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.