DUF_6
Depleted Uranium
Hexafluoride
Conversion Project

DUF_6 PLANT ELECTRICAL SYSTEM PORTSMOUTH AND PADUCAH PLANTS

U.S. Department of Energy
Portsmouth/Paducah Project Office
Portsmouth Site
Paducah Site

APPROVAL PAGE

Listed below are personnel responsible for the preparation, review, and approval of this plan. Signatures for each have been provided on DUF6 Form 4320, *Document Review & Approval Form.*

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REVISION LOG			
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1 INTRODUCTION

This System Design Description (SDD) for the DUF_6 Conversion Facility Plant Electrical System (PES) describes the system scope, the system requirements and bases, and a description of the as-designed Portsmouth and Paducah Plant PES systems. This document also includes references to system component details and Operations, Testing, and Maintenance information. The SDD also demonstrates design conformance with the previously established overall plant operations requirements

1.1 SYSTEM IDENTIFICATION

The Plant Electrical System scope includes the following subsystems:

- Plant Main Alternating Current Power Supply (MPS)
- Plant Standby Power Supply (SPS)
- Direct Current (DC or dc) and Uninterruptible Power Supply (UPS)
- Plant Grounding and Lightning Protection (GLP)
- Plant Illumination and Lighting Subsystem (PLS)
- Plant Cathodic Protection (PCP)
- Plant Communication System (PCS)

Please refer to Figure 1 for the Plant Electrical System scope and boundaries.

1.2 LIMITATIONS OF THIS SDD

The present version of the PES SDD describes the final design that includes the general overview of the subsystems, system functions and classifications, individual subsystem design requirements, and associated bases statements. Section 4 of the SDD describes the system design details that conform to the requirements established in the Section 3 of this SDD. System major component details have been identified based on procurement data. Operations, Testing, and Maintenance information will be developed by the Plant Operations Group based on specific vendor component data.

1.3 OWNERSHIP OF THIS SDD

The owner of this SDD is the System Engineer. The System Engineer is responsible for the technical content of, and for making changes to the SDD.

1.4 DEFINITIONS/GLOSSARY

Term	Definition
Hydrofluoric Acid (HF)	Hydrofluoric acid is a severe respiratory irritant, and in solution, causes severe and painful burns of the skin.
Integrated Control System (ICS)	The Integrated Control System is the network of software and hardware components used to monitor and operate the process. ICS consists of the basic process control system (BPCS) and independent safety system (ISS).
Intelligent Motor Control Center (MCC)	A standard MCC that has individual compartments factory-wired with control system interface modules. These modules will transmit most starter and motor data to the BPCS and allow for connection of external control interlocks.
Operator Workstation (OWS)	An operator interface consisting of a display system and keyboard with a communication link to the ICS. OWS provides the operator interface required for start-up, shutdown and for general plant control and monitoring.
Performance Category (PC)	A classification using a graded approach in which structures, systems, or components in a category are designed to ensure similar levels of protection (i.e., meet the same performance goal and damage consequences) during natural phenomena hazard events.
Production Support	A component or system that is not a major contributor to defense in depth and/or worker safety but is a major contributor to facility production as determined from hazard analysis.
Safety Significant	A component or system whose preventative or mitigative function is a major contributor to defense in depth (i.e., prevention of uncontrolled material release) and/or worker safety as determined from hazard analysis (DOE-STD-3009-94).
Standard Operating Procedure (SOP)	A Standard Operating Procedure is a document that identifies the actions and safeguards that must be taken to perform a task.

Term	Definition
Technical Safety Requirement (TSR)	The limits, controls, and related actions that establish the specific parameters and requisite actions for the safe operation of a nuclear facility and include, as appropriate for the work and the hazards identified in the documented safety analysis for the facility: Safety limits, operating limits, surveillance requirements, administrative and management controls, use and application provisions, and design features, as well as a bases appendix.

1.5 ACRONYMS

Acronym	Definition
AC, ac	Alternating Current
ALARA	As Low As Reasonably Achievable
ANSI	American National Standards Institute
ATS	Automatic Transfer Switch
BOP	Balance of Plant
CCR	Central Control Room
CCW	Closed Cooling Water
CFR	Code of Federal Regulations
DC	Direct Current
DOE	U.S. Department of Energy
DOE O	DOE Order
DUF_6	Depleted Uranium Hexafluoride
EMI	Electromagnetic Frequency Interface
EMT	Electrical Metallic Tubing
EPR	Ethylene Propylene Rubber
FDD	Facility Design Description
GDP	Gaseous Diffusion Plant
GFCI	Ground-Fault-Circuit-Interrupter
GLP	Grounding and Lightning Protection
HID	High Intensity Discharge
HP	Horsepower

Acronym	Definition
HVAC	Heating, Ventilation, and Air-conditioning
Hz	Hertz/cycles per second
ICEA	Insulated Cable Engineers Association
ICS	Integrated Control System
IEEE	Institute of Electrical and Electronic Engineers
IES	Illuminating Engineering Society
kV	Kilovolts
kVA	Kilovolt Amps
LV	Low Voltage
mA	Milliamperes
mV	MillivoltsMCC Motor Control Center
MPS	Main AC Power Supply
MV	Medium Voltage
NACE	National Association of Corrosion Engineers
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NPH	Natural Phenomena Hazard
OSHA	Occupational Safety and Health Administration
OWS	Operator Work Station
PABX	Private Automatic Branch Exchange
PC	Performance Category
PCP	Plant Cathodic Protection
PCS	Plant Communication System
PDP	Power Distribution Panel
PES	Plant Electrical System
P&ID	Piping and Instrumentation Drawings
PLC	Programmable Logic Controller
PLS	Plant Illumination and Lighting Subsystem
PPA	Property Protection Area
PPE	Personal Protective Equipment

Acronym	Definition
PSS	Plant Shift Superintendent
PVC	Polyvinyl Chloride
RAM	Reliability, Availability, and Maintainability
RFI	Radio Frequency Interference
SCR	Silicon Controlled Rectifier
SDD	System Design Description
SNM	Special Nuclear Material
SOP	Standard Operating Procedure
SPS	Standby Power Supply
SRD	System Requirements Document
SSCs	Structures, Systems, and Components
THD	Total Harmonic Distortion
TSR	Technical Safety Requirements
UL	Underwriters Laboratories Inc.
UPS	Uninterruptible Power Supply
USS	Unit Substation
Vac	Voltage Alternating Current
Vdc	Voltage Direct Current
XLP	Cross-linked Polyethylene

2 GENERAL OVERVIEW

2.1 SYSTEM FUNCTIONS

The Plant Electrical System has been designed to perform the following functions:

2.1.1 Primary System Functions

- Supply electric power to the electrically driven equipment pertaining to the Portsmouth and Paducah DUF_6 Conversion Facilities and their plant systems, during all modes of plant operation for a minimum period of 25 years in Paducah and 18 years in Portsmouth, at suitable voltages as determined by the equipment operation characteristics
- Provide reliable on-site power supply source(s) to mitigate loss of off-site utility power supply source event and allow orderly plant shutdown
- Provide facility/plant illumination services for safe and efficient plant operation
- Provide facility/plant communication services for safe and efficient plant operation

2.1.2 Safety Functions

- Protect the public, plant workers, and electrical equipment against all types of electrical faults during all modes of plant operation
- Provide means to protect the public and property from events occurring as a result of natural phenomena such as thunderstorms, tornadoes, and earthquakes

2.2 SYSTEM CLASSIFICATION

Based on the DUF6 Procedure, *Grading of Structures Systems, and Components* (DUF6-U-PEP-1102), the PES classification of the PES is General Support (GS).

The Plant Electrical System is not subject to Technical Safety Requirements (TSRs). The TSRs have been defined in the Technical Safety Requirements for the DUF_6 Conversion Facility documents DUF6-X/C-TSR-002.

2.3 BASIC OPERATIONAL OVERVIEW

The PES receives utility power at 15 kilovolts (kV) (nominal) via two separately derived power feeder sources to the double-ended 15 kV (nominal) switchgear. The Main Power System (MPS) steps down the power to the desired lower voltages to supply the electrically driven plant equipment and devices.

During plant operation, to mitigate the loss of off-site power event, an on-site diesel generator unit (pertaining to the Standby Power Supply subsystem - SPS) automatically starts and is ready to accept loads in less than 60 seconds of the loss detection. The diesel generator provides power to the selected process and balance of plant (BOP) system loads for orderly plant shutdown, and to maintain slightly negative pressure in the Conversion Building, thus precluding any undesirable releases to the atmosphere. [Refer to Table 3, Cable Raceway Arrangement and Table 4, Power Cable Types for the Portsmouth and Paducah Plants, respectively, SPS subsystem load summaries.]

The UPS provides continuous power for the operation of the Integrated Control System (ICS), and other select system loads that require power without any interruption. The UPS is backed by a stationary battery, which is designed to carry the rated load upon loss of all AC power for a minimum of 30 minutes. [Refer to Table 6, Portsmouth Diesel Generator Loads and Table 7, Paducah Diesel Generator Loads for the Portsmouth and Paducah Plants, respectively, UPS subsystem load summaries.]

The other noted subsystems that are part of the PES provide public and equipment protection, and support safe and efficient plant operation.

Refer to Figure 1 below for a simplified system diagram illustrating boundaries and interfaces with the major plant structures, systems, and components (SSCs).

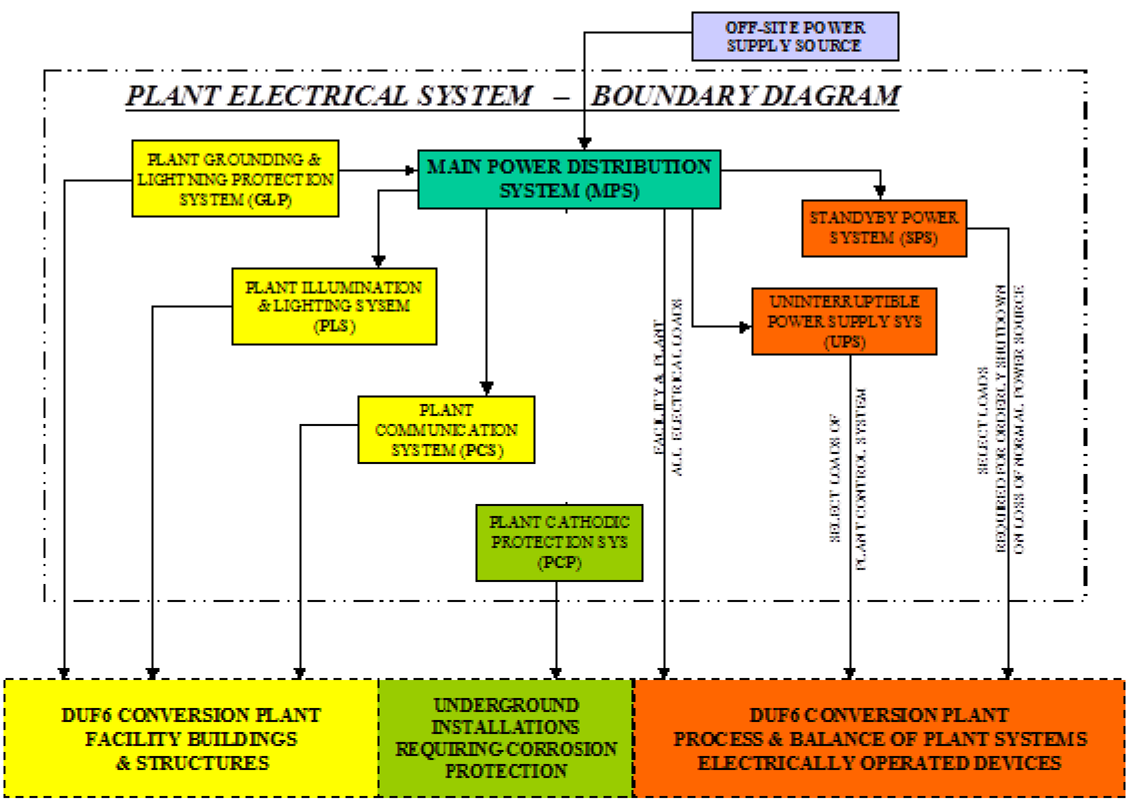

Figure 1, Simplified System Diagram of the Plant Electrical System

3 REQUIREMENTS AND BASES

3.1 GENERAL REQUIREMENTS

3.1.1 System Functional Requirements

3.1.1.1 *Requirement: PES Functions. The PES shall provide electrical power and the other affiliated facility services, as identified in Section 2.1 of this document, to the DUF_6 Conversion Facility process and BOP systems during start-up and testing, normal plant operation, and orderly shutdown of the plant*

Basis: DUF6-UDS-SRD-PORT (PADU) Rev.0, *Portsmouth (Paducah) System Requirements Document*, Rev.0)

3.1.2 Subsystem and Major Components

3.1.2.1 *Requirement: The Plant Electrical System shall include the following subsystems:*

- *MPS*
- *SPS*
- *DC and UPS*
- *GLP*
- *PLS*
- *PCP*
- *PCS*

Basis: To support plant process and BOP system operations.

The major components of the Portsmouth PES are listed in Table 1, Portsmouth DUF_6 Conversion Facility Electrical Major Equipment List.

The major components of the Paducah PES are listed in Table 2, Paducah DUF_6 Conversion Facility Electrical Major Equipment List.

NOTE: There are no major components pertaining to the GLP, PCP or GLP systems.

Table 1, Portsmouth DUF6 Conversion Facility Electrical Major Equipment List

EQUIPMENT TAG NUMBER	EQUIPMENT DESCRIPTION	LOCATION
X-0-MPS-SWGR-AB	13.8 kV Switchgear	Yard
X-0-MPS-USS-XA1	480 Volt Unit Substation 2500/3333 kVA Transformer	Yard
X-0-MPS-USS-XB1	480 Volt Unit Substation 2500/3333 kVA Transformer	Yard

Table 1, Portsmouth DUF6 Conversion Facility Electrical Major Equipment List

EQUIPMENT TAG NUMBER	EQUIPMENT DESCRIPTION	LOCATION
X-0-MPS-USS-XA2	480 Volt Unit Substation 2500/3333 kVA Transformer	Yard
X-0-MPS-USS-XB2	480 Volt Unit Substation 2500/3333 kVA Transformer	Yard
X-0-MPS-USS-A1	480 Volt Unit Substation	Conversion Bldg. - Electrical Room
X-0-MPS-USS-B1	480 Volt Unit Substation	Conversion Bldg. - Electrical Room
X-0-MPS-USS-A2	480 Volt Unit Substation	Conversion Bldg. - Electrical Room
X-0-MPS-USS-B2	480 Volt Unit Substation	Conversion Bldg. - Electrical Room
X-0-MPS-MCC-A11	480 Volt Motor Control Center	Conversion Bldg. - Electrical Room
X-0-MPS-MCC-A12	480 Volt Motor Control Center	Conversion Bldg. - HF Scrubber Room
X-0-MPS-MCC-B11	480 Volt Motor Control Center	Conversion Bldg. - Electrical Room
X-0-MPS-MCC-B12	480 Volt Motor Control Center	Conversion Bldg. - HF Scrubber Room
X-0-MPS-MCC-A21	480 Volt Motor Control Center	Conversion Bldg. - Electrical Room
X-0-MPS-MCC-A22	480 Volt Motor Control Center	Conversion Bldg. - Electrical Room
X-0-MPS-MCC-A23	480 Volt Motor Control Center	KOH Building
X-0-MPS-MCC-B22	480 Volt Motor Control Center	Conversion Bldg. - Electrical Room
X-0-MPS-MCC-B14E	480 Volt Emergency Motor Control Center	Conversion Bldg. - Electrical Room
X-0-MPS-MCC-B14EA	480 Volt Emergency Motor Control Center	Conversion Bldg. - HF Scrubber Room
X-0-SPS-1DG-E1	480 Volt, 350 KW Standby Diesel Generator	Yard
X-0-MPS-PDP-A1-1	480 Volt Power Distribution Panel	Conversion Bldg. - Hot Machine Shop
X-0-MPS-PDP-B2-1	480 Volt Power Distribution Panel	Conversion Bldg. - Mechanical Room (Ground Floor)
X-0-UPS-INV-001	Uninterruptible Power Supply	Conversion Bldg. - Electrical Room
X-0-MPS-HT-B12-1	Plant Heat Trace Panel	Conversion Bldg. - HF Scrubber Room
X-0-MPS-HTX-B12-1	Heat Trace Feed 30 kVA Transformer	Conversion Bldg. - HF Scrubber Room

