utilities transmission lines. Powerhouse design associated with these facilities is usually coordinated with the powerhouse transmission line equipment and ratings, and its metering, relaying, some communications, and overlapping controls. Some of the PMA's equipment may be installed in the powerhouse for these purposes. Often the switchyard's auxiliary power is supplied all or partly from the powerhouse.

(k) Control Systems integrate the operations of the powerhouse major electrical and mechanical components. This integration results in diverse assemblies, such as governors, exciters, auxiliaries, turbine-generator units, working together to achieve the desired results. Control incorporates the monitoring of the controlled equipment's status, operation and the overall protection design for the controlled equipment. Control systems provide automatic and/or operator interface to the controlled equipment for performing such functions as unit or auxiliary systems start/stop, adjusting unit loading, and providing transfers to backup or redundant systems. Monitoring of the equipment's status and operation is by analog or digital metering, lighted window annunciation, status lights, chart recorders, and, where applicable, by the digital control system's status and alarm monitoring software. In this latter case, equipment status and alarms are presented to the project operator on a computer screen and also stored in digital memory. These records are analyzed after equipment or system failures to improve designs and system reliability. Protection incorporates those devices that operate on occurrences of mechanical or electrical abnormal conditions. The operation of protection devices may trip the appropriate breakers to isolate equipment in trouble and to notify the plant operator, through alarm contacts, that corrective action is required. The operation of other protective devices allows the operator to initiate alternative systems prior to damaging failures. Powerhouse control equipment typically includes potential and current transformers and transducers that develop the control signals, panels of switches, control switchboards or panels, annunciators, and display instruments (analog and digital), relay logic schemes for automatic sequences (both discrete hardwired relay and programmable logic controllers (PLCs)), and feedback control circuits. It also includes remote supervisory control and data acquisition (SCADA) systems, computer based data acquisition and control (DACS) automatic control and reporting systems including many types of communication paths, sequence of event (time tagging) recorders, video display terminals for data display and operator command input. Protective equipment includes both analog and digital protective relays.

(l) Station Service Power System consists of the power supply, distribution and controls. Station service power is supplied from station service generators, taps from the main generator or high voltage buses, or from outside sources. Power sources can be for continuous or emergency power, and of full or partial capacity with respect to total project demand. Any combination of the above can be designed for powerhouse and total project service. Power sources can be designed for distribution at generator voltage or at some other voltage. Equipment typically includes station service hydro or engine generators and their auxiliaries, main generator bus or high voltage bus tap equipment, step-down transformers, disconnect switches, current limiting reactors, numerous types of bus or cables, switchgear with circuit breakers, emergency backup battery systems, controls, metering and relaying, and temporary connection facilities. Equipment for supplying station loads requires high reliability to maintain power for generation equipment auxiliaries and the integrity of the main transmission system. Equipment sizing must be coordinated with present and future project needs. Emergency power equipment must function reliably to allow black start of the generators and for power to control flooding, spills, fire, or smoke. Station service distribution is intimately connected with powerhouse operation, as a direct source of power for generation or maintenance auxiliaries. Critical or semi-critical loads exist at all voltage levels, including as low as 120 volts, or lower for some alarm systems, and most dc systems. Non-critical subsystems should be isolated, or fault-tripping coordination such that design of modifications within these systems will not affect generation. Subsystem loads must be coordinated with the source capacities. It is desirable to separate the distribution for powerhouse and non-powerhouse circuits to the maximum possible extent. The portions of the distribution system which are directly related to power generation, or which can readily affect it, is in the realm of powerhouse design. Design for other circuits must be coordinated with powerhouse design to assure that the load will not adversely impact the power sources and equipment location will not compromise safety of adjacent powerhouse equipment.

(m) Powerhouse Auxiliary Electrical Equipment - Group A directly affects the ability of a powerhouse to successfully produce power on a reliable basis. Generally, it consists of the equipment that provides power and control to the Mechanical Peripheral Equipment - Group A.

(n) Powerhouse Auxiliary Electrical Equipment - Group B includes systems that are not considered critical to power generation. Group B includes lighting and, in general, all other equipment that provides power and control to the Mechanical Peripheral Equipment - Group B.

APPENDIX B
STATION SERVICE POWER

B-1. Definition. Station service power, for the purpose of this appendix, is the supply of electrical power required to operate a flood control, navigation or other non-hydropower facility or for other project purposes by a hydroelectric unit.

B-2. Requirements.

a. Station service power can only be provided when the commercial power source is determined to be unreliable and/or when there is a specific engineering requirement for using a hydroelectric unit.

b. Any excess power generated will be provided to the local power marketing agency (PMA). A power marketing agreement will be developed with the PMA for the excess power generated. The agreement will be prepared for the signature of the Division Commander.

c. Operation of the hydroelectric unit will be coordinated with the PMA in accordance with ER 1130-2-510.

d. An economic analysis will be performed in accordance with ER 1105-2-100. The costs to be used in the analysis of economic feasibility are total implementation (design, construction, interest during construction) and annual costs (operation, maintenance, repair, replacement and rehabilitation). Station service generator benefits are estimated as the marginal (incremental) costs of production that would be required of the local power supplier in the absence of the station service generator.

e. A complete engineering analysis will be performed. All engineering and design services will be provided by HDC.

f. The project potential for hydropower, including flow duration, pool-duration, available head and proposed hydraulic capacity of the unit will be analyzed.

g. A study of the environmental and operational impacts to the facility will be performed. The project should not continue if any adverse impacts are revealed.

h. The maximum installed capacity of the station service hydroelectric unit will be less than the peak load.