Table 1, Portsmouth DUF6 Conversion Facility Electrical Major Equipment List		
EQUIPMENT TAG NUMBER	**EQUIPMENT DESCRIPTION**	**LOCATION**
X-0-MPS-LPX-A12-1	Site Lighting 75 kVA Transformer	Conversion Bldg. - HF Scrubber Room
X-0-MPS-LDP-A12-1	Site Lighting Panel	Conversion Bldg. - HF Scrubber Room
X-0-MPS-MP-B12-1	Miscellaneous Power Panel	Conversion Bldg. - HF Scrubber Room
X-0-MPS-MPX-B12-1	Miscellaneous Power 45 kVA Transformer	Conversion Bldg. - HF Scrubber Room
X-0-PLS-LDP-B14E-1	Diesel Backed Lighting Panel	Conversion Bldg. - Electrical Room
X-0-PLS-LPX-B14E-1	45 kVA Lighting Transformer	Conversion Bldg. - Electrical Room
X-0-MPS-MP-A22-1	Miscellaneous Power Panel	Conversion Bldg. - VAP Rm.
X-0-MPS-MP-A22-2	Miscellaneous Power Panel	Conversion Bldg. - VAP Rm.
X-0-MPS-MPX-A22-1	Miscellaneous Power 45 kVA Transformer	Conversion Bldg. - VAP Rm.
X-0-MPS-MP-A1-1-1	Miscellaneous Power Panel	Conversion Bldg. - Hot Shop
X-0-MPS-MP-A1-1-2	Miscellaneous Power Panel	Conversion Bldg. - Hot Shop
X-0-MPS-MPX-A1-1-1	Miscellaneous Power 45 kVA Transformer	Conversion Bldg. - Hot Shop
X-0-MPS-MP-A23-3	Miscellaneous Power Panel	KOH Bldg.
X-0-MPS-MPX-A23-3	Miscellaneous Power 45 kVA Transformer	KOH Bldg.
X-0-UPS-PP-001	UPS Panel	Conversion Bldg. - Electrical Room
X-0-UPS-PP-001X	UPS Panel	Conversion Bldg. - Control Room
X-0-MPS-HT-B22-1	Process Heat Trace Panel	Conversion Bldg. - VAP Room
X-0-MPS-HTX-B22-1	Heat Trace Feed 30 kVA Transformer	Conversion Bldg. - VAP Room
X-0-MPS-MP-B11-1	Miscellaneous Power Panel	Conversion Bldg. - Electrical Room
X-0-MPS-MPX-B11-1	Miscellaneous Power 30 kVA Transformer	Conversion Bldg. - Electrical Room
X-0-UPS-MPX-002-1	Miscellaneous Power 30 kVA Transformer	Admin. Bldg.- Server Room
X-0-UPS-MP-002-1	UPS Panel	Admin. Bldg.- Server Room

Table 1, Portsmouth DUF6 Conversion Facility Electrical Major Equipment List

EQUIPMENT TAG NUMBER	EQUIPMENT DESCRIPTION	LOCATION
X-0-MPS-PDP-B1-1	480 Volt Power Distribution Panel	Warehouse/Maintenance Bldg.
X-0-MPS-PDP-B1-1A	480 Volt Power Distribution Panel	Admin. Bldg.- Electrical Room
X-0-MPS-LPX-B1-1A-1	Lighting 45 kVA Transformer	Admin. Bldg.- Yard
X-0-MPS-LP-B1-1A-1	Lighting Panel	Admin. Bldg. - Electrical Room
X-0-MPS-LPX-B1-1A-2	Lighting 45 kVA Transformer	Admin. Bldg. - Yard
X-0-MPS-LDP-B1-1A-2	Lighting Panel	Admin. Bldg. - Electrical Room
X-0-MPS-LP-B1-1A-1X	Lighting Panel	Admin. Bldg. - Mechanical Room
X-0-MPS-PDP-A1-2	Nitrogen Supply System Panel 1	Yard
X-0-MPS-PDP-A2-1	Nitrogen Supply System Panel 2	Yard
X-0-MPS-MPX-A23-2	45 kVA Power Transformer	KOH Bldg.
X-0-MPS-MP-A23-2	HVac Power Panel	KOH Bldg.
X-0-MPS-MP-A23-1	Miscellaneous Power Panel	KOH Bldg.
X-0-MPS-MPX-B14E-1	25 kVA 1 Phase Transformer	Conversion Bldg. - Electrical Room
X-0-MPS-MP-B14E-1	Misc. Power Panel	Scrubber Room
X-0-UPS-MPX-002-1	Maintenance Bypass Panel	Admin. Bldg.- Server Room
X-0-MPS-LP-B1-1A-1Y	Lighting Panel	Admin. Bldg. – Electrical Room
X-0-MPS-HTX-B22-02	45 kVA Isolation Transformer – Crane Rail Heat Trace	Electrical Room
X-0-MPS-HTX-B22-03	45 kVA Isolation Transformer – Crane Rail Heat Trace	Electrical Room
X-0-MPS-MPX-B1-A1	75 kVA Transformer	Warehouse Misc. Power
X-0-MPS-LPX-B1-P1	45 kVA Transformer	X-1700 Maintenance Bldg.
X-0-MPS-LP-B1-P1	Lighting Panel	X-1700 Maintenance Bldg.
X-0-MPS-LPX-B1-P2	45 kVA Transformer	X-1700 Maintenance Bldg.
X-0-MPS-LP-B1-P2	Lighting Panel	X-1700 Maintenance Bldg.
X-0-MPS-HT-B12-1X	Plant Heat Trace Panel	Electrical Room
X-0-MPS-MPX-A1-1-3	45 kVA Transformer	Conversion Bldg. - Hot Shop
X-0-MPS-MP-A1-1-3	Misc. Power Panel	Conversion Bldg. - Hot Shop

Table 1, Portsmouth DUF6 Conversion Facility Electrical Major Equipment List

EQUIPMENT TAG NUMBER	EQUIPMENT DESCRIPTION	LOCATION
X-0-MPS-MPX-B14EA-1	15 kVA Transformer	Conversion Bldg. - Condenser Room
X-0-MPS-MP-B14EA-1	Power Panel	Conversion Bldg. - Condenser Room
X-0-UPS-PP-001Y	UPS Power Panel	Conversion Building - Server Room
X-0-HDS-MPX-005	175 kVA Isolation Transformer for Prism	Outside Scrubber Room
X-0-HDS-DS-005-1	Transfer Switch for PRISM	Outside Scrubber Room

Table 2, Paducah DUF6 Conversion Facility Electrical Major Equipment List

EQUIPMENT TAG NUMBER	EQUIPMENT DESCRIPTION	LOCATION
C-0-MPS-SWGR-AB	14.4 kV Switchgear	Yard
C-0-MPS-USS-XA1	480 Volt Unit Substation 2500/3333 kVA Transformer	Yard
C-0-MPS-USS-XB1	480 Volt Unit Substation 2500/3333 kVA Transformer	Yard
C-0-MPS-USS-XA2	480 Volt Unit Substation 2500/3333 kVA Transformer	Yard
C-0-MPS-USS-XB2	480 Volt Unit Substation 2500/3333 kVA Transformer	Yard
C-0-MPS-USS-A1	480 Volt Unit Substation	Conversion Bldg. - Electrical Room
C-0-MPS-USS-B1	480 Volt Unit Substation	Conversion Bldg. - Electrical Room
C-0-MPS-USS-A2	480 Volt Unit Substation	Conversion Bldg. - Electrical Room
C-0-MPS-USS-B2	480 Volt Unit Substation	Conversion Bldg. - Electrical Room
C-0-MPS-MCC-A11	480 Volt Motor Control Center	Conversion Bldg. - Electrical Room
C-0-MPS-MCC-A12	480 Volt Motor Control Center	Conversion Bldg. - HF Scrubber Room
C-0-MPS-MCC-B11	480 Volt Motor Control Center	Conversion Bldg. - Electrical Room
C-0-MPS-MCC-B12	480 Volt Motor Control Center	Conversion Bldg. - HF Scrubber Room
C-0-MPS-MCC-A21	480 Volt Motor Control Center	Conversion Bldg. - Electrical Room
C-0-MPS-MCC-A22	480 Volt Motor Control Center	Conversion Bldg. - Electrical Room
C-0-MPS-MCC-A23	480 Volt Motor Control Center	KOH Building
C-0-MPS-MCC-B21	480 Volt Motor Control Center	Conversion Bldg. - Electrical Room
C-0-MPS-MCC-B22	480 Volt Motor Control Center	Conversion Bldg. - Electrical Room
C-0-MPS-MCC-B14E	480 Volt Emergency Motor Control Center	Conversion Bldg. - Electrical Room
C-0-MPS-MCC-B14EA	480 Volt Emergency Motor Control Center	Conversion Bldg. - HF Scrubber Room
C-0-SPS-1DG-E1	480 Volt, 350 KW Standby Diesel Generator	Yard
C-0-MPS-PDP-A1-1	480 Volt Power Distribution Panel	Conversion Bldg. - Hot Machine Shop
C-0-MPS-PDP-B2-1	480 Volt Power Distribution Panel	Conversion Bldg. – Mechanical Room (Ground Floor)

Table 2, Paducah DUF6 Conversion Facility Electrical Major Equipment List

EQUIPMENT TAG NUMBER	EQUIPMENT DESCRIPTION	LOCATION
C-0- UPS-INV-001	Uninterruptible Power Supply	Conversion Bldg. - Electrical Room
C-0-MPS-HT-B12-1	Plant Heat Trace Panel	Conversion Bldg. - HF Scrubber Room
C-0-MPS-HTX-B12-1	Heat Trace Feed 45 kVA Transformer	Conversion Bldg. - HF Scrubber Room
C-0-MPS-LPX-A12-1	Site Lighting 75 kVA Transformer	Conversion Bldg. - HF Scrubber Room
C-0-MPS-LDP-A12-1	Site Lighting Panel	Conversion Bldg. - HF Scrubber Room
C-0-MPS-MP-B12-1	Miscellaneous Power Panel	Conversion Bldg. - HF Scrubber Room
C-0-MPS-MPX-B12-1	Miscellaneous Power 45 kVA Transformer	Conversion Bldg. - HF Scrubber Room
C-0-PLS-LDP-B14E-1	Diesel Backed Lighting Panel	Conversion Bldg. - Electrical Room
C-0-PLS-LPX-B14E-1	45 kVA Lighting Transformer	Conversion Bldg. - Electrical Room
C-0-MPS-MP-A22-1	Miscellaneous Power Panel	Conversion Bldg. - Cylinder Evacuation Rm.
C-0-MPS-MP-A22-2	Miscellaneous Power Panel	Conversion Bldg. - Cylinder Evacuation Rm.
C-0-MPS-MPX-A22-1	Miscellaneous Power 45 kVA Transformer	Conversion Bldg. - Cylinder Evacuation Rm.
C-0-MPS-MP-A1-1-1	Miscellaneous Power Panel	Conversion Bldg. - Hot Shop
C-0-MPS-MP-A1-1-2	Miscellaneous Power Panel	Conversion Bldg. - Hot Shop
C-0-MPS-MPX-A1-1-1	Miscellaneous Power 75 kVA Transformer	Conversion Bldg. - Hot Shop
C-0-MPS-MP-A23-3	Miscellaneous Power Panel	KOH Bldg.
C-0-MPS-MPX-A23-3	Miscellaneous Power 45 kVA Transformer	KOH Bldg.
C-0-UPS-PP-001	UPS Panel	Conversion Bldg. - Electrical Room
C-0-UPS-PP-001X	UPS Panel	Control Room
C-0-UPS-PP-001Y	UPS Panel	Control Room
C-0-MPS-HT-B22-1	Process Heat Trace Panel	Conversion Bldg. - Mechanical Room
C-0-MPS-HTX-B22-1	Heat Trace Feed 30 kVA Transformer	Conversion Bldg. - Mechanical Room

Table 2, Paducah DUF6 Conversion Facility Electrical Major Equipment List

EQUIPMENT TAG NUMBER	EQUIPMENT DESCRIPTION	LOCATION
C-0-MPS-MP-B11-1	Miscellaneous Power Panel	Conversion Bldg. - Electrical Room
C-0-MPS-MPX-B11-1	Miscellaneous Power 30 kVA Transformer	Conversion Bldg. - Electrical Room
C-0-MPS-MPX-002-1	Miscellaneous Power 30 kVA Transformer	Admin. Bldg.- Server Room
C-0-UPS-MP-002-1	UPS Panel	Admin. Bldg.- Server Room
C-0-MPS-PDP-B1-1	480 Volt Power Distribution Panel	Warehouse/Maintenance Bldg.
C-0-MPS-PDP-B1-1A	480 Volt Power Distribution Panel	Admin. Bldg.- Electrical Room
C-0-MPS-HT-B21-1	Freeze Protection Power Panel	Conversion Bldg-Electrical Room
C-0-MPS-MP-B12-2	Miscellaneous Power Panel	Conversion Building - Admin Area air lock
C-0-MPS-LPX-B1-1A-1	Lighting 45 kVA Transformer	Admin. Bldg.- Yard
C-0-MPS-LP-B1-1A-1	Lighting Panel	Admin. Bldg. - Electrical Room
C-0-MPS-LPX-B1-1A-2	Lighting 45 kVA Transformer	Admin. Bldg. - Yard
C-0-MPS-LDP-B1-1A-2	Lighting Panel	Admin. Bldg. - Electrical Room
C-0-MPS-LP-B1-1A-1X	Lighting Panel	Admin. Bldg. - Mechanical Room
C-0-MPS-PDP-A1-2	Nitrogen Supply System Panel 1	Yard
C-0-MPS-PDP-A2-1	Nitrogen Supply System Panel 2	Yard
C-0-MPS-MPX-A23-2	45 kVA Power Transformer	KOH Bldg.
C-0-MPS-MP-A23-2	HVac Power Panel	KOH Bldg.
C-0-MPS-MP-A23-1	Miscellaneous Power Panel	KOH Bldg.
C-0-MPS-MPX-B14E-1	25 kVA 1 Phase Transformer	Conversion Bldg. - Electrical Room
C-0-UPS-MPX-002-1	Maintenance Bypass Panel	Admin. Bldg.- Server Room
C-0-MPS-HTX-B21-1	30 kVA Power Transformers	Conversion Bldg. - Electrical Room
C-0-MPS-MPX-B12-2	75 kVA Power Transformer	Conversion Bldg. - Condenser Room
C-0-MPS-MP-A1-1-3	Miscellaneous Power Panel	C-1300 Hot Shop
C-0-MPS-MPX-A1-1-3	37.5 kVA 1 phase Transformer	C-1300 Hot Shop

Table 2, Paducah DUF6 Conversion Facility Electrical Major Equipment List

EQUIPMENT TAG NUMBER	EQUIPMENT DESCRIPTION	LOCATION
C-0-MPS-MPX-A12-1	50 kVA 3 Phase Transformer	C-1100-T-05 Shower Trailer
C-0-MPS-MP-A12-1	Miscellaneous Power Panel	C-1100-T-05 Shower Trailer
C-0-MPS-MPX-A12-2	50 kVA 3 Phase Transformer	C-100-T-09 Office Trailer
C-0-MPS-MP-A12-2	Miscellaneous Power Panel	C-100-T-09 Office Trailer
C-0-MPS-MP-A12-2A	Miscellaneous Power Panel	C-100-T-09 Office Trailer
C-0-MPS-HTX-B22-01	45 kVA Power Transformer	Conversion building – crane rail heat trace
C-0-MPS-HTX-B22-02	45 kVA Power Transformer	Conversion building – crane rail heat trace
C-0-HDS-MPX-005	175 kVA Isolation Transformer for C-0-HDS-SK-005	Conversion building - East Side
C-0-HDS-DS-005-1	Transformer Switch for C-0-HDS-SK-005	Conversion building - East Side

3.1.3 Boundaries and Interfaces

3.1.3.1 *Requirement: The PES and its associated subsystems interface with the process and BOP system equipment that require electrical power for its operation.*

The system boundaries for the MPS, SPS, and UPS power supply systems include all the pertinent distribution equipment belonging to the system and up to the load feeder interrupting devices such as breakers and fuses. The feeder cables are procured and installed as a part of the PES. However, feeder cables are designated with a tag that relates to the individual process/BOP system load device, thus providing easy system reference during construction, start-up, and operations.

Basis: To support BOP and process equipment operation.

3.1.4 Codes, Standards, and Regulations

The editions of the Codes and Standards shall be those in effect on August 2002 unless otherwise indicated.

3.1.4.1 *Code of Federal Regulations (CFR)*

- 29 CFR 1910, Occupational Safety and Health Administration (OSHA) Standards

3.1.4.2 *American National Standards Institute (ANSI)*

- ANSI C2-2001, National Electrical Safety Code
- ANSI C37, Circuit Breakers, Switchgear, Relays, Substations, and Fuses (Applicable Standards)
- ANSI C50, Rotating Electrical Machinery (Applicable Standards)
- ANSI C57, Transformers, Distribution, Power and Regulating (Applicable Standards)
- ANSI C80.1-1994, Specification for Rigid Steel Conduit, Zinc Coated
- ANSI C84.1-2001, Electric Power Systems and Equipment - Voltage Ratings (60 Hertz)
- ANSI/EIA 472-1985, Generic Specification for Fiber Optic Cables

3.1.4.3 *Department of Energy (DOE)*

- DOE-STD-1021-93 (R 1996), Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components
- DOE-STD-3003-00, Backup Power Sources for DOE Facilities
- DOE Order (O) 420.1, Facility Safety (including Implementation Guide for Nonreactor Nuclear Safety Design Criteria and Explosives Safety Criteria, Draft Revision G, dated September 1995)
- DOE O 473.1, Physical Protection Program
- DOE O 5480.4, Environmental Protection, Safety, and Health Protection Standards, May 6, 1989
- DOE Handbook 1140-2001, Human Factors/Ergonomics Handbook for the Design for Ease of Maintenance
- 10 CFR Part 851, Worker Safety and Health Program

3.1.4.4 *Insulated Cable Engineers Association (ICEA)*

- ICEA P-46-426-2000, Power Cable Ampacities, Volume I (Copper)
- ICEA P-54-440-2000, Ampacities of Cables in Open-Top Cable Trays (NEMA WC 51-1986) (R1991)
- ICEA S-19-81–2000, Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC 3-1994)
- ICEA S-61-402-2000, Wires and Cables, Thermoplastic-Insulated (NEMA WC 5-1996)
- ICEA S-66-524-2000, Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC 7-1998)

3.1.4.5 *Institute of Electrical and Electronics Engineers (IEEE)*

- IEEE 1-2000, General Principles for Temperature Limits in the Rating of Electrical Equipment and for the Evaluation of Electrical Insulation
- IEEE 32-1997, Requirements, Terminology and Test Procedures for Neutral Grounding Devices (Rev. 1997)
- IEEE 81-2012, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
- IEEE 112-2017, Test Procedure for Polyphase Induction Motors and Generators
- IEEE 141-1999, Recommended Practice for Electric Power Distribution for Industrial Plants
- IEEE 142-1996, Recommended Practice for Grounding of Industrial and Commercial Power Systems
- IEEE 242-2007, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
- IEEE 446-2000, Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications
- IEEE 515-2017, Standard for the Testing, Design, Installation and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications
- IEEE 518-1997, IEEE Guide for the Installation of Electrical Equipment to Minimize Electrical Noise Inputs to Controllers from External Sources
- IEEE 519-2014, IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
- IEEE 835-2012, IEEE Std. Power Cable Ampacity Tables
- IEEE 1023-2010, Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations
- IEEE 1100-2005 Recommended Practice for Powering and Grounding Sensitive Electronic Equipment
- IEEE 1584 -2018, Guide for performing Arc-Flash Hazard Calculations

3.1.4.6 *Illuminating Engineering Society (IES)*

- IES RP-1, 2017, Recommended Practice for Office Lighting
- IES RP-7-17, Recommended Practice for Lighting Industrial Facilities
- IES,2011 Lighting Handbook: Reference and Application - 2000.

3.1.4.7 *National Association of Corrosion Engineers (NACE)*

- NACE SP0169,2013, Control of External Corrosion on Underground or Submerged Metallic Piping Systems

3.1.4.8 *National Electrical Manufacturers Association (NEMA)*

- NEMA AB 1-2002, Molded Case Circuit Breakers and Molded Case Switches
- NEMA FU 1-2012, Low Voltage Cartridge Fuses
- NEMA ICS 1-2015, Industrial Control and Systems: General Standards
- NEMA ICS 2-2005, Industrial Control and Systems: Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC
- NEMA ICS 4-2015, Industrial Control and Systems: Terminal Blocks for Industrial Use
- NEMA ICS 6-2016, Industrial Control and Systems: Enclosures
- NEMA MG 1-2016, Motors and Generators
- NEMA PB 1-2011, Panel Boards
- NEMA SG 3-1995, Low Voltage Power Circuit Breakers
- NEMA SG 5-1995, Power Switchgear Assemblies
- NEMA ST 20-2014, Dry Type Transformers for General Applications
- NEMA TC 2-2013, Electrical Plastic Tubing (EPT) and Conduit
- NEMA TC 6 & 8-2013, Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations
- NEMA VE 1-2017, Metallic Cable Tray Systems

3.1.4.9 *National Fire Protection Association (NFPA)*

- NFPA 20-2019, Standard for the Installation of Stationary Pumps for Fire Protection
- NFPA 70-2017, National Electrical Code
- NFPA 70E-2018, Standard for Electrical Safety Requirements for Employee Workplaces
- NFPA 72-2018, National Fire Alarm and signaling code
- NFPA 101, 2018, Life Safety Code
- NFPA 110-2019, Standard for Emergency and Standby Power Systems
- NFPA 497-2017, Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas
- NFPA 654-2020, Standard for Prevention of Fire and Dust Explosions from the Manufacturing, Process and Handling of Combustible Particulates and Solids
- NFPA 780-2020, Standard for the Installation of Lightning Protection Systems

3.1.4.10 *RAMI requirements*

- Reliability, Availability, Maintainability, and Inspectability

3.1.4.11 *Underwriters Laboratories Inc. (UL)*

- UL 1-2005, Flexible Metal Conduit
- UL 6-2007, Electrical Rigid Metal Conduits
- UL 44-2018, Thermoset Insulated Wires and Cables
- UL 50-2015, Cabinets and Boxes
- UL 67-2018, Panel boards
- UL 83-2017, Thermoplastic-Insulated Wires and Cables
- UL 96-2016, Lightning Protection Components
- UL 429-2013, Electrically Operated Valves
- UL 489-2016, Molded-Case Circuit Breakers and Circuit Breaker Enclosures
- UL 521-1999, Heat Detectors for Fire Protective Signaling Systems
- UL 651-2011, Schedule 40 and 80 Rigid PVC Conduit
- UL 797-2007, Electrical Metallic Tubing
- UL 844-2012, Electric Lighting Fixtures for Use in Hazardous (Classified) Locations
- UL 845-2005, Motor Control Centers
- UL 924-2016, Emergency Lighting and Power Equipment

Basis: The above listing provides all applicable codes and standards for the services and the equipment/components necessary for the satisfactory system operation.

3.1.5 Operability

3.1.5.1 *Requirement: The PES and the associated subsystems shall be operable to support in-situ start-up testing of the process and BOP system equipment, and during all modes of plant operation. The MPS subsystem is considered operable when the off-site utility power source is energized to allow power flow to the DUF_6 Conversion Facility electrical distribution equipment.*

Basis: To support satisfactory operations of the DUF_6 conversion process and BOP systems.

3.2 SPECIAL REQUIREMENTS

3.2.1 Radiation and Other Hazards

There are no radiation hazards associated with the PES system.

3.2.2 ALARA

An engineering study has been developed to evaluate radiation exposure at the DUF_6 facilities. DUF6-G-Q-STU-002, *ALARA Study – Radiation Exposure Evaluation*, determined that the maximum dose to any facility worker would be less than 1 rem/yr, which is lower than the DOE administrative control limit of 2 rem/yr. DUF6-PLN-007, *Radiation Protection Program*, is in place for controlling personnel exposure from external sources of radiation to levels below 1 rem/yr and as far below this average as reasonably achievable. The highest anticipated radiation exposures are associated with cylinder operations.

3.2.3 Nuclear Criticality Safety

Nuclear Criticality Safety requirements are not identified since *Safety Management Program Descriptions for the DUF_6 Conversion Project* (DUF6-U-SMP-005) has certified that the nuclear criticality accident is not credible.

3.2.4 Industrial Hazards

3.2.4.1 *Requirement: The PES design shall comply with 29 CFR 1910, Occupational Safety and Health Administration Standards.*

Basis: To support safe operation and prevent personnel injuries.

3.2.4.2 *Requirement: The PES design shall comply with NFPA-70, National Electrical Code, and ANSI C2, National Electrical Safety Code.*

Basis: To support safe operation and prevent personnel injuries.

3.2.4.3 *Requirement: Special design features shall be implemented in the vicinity of hydrogen generation and usage areas in the DUF_6 Conversion Plant in compliance with NFPA 70 Article 500 and NFPA 497.*

Basis: To support safe operation and prevent personnel injuries.

3.2.4.4 *Requirement: Explosion proof fittings and component design suitable for hazardous location shall be implemented in the vicinity of hydrogen generation and usage areas in the DUF_6 conversion plant in compliance with NFPA 497 and NEC Article 500. Refer to Electrical Area Classification Plan Drawing # D-X-0000-GEN-1301-E / D-C-0000-GEN-1301-E and D-X-0000-GEN-1302-E / D-C-0000-GEN-1302-E.*

Basis: To support safe operation and prevent personnel injuries.

3.2.4.5 *Requirement: Permanent Power distribution system Arc Flash Hazards Analysis shall be performed to identify flash hazards boundaries at various locations where 480 V and above power distribution equipment is located, and determine appropriate levels of Personal Protective Equipment (PPE) necessary to safeguard workers.*

Basis: To support safe operation and prevent personnel injuries.

3.2.5 Operating Environment and Natural Phenomena

PES components shall be designed and supported in conformance with the Performance Category I (PC-1). The system components located inside the Conversion Building shall be supported in compliance with PC-2 category so as not to become missiles in the event of tornado or earthquake. There are no special design requirements imposed on the operability of PES components during natural phenomenon occurrences.

3.2.5.1 *Requirement: The power cabling and the instrumentation and controls wiring shall be designed and routed within the plant area in a manner so as not to cause malfunction due to electromagnetic or radio frequency interference (EMI/RFI).*

Basis: To support safe operation, and prevent personnel injuries.

3.2.6 Human Interface Requirements

The operator's primary interface for all process functions will be the Operator Workstation (OWS). The OWS will provide the operator with access to all the facility process and BOP systems for control, data acquisition, communications, logging, trending and alarming. Alarm indication at the OWS will be composed of a visual indication on the monitor, as well as a local visual and audible indication adjacent to the OWS. In general, all alarms can be acknowledged at the OWS by the operator. Identified are those alarms that require specific manual intervention from the operator. Specific alarm instrumentation, alarm conditions, set-points, operator responses and ICS actions are defined in detail in Section 4.1.6 for normal process alarms. Only those alarms that are safety significant or require off-normal operator responses are listed in this section.

3.2.6.1 *Requirement: The PES design shall comply with the guidelines provided in the DOE Handbook 1140-2001, Human Factors/Ergonomics Handbook.*

Basis: DOE guidance document.

3.2.6.2 *Requirement: Any upset condition or equipment failure of the components pertaining to the PES or its subsystems shall be annunciated in the control room for operator attention and follow-up remedial action.*

Basis: To support plant process and BOP system safe operations goal.

3.2.7 Specific Commitments

There are no other specific commitments identified for the PES.

3.3 ENGINEERING DISCIPLINARY REQUIREMENTS

3.3.1 Civil and Structural

3.3.1.1 *Requirement: All equipment and components associated with the PES that are located in the Conversion Building shall be seismically supported on the Conversion Building structure or foundation.* The system components located within the Conversion Building shall be supported in compliance with PC-2 category requirements.

Basis: To provide safe operation and to prevent dislodging of the PES system components to compromise safety system performance or cause personnel injury.

3.3.2 Mechanical and Materials

No unique mechanical and materials requirements have been identified.

3.3.3 Chemical and Process

No unique chemical and process requirements have been identified.

3.3.4 Plant Main AC Power Supply

3.3.4.1 *Requirement: The DUF_6 MPS subsystem shall include the protection of all plant electrical equipment up to the point of the utility interconnection.*

Basis: IEEE 242 and standard engineering practice.

3.3.4.2 *Requirement: The power distribution system protection shall be designed in accordance with the consensus industry standard protection practices.*

Basis: IEEE 242 and standard engineering practice.

3.3.4.3 *Requirement: Settings of the protective devices, short circuit ratings, etc., shall be coordinated between the DUF_6 Conversion Facility and the utility protection schemes to ensure proper operation of the respective protection systems.*

Basis: IEEE 242 and standard engineering practice.

3.3.4.4 *Requirement: Utilization Voltage. The system voltages for the electrical power system to supply electrical power to plant loads shall be as follows:*

Medium Voltage (MV) Distribution System:

13.8 kVac, 3 phase, 3 wire (Portsmouth Plant)

14.4 kVac, 3 phase, 3 wire (Paducah Plant)

(Note: Except for this distinction between the two sites, all other voltage ratings are identical. Hence, in the MV is referred to as “15 kV [nominal]”).

Low Voltage (LV) Distribution System:

480 Vac, 3 phase, 3 wire

480Y/277 Vac, 3 phase, 4 wire

208Y/120 Vac, 3 phase, 4 wire

240Y/120 VAC, Single phase 3 wire

120 Vac, 1 phase, 2 wire

The electrical power system shall be designed to operate in the following voltage and frequency ranges:

1. *Voltage range: ANSI C84.1, Voltage Range A*
2. *AC frequency and range: 60 Hertz (Hz/cycles per second) + 5*

Basis: ANSI consensus industry standards.

3.3.4.5 *Requirement: Capacity Margin. To address future system modifications and load growth, a 20% capacity margin were included in the initial design of the electrical power systems. The voltage regulation, motor starting capability, and maximum short circuit current analyses shall be performed with a consideration of capacity margins to satisfy DUF_6 design requirements.*

Analyses shall be periodically updated to demonstrate the capacity and capability of the electrical power systems to operate satisfactorily under all normal and abnormal operating conditions. Short circuit and voltage drop studies shall be performed with the following boundary conditions:

- *Utility grid system operating voltage range of 0.95 to 1.05pu*
- *Future load growth 20% of full production operation loads*
- *Utilization voltage range of +10% of the nominal voltage, or ANSI C84.1 Voltage Range A (worst case)*
- *Utility short circuit contribution based on utility source data*

Basis: DUF6-SRD-PORT (PADU) Rev. 0, *Portsmouth (Paducah) SRD*, and consensus industry standard practice.

3.3.4.6 *Requirement: MV Switchgear. Two separate, incoming, MV feeder lines shall be provided, terminating at an outdoor 15 kV (nominal) switchgear located adjacent to the outdoor transformer yard.*

Basis: Utility source availability, DUF6-SRD-PORT (PADU) Rev. 0, *Portsmouth (Paducah) SRD*, and consensus industry ANSI/IEEE standards.

3.3.4.7 *Requirement: MV Switchgear. The main 15 kV (nominal) switchgear shall provide alternating current (ac or AC) electrical power to the DUF_6 Conversion Facility via 480 volt unit substation transformers.*

Basis: Utility source availability, DUF6-SRD-PORT (PADU) Rev. 0, *Portsmouth (Paducah) SRD*, and consensus industry ANSI/IEEE standards.

3.3.4.8 *Requirement: MV Switchgear. The MV switchgear rating shall be selected on the basis of maximum available short circuit and continuous current rating. Short circuit fault levels of the plant electrical distribution system shall be calculated based on fault current contribution from connected motor loads, standby generator in test mode, and the utility source. The switchgear interrupting capacities shall be determined in accordance with the requirements of ANSI C37.010. The circuit breakers shall be vacuum type and shall be sized and designed in accordance with ANSI C37.06. The design of the medium voltage switchgear shall be based on the use of vacuum technology to reduce space and maintenance requirements and to improve reliability.*

Basis: Utility source availability, DUF6-SRD-PORT (PADU) Rev. 0, *Portsmouth (Paducah) SRD*, and consensus industry ANSI/IEEE standards.

3.3.4.9 *Requirement: MV Switchgear. A provision shall be made for operating the medium voltage breakers manually in case of a control power source failure.*

Basis: Utility source availability, DUF6-SRD-PORT (PADU) Rev. 0, *Portsmouth (Paducah) SRD*, and consensus industry ANSI/IEEE standards.

3.3.4.10 *Requirement: MV Switchgear. Located outdoors in a walk-in enclosure, the switchgear assembly shall be rated 15 kVac (nominal), 3 phase, 60 Hz, with a 750 MVA short circuit rating. Each switchgear section shall have a 1200 A continuous main bus. All switchgear breakers shall be rated 1200 A.*

Basis: Utility source availability, DUF6-SRD-PORT (PADU) Rev. 0, *Portsmouth (Paducah) SRD*, and consensus industry ANSI/IEEE standards.

3.3.4.11 *Requirement: MV Switchgear. The switchgear shall consist of two bus sections connected by a single, normally open tie breaker. Each bus section shall be fed by independent utility feeders. Each feeder shall be capable of carrying 100% of the plant load. Both feeds shall supply power during normal plant operation.*

Basis: Utility source availability, DUF6-SRD-PORT (PADU) Rev. 0, *Portsmouth (Paducah) SRD*, and consensus industry ANSI/IEEE standards.

3.3.4.12 *Requirement: MV Switchgear. Electronic metering of power functions shall be provided suitable for transmission over the plant data bus.*

Basis: Utility source availability, DUF6-SRD-PORT (PADU) Rev. 0, *Portsmouth (Paducah) SRD*, and consensus industry ANSI/IEEE standards.

3.3.4.13 *Requirement: Tie Breaker Operation. The two utility power supply sources are in phase synchronism; however, they may have different bus voltages. Hence, the two utility feeders shall not be connected in parallel via the bus tie breaker to preclude high circulating currents.*

Basis: To comply with the utility source restrictions.

3.3.4.14 *Requirement: Loss of One Utility Source Feeder. On loss of one of the utility feeder power sources, the associated 15 kV (nominal) incoming breaker at the medium voltage switchgear bus shall be tripped, and the tripped breaker shall send a signal to close the tie breaker automatically, thus restoring power to the bus within a few cycles.*

Basis: To improve utility power availability in support of continued plant operation with minimal power interruption, DUF6-SRD-PORT (PADU) Rev. 0, *Portsmouth and Paducah SRD.*

3.3.4.15 *Requirement: MV Feeders. Underground 15 kV feeders from the MV switchgear shall be provided to feed each low voltage unit substation transformer.*

Basis: Utility source availability.

3.3.4.16 *Requirement: LV Unit Substations. 15 kV (nominal)-480 Vac unit substation power transformers shall be utilized having delta-connected primary and wye-connected secondary windings. They shall be cast coil, dry type, installed outdoors, and connected to the 480 Volt switchgear via non-segregated bus duct. The neutrals of all wye-connected secondary windings shall be connected to ground via neutral grounding resistors. Distribution Class surge arrestors shall be provided on the primary side of the unit substation transformers.*

The LV switchgear of the unit substation shall be of metal enclosed construction with draw-out-type 600 Vac circuit breakers and shall be in conformance with ANSI C37.20.1, rated 600 Vac, maximum 4000 A continuous main bus, braced to withstand 65 kA. The switchgear shall be located indoors and shall be provided with NEMA 1A gasketed enclosures.

The 480 Vac indoor switchgear pair and the two outdoor 15 kV (nominal)-480 V transformers shall be considered as unit substations. There will be two unit substations.

The load distribution will be based on the division of plant loads into four separate process lines. The BOP loads will be distributed on a load-balancing basis. Note: The Portsmouth plant shall have three process lines, with a future electrical design provision to add the fourth process line.

The unit substation shall be configured having a double-bus (secondary selective) configuration (designated Bus A1 [A2] and Bus B1 [B2]) and shall have a normally open bus tie breaker between the two buses. Each bus, through feeder breakers, shall feed 480 Vac MCCs and power panels located throughout the plant. The tie breaker scheme shall be designed to manually transfer load to the other substation pair on a trip of one of the substation main breakers.

Basis: ANSI and NEMA consensus industry standards and standard engineering practice.

3.3.4.17 *Requirement: LV Feeders. 480 V feeders shall supply power to the low voltage MCCs, 480 Vac power distribution panels and large motor loads. The power cables shall exit the 480 Vac substation assemblies from the top and shall be routed via cable tray to the motor control centers, panel boards, or large motor loads within the plant. Remote building feeders shall be routed via a combination of cable tray and underground duct.*

Basis: Standard engineering practice for servicing loads of this type .

3.3.4.18 *Requirement: LV Distribution. LV equipment ratings, including circuit breaker interrupting capacities, shall be selected such that the rated symmetrical interrupting current capacity exceeds the calculated fault current. The fault duty calculations shall be performed in accordance with the requirements of ANSI C37.13 and NEMA AB 1.*

Basis: ANSI and NEMA consensus industry standards.

3.3.4.19 *Requirement: Power Utilization. The power utilization equipment (electrical loads) in general shall be served radially from starters and circuit breakers located in MCCs or power distribution panels (PDPs).*

Basis: Standard engineering practice.

3.3.4.20 *Requirement: Voltage Levels. Electrical equipment shall be designed to operate at the system voltages listed below:*

480 Volts, 3 Phase, 60 Hertz for:

- *Motors rated 1/2 HP to 75 HP*
- *Process Heaters*
- *Welding or specialized receptacles for the portable equipment*
- *LED Lighting in Industrial Areas*

277 Volts, 1 Phase, 60 Hertz for:

- *High Intensity Discharge (HID) Lighting*
- *Fluorescent Lighting in Industrial Areas*
- *LED Lighting in Industrial Areas*
- *Electric Process Heat Tracing*
- *Fluorescent Emergency Lighting in Industrial Areas*
- *Illuminated Exit Signs in Industrial Areas*
- *Illuminated Exit Signs and Emergency Lighting Battery Units*

120 Volts, 1 Phase, 60 Hertz for:

- *Motors less than 1/2 HP*
- *Convenience receptacles*
- *Miscellaneous small power users*
- *Controls for packaged units*
- *Instruments requiring separate power supplies*
- *Control devices, such as solenoid valves*
- *Convenience receptacles and power supplies to ICS equipment shall be powered from UPS source panels*

24 Vdc for:

- *Electronic analog instrumentation, such as transmitters, control valves, and other analog input and output circuits*
- *MCC control power (derived from MCC-mounted power supplies)*

Basis: Standard NEMA equipment voltage ratings.

3.3.4.21 *Requirement: LV MCCs. The LV MCCs shall be rated for 600 Vac, with minimum ratings of 800 amperes for the main horizontal bus and 300 amperes for the vertical buses.*

Each MCC shall be braced for minimum 65,000 amperes symmetrical short circuit duty.

Motors rated 150 HP or less and process system heaters shall be supplied from motor control centers designed for sufficient loading capacity. MCCs shall be located in non-radiological controlled areas.

All MCCs shall have a single feeder from the 480 Vac switchgear with no incoming feeder circuit breaker.

An essential MCC (i.e., an MCC connected to the normal plant power source; however, having the capability to receive power from the on-site diesel generator source, on loss of normal power) shall be provided to supply AC power to the designated plant loads required for orderly shutdown of the plant. This MCC shall receive backup power from the on-site standby diesel generator.

Basis: Equipment ratings are typical commercially available. Design features conform to standard engineering practice.

3.3.4.22 *Requirement: LV MCC. Starters for 460 Vac process motors shall be "smart" type, equipped with motor circuit protectors and electronic interfaces (e.g., Profibus) to allow monitoring of motor parameters. The interface will allow direct connection to the plant ICS control bus.*

Other non-motor feeders shall be equipped with molded case breakers with thermal and magnetic trip elements for overload and short circuit protection.

Basis: Standard engineering practice.

3.3.4.23 *Requirement: Power Distribution Panels. The 480 Vac power distribution panels shall be designed in accordance with NEMA PB 1 and UL 67. Power distribution panels located indoors shall be NEMA ICS 6 - Type 12, and those located outdoors shall be NEMA ICS 6 - Type 3R with threaded hubs for conduits.*

Circuit breakers used in power distribution panels shall be molded case, thermal magnetic, ambient compensated. The minimum circuit breaker size shall be 20 A. Molded case circuit breakers shall comply with NEMA AB 1 and UL 489.

A ground bus shall be provided in each distribution panel.

Power distribution panels shall be provided with approximately 20% spare breakers for future use.

Power distribution panels' short circuit ratings shall be a minimum of 22,000 amperes. Higher ratings shall be provided if so determined based on short circuit calculation results. Panels shall be equipped with surge suppression devices.

Basis: Standard engineering practice in conformance with consensus industry NEMA and UL standards.

3.3.4.24 *Requirement: Dry-Type Transformers. Small, dry-type distribution transformers shall be provided to supply 120 and 277 V lighting, electric heat tracing, instrument, and small power loads.*

Lighting and small distribution power transformers shall be rated 480-480Y/277 volts, 3 phase, 60 Hz, or 480-208Y/120 volts, 3 phase, 60 Hz with standard primary taps. Neutral shall be solidly grounded.

Transformers shall be designed for 115°C rise over 40°C ambient, and shall have a 220°C UL-recognized component insulation system.

Transformers, serving loads consisting largely of fluorescent and HID lighting fixtures, shall have a K-factor rating of 13, per ANSI C57.110-1986. Those transformers serving computer-type loads, including desktop personal computers, shall have a K-factor of 13 and electrostatic shields between the primary and secondary windings to prevent electrical noise. For standardization of the design, all small power transformers shall have a K-factor of 13.

Unless otherwise specified, the small, dry-type transformers shall generally be limited to 45 kVA, to limit the amount of short circuit current available at the panel boards they serve.

Basis: Consensus industry standard design.

3.3.4.25 *Requirement: Disconnect Means. Local disconnect switches shall be provided in accordance with NFPA 70 (National Electrical Code [NEC]) for heating, ventilating, and air-conditioning (HVAC) fan motors. All other required local disconnect switches shall be included with the vendor-packaged equipment.*

Basis: Consensus industry standard practice in accordance with NFPA 70.

3.3.4.26 *Requirement: Power Outlets. 480 Vac, 3 phase, 60 Hz interlocked receptacles with disconnect switches shall be provided for supplying power to portable equipment such* as welding equipment.

Power outlets shall be located, in Conversion Building Machine Shop, and Warehouse/Maintenance area, to support welding activity.

A branch circuit supplying power outlets shall serve no other equipment, and one circuit shall supply not more than three outlets. Each branch circuit shall be protected by a 60 A circuit breaker in a 480 V motor control center or power distribution panel.

Basis: Process operation needs and standard engineering practice in conformance with NFPA 70.

3.3.4.27 *Requirement: Process Equipment Packages. Where vendor-supplied packages are provided, each equipment package shall be served by only one feeder or branch circuit. The vendor shall provide necessary power distribution within the package. Where more than one voltage is required by the vendor's system, the vendor shall provide the necessary transformer(s).*

Variable frequency drives and silicon controlled rectifier (SCR) controllers are being provided as a part of many of the equipment packages. These units shall be fed via feeder breakers at the MCCs or via independent 480 Volt panel boards. The vendor's control package shall provide a data signal for motor status and/or alarm information to be tied back into the ICS. In general, any local, hardwired control switches shall be provided by the equipment vendor.

The vendor shall provide all internal grounding to the package and grounding stud(s) for field bonding to the Plant Grounding subsystem.

Basis: Standard engineering practice.

3.3.4.28 *Requirement: Wiring Methods for Power Utilization. The primary wiring method for branch circuit wiring from MCCs or PDPs to load shall be via cable trays using tray-type cable. Conduit and single conductor wire shall be used where cable tray is not feasible.*

Basis: Standard engineering practice in conformance with NFPA 70.

3.3.4.29 *Requirement: Harmonics Control. The power supply systems shall be evaluated for the magnitude of linear and non-linear loads to determine if any harmonic control is required. The harmonics generated at the distribution transformers shall conform to the recommended practices and requirements defined in IEEE 519, unless otherwise specified.*

Basis: Consensus industry standard design.

3.3.4.30 *Requirement: Power Cable Ampacity. Unit substation power transformer primary supply cables shall be capable of continuously carrying a minimum of 125% of the transformer rating.*

Cables feeding continuous duty motors shall be sized for at least 125% of the full load current of the motor.

Cable ampacity shall be derived from the IEEE 835 Standard (enhanced version of ICEA Publications P-46-426 and P-54-440), and applicable NEC cable ampacity tables based on 90°C conductor temperature and 40°C ambient temperature with considerations for cable ampacity derating as stated in the subsection for MPS Cable Derating.

For circuits that will be routed partly through conduit and partly through trays or underground ducts, the cable size shall be based on the ampacity in that portion of the circuit with the lowest indicated current carrying capacity. Cable de-rating due to cables passing through fire barriers shall be considered.

Basis: Standard engineering practice in conformance with IEEE 835 and NFPA 70.

3.3.4.31 *Requirement: Short Circuit Duty. The maximum available short circuit current, circuit breaker tripping, fuse melting times, and conductor allowable temperature rise shall be used to determine the minimum size of MV and LV power cables.*

Basis: Standard engineering practice in conformance with IEEE 835 and NFPA 70.

3.3.4.32 *Requirement: Voltage Drop. Voltage drop calculations shall be performed to ensure that the available voltage at the terminals of equipment is within the specified operating range.*

The AC feeder cable sizes shall limit the steady state voltage drops to allowable limits as stated in NEC Article 210-19(A), Note No. 4 for branch circuits and Article 215-2(B), Note No. 2 for feeders.

Analyses shall be performed to verify that, while starting the largest motor, the motor terminal voltage of running motors shall not dip below 70%.

Basis: Standard engineering practice in conformance with NFPA 70 and NEMA.

3.3.4.33 *Requirement: Control Cable Sizing. Worst-case control circuit voltage drop calculations shall be performed to ensure that, under minimum operating voltage conditions, the voltage at terminals of control devices is within its specified operating range.*

The minimum acceptable conductor size for control cables shall be No. 16AWG. For potential and current transformers, the minimum acceptable cable size shall be No. 12AWG and No. 10AWG, respectively.

Basis: Standard engineering practice.

3.3.4.34 *Requirement: Cable Derating. The power and control cable insulation shall be designed for a base conductor temperature of 90°C. The allowable current carrying capacity of the cable shall be based on not exceeding the insulation design temperature while the surrounding air is at an ambient temperature of 40°C (104°F) for process areas and 30°C (85°F) for office areas.*

The power cable ampacity shall be established by calculation. The method of calculating derating factors shall be determined from the ICEA publications, IEEE 835, NEC, and other applicable standards with consideration of the following parameters:

- *Type of installation/underground duct banks*
- *Conductor temperature*
- *Ambient temperature*
- *Number of cables in a raceway*
- *Grouping of raceways*
- *Use of fire-proof wrapping or fire barriers*

Instrumentation cable insulation shall also be based on a conductor temperature of 90°C. The operating voltage/current of these cables are low (usually mV or mA) and do not cause the design temperature to be exceeded at maximum design ambient temperature. As such, no derating shall be applied to instrumentation cables.

Power cables in cable trays shall be derated based on cable fill in accordance with NEC, Article 392. For control and instrumentation cable trays, the fill shall be based on 40 percent of the usable tray cross-section area.

Basis: NFPA 70, IEEE, ICEA, and NEMA consensus industry standards.

3.3.4.35 *Requirement: Conduit Fill. Conduit fill shall be in compliance with Tables 1 and 4 of NEC Chapter 9.*

Basis: Consensus industry standard.

3.3.4.36 *Requirement: Cable Terminations. Terminations of power, control, and instrumentation cables shall be in accordance with the following criteria:*

- *All current transformer wiring shall use ring type terminals and terminate on a shorting block.*
- *All potential transformer wiring shall be connected to a disconnect switch or a disconnect type terminal block.*
- *Motors supplied with pigtails, which are not terminated on a terminal block, shall be terminated using engineering approved motor cable termination kits. The terminations shall be made inside the motor terminal box.*
- *Termination requirements for special purpose cables utilizing connectors shall be in accordance with the cable manufacturer's requirements.*
- *All auxiliary equipment inside cabinets, including spare contacts and auxiliary switches, shall be wired to the terminal blocks.*
- *15 to 20 percent spare terminals shall be provided in each panel for future use.*

Basis: Standard engineering practice.

3.3.4.37 *Requirement: Separation. Cable systems shall be designed to comply with the NEC voltage separation requirements. Any separation required to prevent signal interference will be accomplished via metallic raceway barriers, such as conduit, cable tray covers, and wiring trough separators.*

Basis: Consensus industry standard design.

3.3.4.38 *Requirement: 460 Volt Motors. Low voltage motor control equipment shall be housed in motor control centers with NEMA Class I Type B wiring.*

In general, individual motor controllers shall be across-the-line type, equipped with combination starters with magnetic-only type molded case circuit breaker, air break magnetic contactor, and solid-state overload relay. The circuit breaker and starter combination shall have minimum interrupting capacity of 65,000 amperes rms, symmetrical at 480 V. Circuit breaker handles shall have provisions for padlocking in the "OPEN" position.

Motor control circuits shall be rated at 24 Vdc derived from dual redundant power supplies.

Control wiring to MCCs shall be terminated on terminals mounted in the starter compartment. Use of auxiliary contacts will be minimized since monitoring and interlocking to the motor starters shall be through a communications bus (e.g., Profibus).

A red "RUN" indicating light shall be provided on the door of each starter compartment.

Power shall be distributed to individual 480 V loads (other than motors) by means of thermal-magnetic circuit breakers located in motor control centers. Circuit breakers shall have a minimum interrupting capacity of 65,000 amperes rms, symmetrical at 480 V.

Selected motors that have extended starting times shall be provided with solid-state reduced voltage starters, with a primary circuit breaker disconnect (soft start). No bypass or isolation contactors shall be provided.

Basis: Consensus industry standard practice.

3.3.4.39 *Requirement: AC Motors. Under steady state running condition, voltage at the motor terminals shall be maintained within 90 to 110% of motor rated voltage.*

Voltage at the terminals of running motors shall not dip below 70% of motor rated voltage when starting the largest motor on that bus system.

All AC motors shall be suitable for full-voltage starting. In general, they shall be designed to accelerate their connected loads with a minimum 80% voltage at the motor terminals. Other engineering approved reduced voltage motor starting methods shall be used if the degree of inrush current is excessive.

Motors for the loads requiring successive starts shall be rated for multiple start duty cycle.

Basis: NEMA MG 1, an industry consensus standard, provides operational requirements for motors.

3.3.4.40 *Requirement: Cable Raceways. Raceway system design shall comply with NFPA 70 for installing and supporting cable runs between electrical equipment, including physical protection. Raceway systems consist primarily of cable tray, conduit, and wireways. Cable tray is preferred over other types of raceways. Wireways are used to supplement cable trays in those locations restrictive to cable tray application. Use of conduit shall be minimized.*

Basis: Consensus industry standard practice.

3.3.4.41 *Requirement: Cable Trays. Power and control type cable trays shall be metal, ladder type, manufactured in accordance with NEMA VE 1, consisting of solid side channels with cable-supporting cross members.*

Cable trays shall not be utilized to carry or support equipment, piping, conduit, or instrument tubing.

Cable trays containing low level signal instrumentation cables shall be designed for protection against spurious signal sources using solid bottom trays with solid covers.

All vertical and horizontal tray bends shall have a 12-inch minimum inside radius.

For cable trays installed in tiers, the minimum vertical distance between trays shall be 12 inches (bottom of upper tray to top [side rail] of lower tray).

Minimum horizontal distance between adjacent trays within the same voltage class shall be as required for installation.

A minimum 2'-0" horizontal access on one side of each tray shall be provided for installation of cables in the trays.

Basis: Standard engineering practice.

3.3.4.42 *Requirement: Conduit. Underground, exposed, and embedded conduits shall be used where the use of trays or wireways is not practical.*

Non-metallic (schedule 40 polyvinyl chloride [PVC]) conduits encased in concrete shall be used for underground duct bank runs except under roadways. Steel conduit shall be used where duct banks cross roadways. The minimum size shall be four inches.

Slab- and wall-embedded conduits, three inches and larger, shall be schedule 40 PVC or rigid steel. Conduits 2" and smaller shall be rigid steel.

Conduit connections to motors, devices, and instrument points and other equipment subject to vibration or expansion movement shall be made with flexible metal conduit. In outdoor and indoor locations subject to wet conditions, liquid-tight flexible metal conduit shall be used.

All rigid steel conduit shall be hot-dip galvanized or electro-galvanized steel, manufactured to ANSI C80.1 and UL 6 requirements. Minimum exposed conduit size shall be 3/4 inches and minimum embedded size shall be two inches.

Conduit expansion fittings shall be used at all structural expansion joints.

Conduit "stub-ups" and "stub-outs" shall be terminated in a coupling set flush with the floor or the wall whenever possible and shall be capped.

Basis: Standard engineering practice.

3.3.4.43 *Requirement: Fractional Horsepower Motor Controls. Starters for single phase, fractional horsepower, 115 V motors shall be air break, manually operated, across-the-line type, and providing thermal overload protection only. The starters shall be mounted near the motors they control. Several starters may be grouped on a single feeder protected by a 20 A circuit breaker located in a 208Y/120 V power panelboard.*

Basis: Standard engineering practice.

3.3.4.44 *Requirement: Motor Ratings. Motors 1/2 hp to 150 hp shall be rated 460 V, 60 Hz, 3 phase, and generally shall be powered from 480 Vac MCCs.*

All AC motor operators for the motor operated valves shall be rated at 460 Vac, 60 Hz, 3 phase, and be powered from the MCCs.

Motors less than 1/2 hp shall be rated 120 V, 60 Hz, 1 phase.

Basis: Consensus industry standard equipment ratings.

3.3.4.45 *Requirement: Motor Wiring Methods. Flexible conduit connections shall be utilized between conduit and motor terminal boxes to reduce the transmission of vibration.*

Basis: Standard engineering practice.

3.3.4.46 *Requirement: Motors. All motors shall be rated, built, tested, and applied in accordance with ANSI C50.41 and NEMA Standard MG 1.*

Low voltage motors shall be designed for Class B temperature rise and shall be provided with Class F or better insulation.

Basis: ANSI and NEMA consensus industry standards. Insulation is in accordance with standard engineering practice.

3.3.4.47 *Requirement: Physical Arrangement. Cable raceways shall be arranged physically from top to bottom, in accordance with the voltage class and function of the cables, as follows:*

Table 1, Cable Raceway Arrangement

SERVICE	RACEWAY CODE
Medium voltage power [15 kV (nominal) ac]	MDPV4
Low voltage power cables (480, 120 Vac) Multi-Conductor	LMT
Low voltage power cables (480, 120 Vac) Single Conductor	LST
High Level signal and control cables (120 Vac)	CCRMC
Instrumentation (Analog and Shielded Digital)	IMRMC

Separate raceways shall be provided for different voltage groups. However, non-shielded digital (instrument) circuit cables may be routed with control cables of the same insulation voltage level. Fiber-optic cables may be combined with cables of any voltage group.

All cases of heat source proximity, which may cause the cable design temperature to exceed, shall be evaluated. Supplemental heat shielding or cable ampacity derating shall be applied as required.

The raceways shall be designed considering the layout requirements of other disciplines for close measurements, cramped spaces, interference, ease of cable installation, and equipment maintenance.

Basis: Standard engineering practice.

3.3.4.48 *Requirement: Power & Control Cables. Power cables are those cables that conduct electrical energy at 15 kV, 480 Vac, 277 Vac, 208 Vac, and 120 Vac.*

The medium voltage cables shall be provided with 15 kV insulation with shielding to accommodate possible sustained and transient overvoltage during a line-to-ground fault. The sustained overvoltage for the low voltage system shall be limited by the high resistance grounded system, which will limit the ground current to a low value.

For load circuits with voltage levels at 480 Vac or lower, cables with 600 V insulation shall be used.

Control cables are generally used for 120 Vac circuits for automatic or manual initiation of auxiliary control functions. Control cables shall be rated at 600 V insulation class for standardization.

MV power cables shall have ethylene propylene rubber (EPR) insulation or engineer approved equal. The jacket material shall be chlorosulfonated polyethylene (Hypalon) or engineer approved equal. LV power and control cables shall be XHHW type with cross-linked polyethylene (XLP) insulation. The following table summarizes the cable types for each particular power service.

Table 2, Power Cable Types

SERVICE	CABLE TYPE
15 kV (nominal), Incoming Power	MV-90 Rated for EPR 133% insulation
15 kV (nominal), Transformer Primary Feeders	MV-90 Rated for EPR 133% insulation
480 V Main Feeders	XHHW
480 V, 3 phase Branch Circuits to loads	XHHW
277 V, 1 phase Branch Circuits to loads	XHHW
240/208/120 V, Branch Circuits to loads	XHHW (Process Areas) THHN or THWN (Office Areas)

Basis: Standard engineering practice

3.3.4.49 *Requirement: Electrical Protection. Protective relays and direct acting trip devices shall be provided for the electrical power distribution systems to:*

- *Provide for the safety of personnel*
- *Minimize damage to equipment*
- *Minimize system disturbances*
- *Isolate faulted equipment and circuits from unfaulted equipment and circuits*
- *Maintain power supply continuity by selective tripping*

The short circuit protective system shall be analyzed to ensure that various adjustable protection devices are applied within their ratings and are set to be coordinated with each other to attain selectivity.

The protective relays used in the electrical system shall be digital, solid-state type when available.

Basis: DUF6-SRD-PORT (PADU) Rev. 0, *Portsmouth (Paducah) SRD*, and standard engineering practice.

3.3.4.50 *Requirement: MV System. Electrical protection for the MV distribution system shall meet the applicable guidelines of IEEE 242.*

Basis: IEEE 242 is a consensus industry standard.

3.3.4.51 *Requirement: Overcurrent Relaying. MV source incoming breakers shall be provided with a multifunction solid-state (microprocessor-based) inverse-time overcurrent device (51) and an inverse-time ground fault device (51N) for bus protection.*

Each MV feeder breaker shall be provided with solid-state (microprocessor-based) overcurrent (long time and short time) and ground fault protection.

Basis: Standard engineering practice.

3.3.4.52 *Requirement: 480 V Unit Substations. Electrical protection for the LV distribution system shall meet the applicable guidelines of IEEE 242.*

Each circuit breaker in unit substations shall be provided with a microprocessor-based adjustable trip device with long time, instantaneous, and ground fault tripping features as applicable.

Unit substation transformers shall be equipped with a transformer winding temperature relay (device 49T), which will provide input to the plant ICS on transformer overload.

Basis: Standard engineering practice.

3.3.4.53 *Requirement: LV MCCs. Other non-motor feeders shall be equipped with molded case breakers with thermal and magnetic trip elements for overload and short circuit protection.*

Basis: Standard engineering practice.

3.3.4.54 *Requirement: Cable Systems. Maximum temperature ratings of conductors shall be 90°C (194°F) under normal operation, 130°C (260°F) under emergency overload conditions, and 250°C (482°F) under short circuit conditions. The design of the conductors shall also consider the temperature limitation provisions of NEC Article 110-14(c). Use of PVC shall be minimized in cable construction. In general, PVC will not be specified for cable tray use and other uses where a fire could cause release of toxic fumes into the surrounding atmosphere. Cable splices shall be prohibited unless protected by junction boxes specifically intended for that purpose. Cables or wires being spliced together shall be of the same construction. The splices shall only be constructed of materials specifically approved for the expected operating environment. No splices shall be allowed in cable trays.*

The following types of cables shall be selected based on intended usage:

- *MV power, 15 kV, shielded*
- *LV power, 600 V*
- *Control, 600 V*
- *Lighting, 600 V*
- *Communication, 300 V*
- *Instrumentation, 300 V*
- *Fiber-optic for data communication*
- *Special purpose analog signal, coaxial and triaxial.*

The cables shall be designed to the requirements provided in ICEA and NEMA standards. All wiring located inside auxiliary electrical equipment cabinets shall be NEC type SIS multi-strand conductors or engineer approved equal.

Basis: Consensus industry standard practice.

3.3.4.55 *Requirement: Fiber-Optic Cable. Fiber-optic cables shall be utilized for the data highway bus and for the Ethernet bus (if distances dictate) that interconnect the plant systems and the Central Control Room. Fiber-optic cable shall be constructed as specified in ANSI/EIA 472.*

Basis: Consensus industry standard design.

3.3.4.56 *Requirement: Instrumentation & Special Cables. Instrumentation cables are those cables conducting low-energy instrumentation and control signals. These signals can be either analog or digital. Typically, these cables carry signals from thermocouples, resistance temperature detectors, transducers, etc.*

Special purpose cables shall have insulation and jacket materials in conformance with the specific application. The cables used in radiation areas shall be radiation resistant.

Twisted pair cables shall be used for low level instrumentation signals to reduce the electrical noise caused by magnetic coupling.

Basis: Standard engineering practice.

3.3.4.57 *Requirement: Underground Duct Banks. Underground, concrete-encased conduits shall be engineer approved (NEMA TC 2 and TC 6), schedule 40 PVC. The top of the duct bank shall be buried a minimum of two feet below grade or below the frost line, whichever is greater. A continuous, yellow caution tape shall be buried 1'-6" below grade above the duct bank. End bells are to be installed at the end of underground runs entering or leaving manholes.*

Basis: Standard engineering practice.

3.3.5 Standby Power Supply Subsystem

3.3.5.1 *Requirement: Life Safety System. The life safety electrical system shall consist of small, stand-alone, self-contained battery units used for all essential-to-life equipment (emergency lighting and exit signs). This system shall be designed in accordance with NEC Article 700.*

Basis: NFPA 101 and NFPA 70.

3.3.5.2 *Requirement: SPS. Standby power source shall be provided to systems and components that are required to operate during a loss of the normal power source. Standby power supply sources shall include standby diesel-generator and an UPS. The standby power supply subsystem shall be designed in accordance with IEEE 446 and DOE-STD-3003-00.*

Basis: DOE-STD-3003-00, IEEE, and standard design practice for industrial plants.

3.3.5.3 *Requirement: General. The on-site standby AC power generation source consists of one standby generator unit, its associated auxiliaries, and the generator output breaker. The standby AC power source shall also conform to the codes and standards specified in Section 5.23 of DOE O 420.1.*

The standby AC power shall be designed to supply reliable AC backup power to the selected plant loads, in the event of a loss of the normal power sources. Selection of loads and time duration for which they are required to operate shall be based on consideration of personnel and public safety, environmental and process equipment operation needs, and safeguarding the owners' investment.

Basis: DUF_6 Portsmouth SRD, DOE O 420.1, and standard engineering practice.

3.3.5.4 *Requirement: System Configuration. The standby generator shall be rated to provide backup AC power to the selected plant critical loads at 480 volts. Standby distribution will be via a 480 volt MCC.*

Basis: Utilization voltage for process equipment is 480 Vac.

3.3.5.5 *Requirement: System Design. The standby generator unit shall be an independent self-contained system, complete with all the necessary support subsystems, including:*

- *Diesel engine*
- *Engine starting system*
- *Combustion air intake and engine exhaust*
- *Engine cooling*
- *Engine lubrication*
- *Engine fuel supply and governor*
- *Generator, static exciter, generator protection, and associated monitoring instrumentation*

The generator unit shall be able to withstand a voltage dip of 25% of the normal voltage due to motor starting. It shall be provided with local and remote monitoring, and control for manual start-up, shutdown, and operating performance feedback. The monitoring subsystem shall include starting, cooling, lubrication, fuel supply, combustion air intake/exhaust, excitation, and voltage regulation. The subsystem component design shall ensure that the unit's performance conforms to its nameplate rating.

An automatic transfer switch shall be housed in the MCC to facilitate the transfer of normal and emergency power. A generator circuit breaker shall be located at the unit housing.

The standby generator unit shall produce rated power at 480 Vac, 60 Hz, 3 phase and shall be rated to supply the selected design loads with an additional 10 to 15 percent margin to address future load growth. Refer to Table 6, Portsmouth Diesel Generator Loads *for the Portsmouth and* Table 7, Paducah Diesel Generator Loads *for the Paducah Plant diesel-generator loading details.*

Upon loss of plant normal power supply source, the standby generator power shall be available for a period of eight hours to support the process systems.

The standby generator design shall be compatible with the step loading requirements dictated by the plant system performance needs and as established in the diesel-generator loading calculation. The generator exciter and voltage regulator systems shall be capable of providing full voltage control during all operating conditions including postulated fault conditions.

Basis: Standard standby generator components and performance characteristics. The selected margin and availability duration are based on operational experience and the process plant needs.

3.3.5.6 *Requirement: Electrical Protection. The electrical protection for backup power systems shall be designed in accordance with the applicable guidance of IEEE 446.*

The following generator protection devices shall be provided, as a minimum:

- *Differential*
- *Overcurrent*
- *Reverse power*
- *Under frequency*
- *Under/overvoltage*
- *Loss of excitation*
- *Ground fault*
- *Negative phase sequence*
- *Voltage balance*

Basis: Consensus industry standard IEEE 446.

3.3.5.7 *Requirement: Generator Start-up. The standby generator shall have two modes of start-up operation: “MANUAL” and “AUTO.” Manual operation shall be used for generator unit testing. In the automatic mode, the standby generator shall start, automatically, upon detection of undervoltage on the associated essential MCC.*

Basis: Standard engineering practice.

3.3.5.8 *Requirement: Sequential Bus Loading. The standby generator-backed MCC shall normally be powered via the normal 480 Vac electrical distribution system. On detection of a preset bus undervoltage, a bus undervoltage condition shall initiate a signal to start the standby generator and actuate the automatic transfer switch.*

On attaining the rated frequency and voltage levels, the generator output breaker shall be automatically connected to the associated de-energized bus and shall initiate load sequencing operation.

The standby generator shall be designed to supply power to the associated MCC loads within 60 seconds of bus undervoltage event detection.

Upon return of normal power, the automatic transfer switch will transfer the load back to the normal power source after a preset time delay.

Basis: Standard engineering practice.

3.3.6 Direct Current and Uninterruptible Power Supply

3.3.6.1 *Requirement: General. The UPS subsystem shall be provided to support the critical loads in the process areas and in the Central Control Room. The standby generator-backed MCC shall be the normal and bypass AC power sources for the UPS.*

Basis: DOE Standard DOE-STD-3003-00 and standard industry practice.

3.3.6.2 *Requirement: General. The stationary battery unit of the UPS shall be sized to provide a minimum of 30 minutes of backup power to the selected critical loads.*

Basis: This requirement is based on the estimated time required to support control system operation for orderly shutdown of the plant during loss of normal AC power supply source event.

3.3.6.3 *Requirement: Output Voltages. UPS Output Voltage shall be: 120 Vac, two–wire single phase 60 Hz. Total Harmonic Distortion (THD) shall be < + 5%; Voltage Regulation shall be < ± 5%; and Frequency Regulation shall be< ± 0.5 Hz.*

Basis: IEEE 446, an industry consensus standard, provides guidance and recommendations for THD, Voltage Regulation, and Frequency Variation. Output voltage is based on typical equipment needs.

3.3.6.4 *Requirement: System Configuration. The UPS subsystem shall include appropriately sized battery banks, charger, inverter, regulating (bypass) transformer, and system monitoring instrumentation.*

Basis: Consensus industry standard design.

3.3.6.5 *Requirement: System Design. The normal power source for the UPS subsystem shall be the 480 Vac MCC that is backed by the on-site standby diesel-generator.*

The UPS subsystem shall be provided with a backup AC power source, of sufficient capacity and characteristic, to allow normal system operation during inverter maintenance outage.

In the event the inverter becomes inoperable, the power shall be transferred automatically to the regulating transformer by a static transfer switch featuring a make-before-break contact arrangement. In addition, a manual mechanical bypass switch shall be provided to allow connection of the regulating transformer when the inverter is removed from service for maintenance.

The UPS subsystem equipment, and its enclosure, shall be qualified to withstand a postulated seismic event as stated in the DUF_6 Conversion Project civil/structural design criteria and as determined based on the specific state building codes.

Basis: Consensus industry standard design.

3.3.6.6 *Requirement: Equipment Requirements. The UPS subsystem shall be designed to operate with input power at 480 Vac nominal, and 120 Vac, single-phase, two-wire, 60 Hz, output, while maintaining steady-state output voltage within ± 2% and frequency within ± 1/2 Hz.*

The subsystem shall be provided with under/overvoltage and under/over frequency protection. Each regulating transformer (bypass transformer) shall be provided with a control circuit that will open the input feeder circuit breaker if the AC input power source drifts outside the acceptance limit. The regulating transformers shall be provided with Class H or better insulation to ensure long-term reliability. Surge suppression devices shall be provided at the input terminals of inverters and regulating transformers.

Basis: IEEE 446, an industry consensus standard, provides guidance and recommendations for Voltage Regulation and Frequency Variation. Input and output protection and bypass transformer requirements are in accordance with consensus industry standards.

3.3.7 Plant Grounding and Lightning Protection

3.3.7.1 *Requirement: General. The GLP subsystem shall perform the following principal functions to provide personnel safety and investment protection:*

- *Maintain safe voltages across all areas of the yard during high voltage system transients*
- *Provide a low impedance path ground fault current return*
- *Maintain safe voltages within DUF_6 Conversion Facility structures during electrical transients*
- *Provide instrumentation ground*
- *Minimize the effects of lightning surges on equipment and structures*

The design and analysis of the grounding subsystem shall follow the procedures and recommended practices as stated in the IEEE 142 standard. The design and installation of the lightning protection subsystem shall be in accordance with NFPA 780. The design shall provide the minimum requirements for application of lightning arresters, grounding electrodes, and grids.

Basis: *DUF_6 Portsmouth/Paducah SRD* (DUF6-SRD-PORT/PADU) and consensus industry standards.

3.3.7.2 *Requirement: System Grounding. The system grounding shall be selected to enhance the availability and proper coordination of current interrupting devices of the power supply system.*

Basis: Standard engineering practice.

3.3.7.3 *Requirement: Metallic Structure Grounding. All metallic structures and equipment, such as crane rails, stairs, handrails, tanks, doorframes, etc., shall be permanently grounded and directly connected to the building ground loop.*

Building steel shall be grounded at the base elevation by connecting structural columns to the ground grid.

Structures welded or adequately bolted to the building steel or solidly connected to the building steel by means of suitable grounding cable shall be considered effectively grounded.

All metal chimneys and above grade tanks shall be grounded directly to a ground grid supplemented with ground rods and shall be interconnected with the main ground grid.

Basis: Standard engineering practice.

3.3.7.4 *Requirement: Grounding of Railway Rails. All railway rail joints within the plant ground grid area shall be bonded across with a No. 2 AWG grounding conductor.*

Railway rails shall preferably be bonded to adjacent structures that are already connected to the ground grid or directly to the ground grid at intervals of not more than 50 feet.

Where railway rails leave the plant grid area, insulating joints shall be placed. One set of insulating joints shall be placed twenty feet from the point where the railroad leaves the plant grid area. A second set of insulating joints shall be placed so as to avoid shunting of a single set by a metal car or the soil itself.

Basis: General system design practices and requirements.

3.3.7.5 *Requirement: Cylinder Yard Security Fence. Cylinder yard security fence shall be grounded every 500 feet using local ground rods. Where overhead energized conductors may cross the fence that portion of the fence shall be grounded using local ground rods on each side of the span. This section shall be isolated from the remaining portion of the fence.*

The motor-operated gate section shall be separated from the property security fence using ground isolators. The motor-operated gate shall be grounded via local ground rods.

Basis:

3.3.7.6 *Requirement: Equipment Grounding. Equipment grounding of all electrical equipment in the plant area shall be provided. The grounding/bonding conductor shall be sized in accordance with the IEEE 142 standard and NEC Article 250.*

Basis: Consensus industry standards.

3.3.7.7 *Requirement: Equipment Grounding. Connections to equipment and ground buses shall be made with lugs attached to the equipment by means of bolts. Anchor bolts of equipment housings shall not be used for fastening lugs of the grounding cable. Connections for cable to cable shall be made by means of the Thermit weld process. The switchgear and the MCC ground buses shall be connected to the Electrical Room ground loop.*

Basis: Industry standard design practices.

3.3.7.8 *Requirement: Equipment Grounding. Motors rated at 460 V shall be grounded by installing a ground conductor from the source of supply (with the motor's power conductors) and bonding the conductor to the enclosures at each end. The ground conductor shall be sized, as a minimum, per NEC Table 250-122. The ground conductor jacket shall be colored green.*

Small equipment and instrument enclosures (without 120 V power supply) shall be grounded by means of the conduit or raceway containing the circuit conductors.

Liquid-tight, flexible, metal conduit, with approved connectors in trade sizes 1-1/4" and smaller, shall be considered as a suitable grounding conductor path where the total length of the conduit does not exceed 6 feet, when terminated at both ends with approved fittings which are UL listed for grounding, and where the circuit overcurrent protection is 20A or less.

Grounding bushings and jumpers shall be installed on conduits where threaded fittings are not used, such as locknut entrances to the sheet metal MCCs, junction boxes, panel boards, and cabinets.

Outdoor, metallic lighting fixtures mounted on lighting poles, such as along roads, shall be internally connected to a No. 2AWG buried bare grounding cable that is connected to a grounding cable tap from one of the main grounding loops. The grounding cable tap shall be buried close to the line of lighting fixtures.

Basis: Standard industry design practices and the NEC.

3.3.7.9 *Requirement: Equipment. The equipment requirements of each distribution system are described below:*

- *480 Volt Unit Substation Transformer Grounding Resistors: High-resistance grounded through a separate grounding resistor rated to limit the ground current to 5 amperes*
- *On-site Standby Generator: The neutral shall be solidly grounded using copper cable*
- *Lighting and Distribution Transformers: The lighting and distribution transformers shall have solidly grounded, wye secondary windings using copper cable*

Basis: General system design practices and requirements.

3.3.7.10 *Requirement: Raceway Grounding. Metallic conduit shall be electrically continuous and connected to the grounding network. Discontinuities, such as those caused by non-metallic boxes, gaps in conduit, plastic conduit sections, etc., shall be avoided by installation of No. 2AWG copper cable bonded across such discontinuities. For buried or submerged bonds, insulated cable and tape connections with PVC electrical tape shall be used. Steel conduits terminating at steel panels shall be grounded to the panel by use of double locknuts or grounding bushings.*

Cable tray sections and fittings shall be connected together to ensure electrical continuity throughout the cable tray system. Cable trays supported from the building steel shall be considered effectively grounded. Otherwise, at intervals of 50 feet, the trays shall either be bonded to the building steel, or ground conductors of No. 2/0AWG size shall bond the tray system to the building/plant ground loops.

Basis: Standard engineering practice.

3.3.7.11 *Requirement: Instrument Computer Grounding. The instrument/computer grounding shall employ single point grounding. Each instrument and computer cabinet shall be provided with an isolated ground bus. The isolated ground buses are interconnected using insulated copper cables and are connected to the ground grid through only one connection in conformance with IEEE 141, Section 5.5.4.*

For sensitive signal circuits, a shield shall be employed to further reduce or eliminate electrical field effects. The shield shall be grounded at the source and floating on the receiving end. The conductor of coaxial cables shall be grounded at the source and deemed adequate against the effects of magnetic and electric interference. Triaxial cable is identical to coaxial with the addition of an outer braid that serves as a shield, which shall be grounded at the source end only.

Basis: Standard engineering practice.

3.3.7.12 *Requirement: Static Grounding. Static grounding shall be provided to discharge accumulated static electricity on the equipment, on materials being handled or processed, and on operating personnel in the areas where flammable liquids, gases, dust, or fibers are present. The static grounding shall be designed in accordance with IEEE 142.*

Metallic piping containing flammable or combustible (hazardous) materials shall be designed to maintain continuity and to minimize resistance to ground. Bonding jumpers shall be installed across all metallic pipe joints and flanges and across flexible joints or couplings.

Loading, unloading, and filling facilities handling flammable liquids, vapors, or combustible dust, shall be connected to the plant ground. Special precautions shall be taken for protection against static sparks by providing an electrical bond between electrically conductive materials between which sparking may occur.

Provisions shall be made for the grounding of trucks containing flammable materials during loading and unloading operations.

All metallic machines, equipment, and components in Class II hazardous locations shall be grounded and bonded per NFPA 654, Section 5.3 that states, "A ground bus shall be provided in the locations of portable equipment. Bonding jumpers shall be installed across all metallic pipe flanges. Jumpers shall be installed across flexible metallic and non-metallic pipe joints to provide electrical continuity."

Basis: Consensus industry standards and standard engineering practice.

3.3.7.13 *Requirement: Lightning Protection. The lightning protection subsystem shall be provided for the protection of the cooling towers and other exposed structures, and buildings such as the standby generator building, etc., in accordance with the lightning protection code, NFPA 780.*

Surge suppressors shall be provided to protect the plant instrumentation and monitoring equipment from lightning-induced surges in the signal and power cables connected to devices located outside.

Basis: Consensus industry standard and standard engineering practice.

3.3.8 Plant Illumination and Lighting

3.3.8.1 *Requirement: Convenience Receptacles. Convenience receptacles for 120 V operation shall be provided throughout the plant areas to furnish power for small electric tools and portable equipment. The receptacles shall be so located that a maximum 50-foot extension cord would reach any point in the working area where such use is expected.*

Receptacles shall be the 3-wire, 2-pole grounding type, suitable for the area in which they are installed. In wet locations, receptacles with ground-fault-circuit-interrupter (GFCI) protection units shall be provided in accordance with NEC requirements.

In general, the indoor areas shall be supplied with 15 A, 125 V, grounding type, duplex receptacles, and flush-mounted 1'-6" above the floor.

Basis: Consensus industry standard and standard engineering practice.

3.3.8.2 *Requirement: General. Provide normal lighting to meet the visual requirements of occupied and unoccupied plant areas when the normal ac power source is available.*

In the event of a loss of normal ac power, standby generator-backed power shall be provided for the lighting in the CCR and other areas where shutdown operations are expected to be performed.

In the event of a loss of normal ac power, provide essential-to-life emergency battery packs for illumination in all areas required for emergency egress.

The following luminaries/fixtures shall be used for the lighting system:

- *LED - wherever possible and still maintain existing lighting levels or better*
- *Incandescent – for spot lighting*

- *Fluorescent with high efficiency ballast – for general plant and office areas*
- *Metal halide – for indoor, high bay areas*
- *High-pressure sodium – for roadway lighting.*
- *The CCR lighting system shall be provided with fluorescent lighting, glare-free ceiling diffusers*

Basis: Operational experience and standard engineering practice.

3.3.8.3 *Requirement: Illumination Level. The illumination levels for area lighting shall meet the minimum requirements indicated in Table 5, Illumination Requirements:*

Table 3, Illumination Requirements

Area Type	**Illumination Elevation**	**Foot-Candle Level**	**Reference Standard**
Mechanical Room	Floor	5	IES RP-7-17
Scrubber Area	Floor	5	IES RP-7-17
Vaporization Room	Floor	15	IES RP-7-17
Powder Transfer Room	Floor	5	IES RP-7-17
Crane Transport Areas	Floor	5	IES RP-7-17
Central Control Room	30” above finished floor	40	IES RP-7-17
Electrical Room	Floor	5	IES RP-7-17
Radioactive Machine Shop	30” above finished floor	50	IES RP-7-17
Warehouse Areas	Floor	10	IES RP-7-17
Laboratory Areas	30” above finished floor	50	IES RP-7-17
Roadway Lighting	Ground	1	IES Handbook
Office Areas	30” above finished floor	40	IES RP-1

3.3.8.4 *Requirement: Lighting Control and Circuiting. 120 V lighting fixtures shall be supplied from 20 A circuit breakers located in 208Y/120 V, 3-phase, 4-wire panel boards. 277 V lighting fixtures shall be supplied from 20 A circuit breakers located in 480Y/277 V, 3 phase, 4-wire panel boards.*

In general, outdoor lighting fixtures shall be controlled automatically by means of photoelectric cells. Such circuits shall be controlled with lighting contactors and "HAND-AUTO" selector switches.

Maximum voltage drop between lighting panel board and branch circuit load center shall not exceed three percent.

HID and fluorescent lamp output tends to follow the alternating current waveform. This condition can cause small, moving objects to flicker (stroboscopic effect). To avoid this potential safety hazard, HID fixtures shall be circuited with alternating phases of 3 phase power.

The lighting distribution shall be designed such that the load is balanced between the 3 phases, as far as practical. Circuits using a common neutral conductor shall be designed for minimum current in the neutral. Circuits serving computer-type loads or fluorescent and HID lighting shall not use a common neutral, as far as possible, because of harmonic content. In cases where common neutral for such loads is unavoidable, the neutral shall be sized for twice the ampacity rating of the phase wires.

Lighting distribution inside a building shall be kept separate and distinct as far as possible from power and instrumentation distribution.

Indoor lighting circuits shall be switched from lighting panel boards, except in personnel areas, such as the CCR, offices, and Electrical Equipment Room, where local switches shall be provided.

Basis: Standard engineering practice.

3.3.8.5 *Requirement: Lighting Distribution Panels. The requirements for power distribution panels shall also apply to lighting distribution panels.*

The lighting distribution panels shall supply 120 Vac power to supplemental work area lighting, receptacles, and miscellaneous small loads.

The 480Y/277 Vac and 208Y/120 Vac lighting distribution panels shall be 3 phase, 4-wire with a grounded neutral system. Each panel shall be provided with a main circuit breaker with 42 single pole spaces for branch feeder breakers, except for the CCR lighting panel, which will have 12 single pole branch feeder breakers.

Basis: Standard engineering practice.

3.3.8.6 *Requirement: Lighting Transformers. The requirements for dry-type transformers shall also apply to lighting transformers.*

Lighting/receptacles transformers shall be 480-208Y/120 Vac delta-wye, dry-type to provide 120 Vac power source to utility receptacles and incandescent and fluorescent lighting fixtures.

Lighting transformers for HID lighting fixtures shall be 480-480Y/277 Vac, delta-wye, dry-type.

Basis: Standard engineering practice.

3.3.8.7 *Requirement: Office Area Lighting. Fluorescent or LED fixtures with cool white lamps shall be provided in indoor personnel areas such as the CCR. Ballasts shall be the energy efficient type. Lighting fixtures shall be suitable for 120 V application. Exit signs shall be provided at exits and, where required, signs shall be provided that indicate the direction of the nearest exit.*

Basis: Standard engineering practice and NFPA 101.

3.3.8.8 *Requirement: Process Area Lighting. Lighting in the plant process area shall be controlled by a lighting control system. 75% of the lighting load will be fed from normal power. Approximately 25% of the lighting load will be fed from the standby generator-backed MCC. Fixtures will be high bay type for the conversion unit area and fluorescent or LED industrial type fixtures for all other process areas. Energy-saving lamps and ballasts shall be used.*

The lighting circuits in individual areas of the plant shall be staggered and supplied by a minimum of two feeder circuits to ensure that some lighting is retained in the area should one circuit trip. The lighting loads shall be distributed between the lighting panels as required by physical arrangement and illumination levels.

The outdoor lighting around the perimeter of the buildings shall be fed from the normal indoor lighting panels.

Basis: *DUF$_6$ Portsmouth (Paducah) SRD* and NFPA 101.

3.3.8.9 *Requirement: Roadway Lighting. Roadway lighting shall provide minimum illumination levels of one foot-candle (refer to the previous table) for all roadways inside the plant areas. Luminaries shall be high-pressure sodium or LED, roadway type fixtures with 480 V or 277 V ballast mounted on 30-foot high, galvanized steel poles with 6-foot arms.*

The fixtures shall be controlled by lighting controllers that are equipped with integrally mounted photoelectric cell control.

Basis: Standard engineering practice.

3.3.8.10 *Requirement: Site General and Security Lighting. General site lighting shall be provided using the same type luminaries as for roadway lighting.*

Illumination shall be designed to aid in the detection of unauthorized persons and vehicles within the Property Protection Area (PPA). Illumination design details shall conform to DOE O 473.3A, Protection Program Operations.

Basis: DOE O 473.3A and standard engineering practice for industrial plants.

3.3.8.11 *Requirement: Standby Lighting. The standby lighting in the CCR shall be fed from a standby generator-backed ac power source such that during an event of a loss of normal power source, the lighting will be restored with minimal interruption. Sufficient illumination (refer to previous table) shall be maintained for the performance of recovery operations, such as the data display and control, communications, and additional tasks performed in the CCR.*

The CCR lighting system shall be provided with LED or fluorescent-lighted, glare-free reflectors to eliminate glares and shadows on control panels and workstations.

The emergency life safety lighting for the plant areas outside the CCR shall be provided with self-contained, battery-pack lighting units. An average of one foot-candle shall be provided for access and egress routes by the battery-pack units. The self-contained battery life shall be at least 90 minutes under continuous load. The self-contained battery shall not be loaded greater than 80% of the battery rated capacity, with additional derating for temperature variations, where applicable. A time delay shall be provided on restoration of the normal AC power so that the battery pack emergency lighting units continue to provide illumination to allow restart times of any normal HID lighting. All other requirements of NEC Article 700 shall be met, especially that all battery packs shall be powered from a normal lighting circuit in the same area.

Basis: *DUF_6 Portsmouth (Paducah) SRD*, NFPA 70, NFPA 101, and standard engineering practice implementing these requirements.

3.3.8.12 *Requirement: Wiring Methods. The wiring methods for the lighting subsystem shall be single-conductor wire in rigid conduit. Electrical metallic tubing (EMT) may be used above accessible ceilings and inside dry partitions in dry, non-hazardous areas. Roadway lighting circuits shall be installed using underground conduit.*

Basis: Standard engineering practice.

3.3.8.13 *Requirement: Lighting Cables. Lighting cables in the process areas shall have 90°C NEC type XHHW insulation. Lighting and receptacle circuits in the non-process buildings shall be 90°C NEC type THHN or THWN. Lighting fixture wiring shall comply with the* requirements of NEC, Article 402.

Basis: NFPA 70 and standard engineering practice.

3.3.9 Plant Cathodic Protection

3.3.9.1 *Requirement: System Design. Cathodic protection may be provided by impressed current, by the sacrificial anode method, or by a combination of the two, to provide an optimum design with regard to effectiveness, economy, operation, and maintenance.*

Based on very few metallic pipe/valve bodies buried underground, sacrificial anode method of PCP was considered for the DUF_6 Portsmouth and Paducah plants.

Basis: Consensus industry standard design.

3.3.9.2 *Requirement: System Design. Localized sacrificial anode cathodic protection system consisting of prepackaged zinc or copper-copper sulfate type reference electrodes shall be permanently installed near poorly accessible protected surfaces to provide a means of monitoring protection level by measuring potentials. Above grade Test stations shall be installed as required, adjacent to the equipment being protected, for termination of test leads from protected structures and permanent reference electrodes.*

The criteria for cathodic protection shall be in conformance with NACE Standard RP-01-69 with applicable minimum negative (cathodic) voltage.

***Basis**: Consensus industry standard design.*

3.3.10 Plant Communication System

3.3.10.1 *Requirement: General. The voice communication system shall provide the effective and diversified means for communication within the plant area and external to the plant during all modes of operation.*

The system shall consist of three subsystems: telephone/page, private automatic branch exchange (PABX), and wireless telephone. Each subsystem shall be completely independent, such that a failure of one subsystem will have no effect on the operability of the other subsystems.

The wireless telephone, telephone/page, and PABX subsystems shall receive power from the 120 Vac UPS subsystem.

The main switchboards for the wireless telephone subsystem and the telephone/page subsystem shall be in separate fire areas such that a fire will not affect more than one of these subsystems.

Each subsystem shall be designed for effective use, including annunciation, under all foreseeable high noise conditions. The wireless telephone, telephone/page, and PABX subsystems shall annunciate in all areas of the plant, both indoors and out. There shall be no area of the plant where these subsystems cannot be accessed and effectively used.

No communication system component shall interfere with the operation of any plant electronic devices and vice versa.

Basis: Standard design practices for industrial plants include communication systems consisting of the above subsystems.

3.3.10.2 *Requirement: PABX Subsystem. The PABX subsystem shall provide the means for communication within the plant areas and between the plant and off-site areas.*

The PABX subsystem shall be a push button telephone system. Phones shall be programmable for one button dialing. This subsystem shall be able to access the wireless telephone units, the telephone/page subsystem, and off-site telephones and telephone subsystems. Ties to outside phones shall be by both commercial telephone lines and dedicated lines (or links) for emergency use by off-site agencies and locations. The subsystem shall be capable of transferring calls and providing conference calls for up to five stations including wireless telephone stations.

This subsystem shall be capable of interfacing with the existing Gaseous Diffusion Plant (GDP) site telecommunication system.

Basis: Consensus industry standard design.

3.3.10.3 *Requirement: Telephone/Page Subsystem. The telephone/page subsystem shall be the primary means of communication throughout the plant.*

The subsystem shall be designed such that any interruption of service to any one area shall not disrupt the balance of the system. As a minimum, No. 14AWG power conductors shall be used throughout, except where voltage drop exceeds the maximum allowable value, in which case larger size conductors shall be used.

This subsystem shall have one page line and five party lines with merge capability.

Paging shall be available at each handset station, which shall be equipped to broadcast speech overall system speakers simultaneously by picking up the handset, depressing the "PAGE" switch on the handset, and speaking into the microphone on the handset. The speaker adjacent to the set shall be silenced automatically when the handset is removed from its cradle switch to prevent acoustic coupling.

Party line channel(s) shall provide two-way conversation capability without interference or cross talk between channels; conversation will not be heard over the speaker system. The channels shall be common talking, so that all stations may take part in any conversation. After paging, the calling party releases the "PAGE" switch and sets his/her party line selector switch to the desired channel. The called party picks up his/her handset, sets his/her party line selector switch to the same channel, and begins the conversation.

The page annunciation lines shall also provide a method for plant-wide alarms.

Basis: Consensus industry standard design.

3.3.10.4 *Requirement: Wireless Telephone Subsystem. The wireless telephone subsystem shall utilize the latest cellular telephone type technology. The movement about the plant and site of a remote unit in use shall have no effect on its use. Remote units shall have the capability of accessing other units, the PABX subsystem, and the telephone/page subsystem. Communication systems shall not interfere with or be interfered with by the process equipment.*

Basis: Consensus industry standard design.

3.3.10.5 *Requirement: Wiring Methods. The cables for the communication subsystems shall be as specified by the equipment manufacturers. The communication cables shall be routed in conduits, or plenum, depending on the routing path.*

Basis: Consensus industry standard design

3.3.11 Plant Security and Access Control

3.3.11.1 *Requirement: General. DUF_6 Plant PPA shall be bounded by the site perimeter fence. Perimeter fence shall be designed to prevent unauthorized personnel and vehicles from gaining access to the PPA. Access control to the site shall be enforced via a DUF6 HSPD-12 compatible automated access control system or mechanical locks and keys.*

Basis: DUF6 Safeguards and Security evaluation of the DOE O 473.3Arequirements applicability to the DUF_6 facility.

3.3.12 Instrumentation and Control

3.3.12.1 *Requirement: Power Distribution System. The MV switchgear breakers shall be equipped with microprocessor based protection relays having metering capabilities. Selected relay output signals shall be connected to the plant-wide ICS. The MV breaker operation shall be programmed in ICS to execute the operation requirements stated in the Section 3.3.4 pertaining to "Main AC Power Supply".*

The LV switchgear breakers shall have microprocessor based feeder protection relays. In compliance with the process and BOP system operation needs, the LV breakers will be manually operated. Certain LV bus metering functions shall be connected to the ICS for data status access to the CCR operators.

MCCs shall be equipped with the "smart" starters having motor circuit protectors with electronic interface (e.g. Profibus) to allow monitoring of all motor parameters. Such electronic interface shall allow direct interface with the plant ICS.

Basis: Process industry I/C architecture design practice.

3.3.12.2 *Requirement: Standby Power Supply - Diesel Generator. The diesel generator unit shall be equipped with an instrumentation and control system that is capable of local and remote monitoring, control of manual start-up and shutdown, and providing operating performance feedback to the central control room based operators. The monitoring subsystem shall include automatic start-up, cooling, lubrication, fuel supply, combustion air intake/exhaust, excitation, and voltage regulation and shall allow direct interface with the plant ICS.*

Basis: Industry standard design practice.

3.3.12.3 *Requirement: Uninterruptible Power Supply (UPS design shall be equipped with instrumentation and control features to allow completely automatic operation, monitoring of the salient operations characteristics thru the ICS system interface.*

Basis: Industry standard design practice

3.3.13 Computer Hardware and Software

There are no computer hardware software requirements unique to the PES.

3.3.14 Fire Protection

There are no fire protection requirements unique to the PES.

3.4 TESTING AND MAINTENANCE REQUIREMENTS

3.4.1 Testability

All components and devices pertaining to the PES are commercially available, and are manufactured to rigorous industry standards that have been around for a number of years. As such, there are no additional unique design requirements to be imposed on the PES.

3.4.2 TSR-Required Surveillances

As stated in Section 2.2, the PES system is not subject to TSRs.

3.4.3 Non-TSR Inspections and Testing

Not applicable.

3.4.4 Maintenance

Prescribed equipment in this system is subject to periodic maintenance through a preventative maintenance program. The equipment subject to this program is maintained and tested based on manufacturer recommendations, engineering, and operational experience.

3.5 OTHER REQUIREMENTS

3.5.1 Security

There are no special security requirements for the PES. The PES is within the boundary of the DUF_6 Conversion Facility. Security requirements applicable to the DUF_6 Conversion Facility can be found in Section 2.1.3.3.1 of the *Facility Design Descriptions* (DUF6-FDD-PADU / DUF6-FDD-PORT).

There are no Special Nuclear Material (SNM) protection requirements for the PES.

3.5.2 Special Installation Requirements

There are no unique design requirements to be imposed on the PES for special installation.

3.5.3 Reliability, Availability, and Preferred Failure Modes

A Reliability, Availability, and Maintainability (RAM) report has been prepared based on operating Dry Conversion Facilities in Richland, Washington and Lingen, Germany. The DUF_6 Conversion Facilities are based on the same technology as these Dry Conversion Facilities, and lessons learned from installation, operation, and maintenance of these facilities has been incorporated into the design of the PES. The RAM analysis is documented in DUF6-G-M-STU-006.

3.5.4 Quality Assurance

The System was designed using the *Project Quality Assurance Plan* (DUF6-PLN-003) that is based on ASME NQA-1-2000 to comply with DOE O 414.1 and 10 CFR 830, Subpart A Quality Assurance.

3.5.5 Miscellaneous

There are no unique requirements developed that do not fit into the categories above.

4 SYSTEM DESCRIPTION

4.1 CONFIGURATION INFORMATION

Refer to the SDD Appendix B for the PES related technical documents and the associated major drawing listings. The listed drawings depict the system design details, including system boundaries and the specific pieces of equipment pertaining the PES and associated subsystems.

4.1.1 Description of System, Subsystems, and Major Components

The PES and its associated subsystems support the process and BOP facility functions and services during all modes of plant operation, including start-up and testing, normal operation, and safe shutdown.

The Plant Electrical System includes the following subsystems:

- MPS
- SPS
- DC and UPS
- GLP
- PLS
- PCP
- PCS

Normal plant operation utilizes two 15 kV (nominal) (nominal) feeders, each rated for 100% plant load, as the normal power source. Provision of a 15 kV (nominal) tie breaker allows power restoration should one of the main feeders be out of commission.

The plant power distribution is provided at 480 V via four 480 Vac unit substations (USS). The USS A1-A2 and USS B1-B2 pairs serve the conversion process and other peripheral equipment. Each of these pairs is connected via a normally open tie breaker. The equipment loads affiliated with the individual process lines are aligned with the individual USS, wherever possible. This design approach serves to minimize the pieces of equipment to be tagged and locked out during partial plant maintenance outages.

Descriptions for the aforementioned subsystems are provided below.

4.1.1.1 *Plant Main AC Power Supply*

Refer to the Overall Key One Line Diagram P&ID # D-X/C-0000-GEN-0010 for the overall power distribution scheme.

The MPS subsystem is designed to support the plant production goals and to ensure power availability during all modes of plant operation.

The MPS subsystem has sufficient capacity and rating to provide electric power to the plant electrical loads at voltage levels and a frequency range compatible for safe operation of the plant electrical equipment.

The MPS subsystem configuration for both the Paducah and Portsmouth plant is very similar as described below:

- For the Portsmouth plant, the main power source for the DUF_6 Conversion Facility is from the existing utility services at the DOE Portsmouth GDP Plant Switchyard # X-530, which is located approximately 3,000 feet away from the DUF_6 Conversion Plant site.
- For the Paducah plant, the main power source for the DUF_6 Conversion Facility is from the existing utility services at the DOE Paducah GDP Plant Switchyard # C-531, which is located approximately 5,100 feet away from the DUF_6 Conversion Plant site.
- Two independent 15 kV (nominal) underground power feeders, each designed to carry 100% plant load, are routed to the plant double-ended 15 kV distribution switchgear enclosure located on a pad in the close proximity of the Conversion Building.
- The 15 kV switchgear consists of two bus sections connected by a normally open tie breaker.
- The main 15 kV (nominal) switchgear provides primary AC electrical power input to the 480 volt USS transformers. The USS transformers are outdoor type, located on pads adjacent to the Conversion Building. A 4,000 ampere rated bus duct connects the transformer secondary output to the associated 480 V switchgears located inside the Electrical Equipment Room.
- The 480 Vac USS switchgear assemblies consist of two separate single-ended substations with a single tie-breaker between each substation pair to further improve power availability for the process loads.
- Further power distribution to the electrical equipment is effected via 480 Vac MCCs and power distribution panels conveniently located near the loads they serve.

Protective relays and direct acting trip devices are provided for the MPS subsystem to:

- Provide for the safety of personnel
- Minimize damage to equipment
- Minimize system disturbances
- Isolate faulted equipment and circuits
- Maintain power supply continuity by selective tripping

The short circuit protective devices are analyzed to ensure that various adjustable settings are applied within their ratings and set to coordinate to attain selectivity. Microprocessor based multifunctional type relays are preferred for the electrical system's protection.

4.1.1.2 *Plant Standby Power Supply*

The SPS subsystem is comprised of an on-site standby power generator source, available within 60 seconds, to support shutdown process operations and achieve orderly plant shutdown in the event of total off-site power source loss. The electrical system design ensures orderly process shutdown without damage to equipment and without causing health, safety, or environmental hazards. All shutdown operation loads are normally powered from USS B1 (MCC B14E) that also receives backup power from the SPS subsystem. System loads necessary for orderly plant shutdown are identified below.

- Caustic Scrubber Recirculating Pump
- Conversion Building Stack Exhaust Fan
- Closed Cooling Water (CCW) System cooling tower fans and circulating pumps
- Scrubber Off-gas Blower
- Process Area Lighting for shutdown operations
- Power feed to the UPS
- Power feed for the selected maintenance area

The standby power generator unit and its accessory equipment are housed in an enclosure, located outdoors. Refer to the Table 6, Portsmouth Diesel Generator Loads and Table 7, Paducah Diesel Generator Loads for the Standby Diesel-Generator Load data respectively for the Portsmouth and Paducah Plants.

Table 4, Portsmouth Diesel Generator Loads

Item No.	Description	DUF_6 Conversion - Portsmouth					Remarks
		Connected Load		Demand Load			
		HP/kVA	kW	Load Factor	kW	Load Step	
1	Diesel Gen Battery Charger, Battery Htr and Control Cab Htr	1 kVA	0.9	1.0	0.9	1	
2	Diesel Gen Coolant Heater	5 kW	5	1.0	0	1	Pre-start Load
3	Diesel Gen Lube Oil Heater	.45 kW	.45	1.0	0	1	Pre-start Load
4	Backup Scrubber Caustic Scrubber Pump	1 HP	1	1.0	1	3	
5	Backup Scrubber Offgas Blower	205 HP	15	1.0	15	3	VFD Control
6	Process Area Emergency Lighting	45 kVA	40	0.5	20	1	Design Load

7	B/U Scrubber Offgas Blower	20HP	15	1.0	15	3	VFD Control
8	Main Process Clg Twr Fans	25 HP	20	1.0	20	4	
9	Main Process Clg Twr Fan	25 HP	20	1.0	20	4	
10	Main Clg Twr Spray Wtr Pumps (2@ 5hp)	10 HP	8	1.0	8	4	
11	Conversion Bldg Exhaust Fan (HVA-051)	75 HP	62	1.0	62	1	
12	Conversion Bldg Exhaust Fan (HVA-052)	75 HP	62	0.0	0	-	
13	Main Plant UPS	15 kVA	20	1.0	20	1	
14	Closed Clg Water Pump	40 HP	32	1.0	32	1	Note 1
15	Closed Clg Water Pump	40 HP	32	0.0	0	-	Note 1
16	Admin Bldg. Server UPS	20 kVA	26	1.0	26	1	
17	Admin Bldg. Server Room 7.5 ton A/C (3 HP + 7.5 HP + .7 HP)	14 HP	12	1.0	12	1	
18	Admin Bldg. Server Room Supp. Heat	36 kVA	36	1.0	36	3	
19	X-0-MPS-MP-B14EA-1	15kVA	15	1.0	15	1	
	Diesel Generator Name Plate Rating (KW)		**350**		Note 1: Only one of two 100% units will operate from the D/G backed power source		

Table 5, Paducah Diesel Generator Loads

Item No.	Description	DUF₆ Conversion - Paducah					Remarks
		Connected Load		Demand Load			
		HP/kVA	kW	Load Factor	kW	Load Step	
1	Diesel Gen Battery Charger	0.3 kVA	0.3	1.0	0.3	1	
2	Diesel Gen Coolant Heater	5 kW	5	1.0	0	1	Pre-start Load
3	Diesel Gen Lube Oil Heater	0.3 kW	0.3	1.0	0	1	Pre-start Load
4	Diesel Control Cabinet Heater	0.2 kW	0.2	1.0	0.2	1	
5	Backup Scrubber Caustic Scrubber Pump	1 HP	1	1.0	1	3	

6	Backup Scrubber Caustic Scrubber Pump	1 HP	1	1.0	1	3	
7	Backup Scrubber Offgas Blower	20 HP	12	1.0	12	3	VFD Control
8	Backup Scrubber Offgas Blower	20 HP	12	1.0	12	3	VFD Control
9	Process Area Emergency Lighting	45 kVA	40	0.5	20	1	Design Load
10	Main Process Clg Twr Fans	30 HP	24	1.0	24	2	
11	Main Process Clg Twr Fan	30 HP	24	1.0	24	2	
12	Main Clg Twr Spray Wtr Pumps (2@5 hp)	15 HP	12	1.0	12	2	
13	Conversion Bldg Exhaust Fan (HVA-051)	75 HP	62	1.0	62	1	
14	Conversion Bldg Exhaust Fan (HVA-052)	75 HP	62	0.0	0	-	
15	Main Plant UPS	15 kVA	15	1.0	15	1	
16	Closed Clg Water Pump	40 HP	32	1.0	32	1	Note 1
17	Closed Clg Water Pump	40 HP	32	0.0	0	-	Note 1
18	Admin Bldg. Server UPS	20 kVA	20	1.0	20	1	
19	Admin Bldg. Server Room 7.5 ton A/C (3 HP + 7.5 HP + .7 HP)	10.2 HP	9.2	1.0	9.2	1	
20	Admin Bldg. Server Room Supp. Heat	40 kVA	40	1.0	40	3	
	Diesel Generator Name Plate Rating (KW)		**350**		Note 1: Only one of two 100% units will operate from the D/G backed power source		

4.1.1.3 *DC and Uninterruptible Power Supply*

The UPS subsystem is provided to support the critical loads in the process areas and in the CCR that require an uninterruptible power source for reliability of operations. Typical examples of such loads are process control, communications, fire protection/detection, etc. The standby power generator-backed essential MCC will be the normal AC power source for the process-related UPS loads.

The sealed batteries of the UPS unit are sized to provide a minimum of 30 minutes backup to support identified process and BOP system critical loads.

Stand-alone and self-contained battery-backed uninterruptible power supplies are used for all essential-to-life equipment (such as emergency evacuation egress lights, fire detection and alarms, etc.). The associated power supply system design conforms to NEC Article 700 - Emergency Systems.

The control power for the 15 kV (nominal) and 480 Vac switchgear breakers is supplied from the UPS-backed 120Vac power source. All DC components in the plant, either associated with the main ICS or plant instrumentation, may require 24 Vdc. Individual power supplies fed from the 120 Vac UPS supply the necessary 24 Vdc control power. Stand-alone UPS equipment will be considered for the office computer needs. Such UPS equipment will not be backed-up by the on-site standby power generator.

Refer to the Table 8, Portsmouth Plant UPS Load Listing and Table 9, Paducah Plant UPS Load Listing for the UPS Load data for the Portsmouth and Paducah Plants.

Table 6, Portsmouth Plant UPS Load Listing

UPS PANEL X-0-UPS-PP-001			
CKT #	**Load Description**	**CKT**	**Load Description**
1	480 V USS A2 CONTROL X-0-MPS-USS-A2	2	SERV WTR ICS I/O RACK X-0-ICS-RIO-0002
3	15 kV SWGR CONTROL X-0-MPS-SWGR-AB	4	PA System
5	ICS CPU CABINET X-0-ICS-PCU-0001 IN ELECT. RM FEED #1	6	480 V USS A1 CONTROL X-0-MPS-USS-A1
7	480 V USS B2 CONTROL X-0-MPS-USS-B2	8	480 V USS B1 CONTROL X-0-MPS-USS-B1
9	ICS CPU CABINET X-0-ICS-PCU-0001 IN ELECT. RM FEED #2	10	KOH ICS I/O RACK X-0-ICS-RIO-0012A
11	CYL TRANS ICS I/O RACK X-0-ICS-RIO-0001	12	SAFETY PLC FEED #1 X-0-ICS-ISS-0001
13	ELEC RM ICS I/O RACK X-0-ICS-RIO-0011A	14	SAFETY PLC FEED #2 X-0-ICS-ISS-0001
15	PROCESS PLC X-1-CON-PLC-1000	16	SAFETY I/O RACK X-0-ICS-RTP-0001
17	PROCESS PLC X-2-CON-PLC-1000	18	HF SCRUBBER ICS I/O RACK X-0-ICS-RIO-0004A
19	MECH RM ICS I/O RACK X-0-ICS-RIO-0009	20	HF SCRUBBER ICS I/O RACK X-0-ICS-RIO-0004B
21	VAPOR RM ICS I/O RACK X-1-ICS-RIO-1001	22	CTRL ROOM UPS SUB PNL X-0-UPS-PP-001X
23	VAPOR RM ICS I/O RACK X-2-ICS-RIO-2001	24	SPARE
25	CONV RM ICS I/O RACK X-1-ICS-RIO-1002	26	CONV RM ICS I/O RACK X-2-ICS-RIO-2002
27	PROCESS PLC X-0-OPH-PLC-451	28	X-0-HVA-VA-0051

29	ELEC RM ICS I/O RACK X-0-ICS-RIO-0011B	30	X-0-HVA-VA-0052
31	Server Room UPS Sub Panel X-0-UPS-PP-001Y		
UPS PANEL X-0-UPS-PP-001X			
CKT #	**Load Description**	**CKT**	**Load Description**
1	CTRL RM WORKSTATION RECEPTACLES #1	2	CTRL RM WORKSTATION RECEPTACLES
3	CYL PREP ICS I/O RACK X-0-ICS-RIO-0003	4	CTRL RM SERVERS ETHERNET SWITCHES
5	HF SCRUBBER ICS I/O RACK X-0-ICS-RIO-0005B	6	HF SCRUBBER ICS I/O RACK X-0-ICS-RIO-0005A
7	COND RM ICS I/O RACK X-0-ICS-RIO-0007A	8	HOT SHOP ICS I/O RACK X-0-ICS-RIO-00008
9	VAPOR RM ICS I/O RACK X-3-ICS-RIO-3001	10	X-0-CON-TB-200 CONV AREA UO_2F_2 DETECTORS
11	PROCESS PLC X-3-CON-PLC-1000	12	SPARE
13	CONV RM ICS I/O RACK X-3-ICS-RIO-3002	14	SPARE
15	CONV RM ICS I/O RACK X-1-ICS-RIO-1003	16	CONV RM ICS I/O RACK X-2-ICS-RIO-2003
17	CONV RM ICS I/O RACK X-3-ICS-RIO-3003	18	SPARE
19	CTRL RM WORKSTATION RECEPTACLES #2	20	X-0-VAP-TB-100
21	CTRL RM WORKSTATION RECPT #3	22	SPARE
23	CTRL RM WORKSTATION RECPT #4	24	PA SYSTEM (GAITRONICS)
25	CTRL RM WORKSTATION RECPT #5	26	SPARE
27	X-0-HDS-SK-005, PRISM Hydrogen Unit	28	SPARE
29	SPARE	30	SPARE

UPS PANEL X-0-UPS-PP-001Y			
1	SERVER ROOM QUADRUPLEX #1	2	SERVER ROOM QUADRUPLEX #2
3	SERVER ROOM QUADRUPLEX #3	4	SPARE
5	SPARE	6	SPARE
7	SPARE	8	SPARE
9	BLANK	10	BLANK
11	BLANK	12	BLANK

Note: Information was retrieved from reference drawing X-0-UPS-0090-E

Table 7, Paducah Plant UPS Load Listing

UPS PANEL C-0-UPS-PP-001			
CKT #	**Load Description**	**CKT #**	**Load Description**
1	C-0-MPS-USS-A2 40 V Unit Sub A2 Control	2	C-0-ICS-RIO-0002 Serv. Water Pumphouse RIO
3	C-0-MPS-SWGR-AB 15 kV Switchgear Control	4	PCS - Page/party System
5	C-0-ICS-PCU-0001 ICS CPU cabinet, Feed #1	6	C-0-MPS-USS-A1 480 V Unit Sub A1 Control
7	C-0-MPS-USS-B2 480 V Unit Sub B2 Control	8	C-0-MPS-USS-B1 480 V Unit Sub B1 Control
9	C-0-ICS-PCU-0001 ICS CPU cabinet, Feed #2	10	C-0-ICS-RIO-0012A KOH Building I/O rack
11	C-0-ICS-RIO-0001 Cylinder Xfer I/O rack	12	C-0-ICS-ISS-0001 Safety PLC Feed #1
13	C-0-ICS-RIO-0011A Elec.Room I/O rack	14	C-0-ICS-ISS-0001 Safety PLC Feed #2
15	C-1-CON-PLC-1000 Line 1 CON process PLC	16	C-0-ICS-RTP-0001 Safety I/O rack - VAP room
17	C-2-CON-PLC-1000 Line 2 CON process PLC	18	C-0-ICS-RIO-0004A HF Scrubber room I/O rack
19	C-0-ICS-RIO-0009 Mechanical Room I/O rack	20	C-0-ICS-RIO-0004B HF Scrubber room I/O rack
21	C-1-ICS-RIO-1001 Line 1 VAP room I/O rack	22	C-0-UPS-PP-001X Control Room UPS panel
23	C-2-ICS-RIO-2001 Line 2 VAP room I/O rack	24	Spare

25	C-1-ICS-RIO-1002 Line 1 CON room 100' I/O	26	C-2-ICS-RIO-2002 Line 2 CON room I/O rack
27	C-0-OPH-PLC-451 OPH process PLC	28	Spare
29	C-0-ICS-RIO-0011B Elec.Room I/O rack	30	Spare

UPS PANEL C-0-UPS-001X			
CKT #	**Load Description**	**CKT #**	**Load Description**
1	Control Room Workstation #1 Receptacles	2	Wireless Metering to FBP
3	C-0-ICS-RIO-0003 Hot Shop RIO cabinet	4	Control Room Servers Ethernet Switches
5	C-0-ICS-RIO-0005B HF Scrubber Room RIO cabinet	6	C-0-ICS-RIO-0005A HF Scrubber Room RIO cabinet
7	C-0-ICS-RIO-0007 Condenser Room RIO cabinet	8	C-0-ICS-RIO-0008 Hot Shop Room RIO cabinet
9	C-3-ICS-RIO-3001 VAP RIO cabinet 100'	10	C-4-ICS-RIO-4001 VAP RIO cabinet 100'
11	C-3-CON-PLC-1000 Conversion Process PLC 126'	12	C-4-ICS-RIO-4002 Conversion RIO cabinet 100'
13	C-3-ICS-RIO-3002 Conversion RIO cabinet 126'	14	C-4-ICS-RIO-4003 Conversion RIO cabinet 126'
15	C-1-ICS-RIO-1003 Conversion RIO cabinet 126'	16	C-2-ICS-RIO-2003 Conversion RIO cabinet 126'
17	C-3-ICS-RIO-3003 Conversion RIO cabinet 126'	18	C-4-CON-PLC-1000 Conversion Process PLC 126'
19	Control Room Workstation #2 Receptacles	20	C-0-VAP-TB-100 VAP area UF6 detectors
21	Control Room Workstation #3 Receptacles	22	C-0-CON-TB-200 CON area UF6 detectors
23	Control Room Workstation #4 Receptacles	24	Control Room Workstation #5 Receptacles
25	Control Room Workstation #5 Receptacles	26	Quad Receptacles Control room east wall
27	C-0-HDS-SK-005, Prism HGU	28	PCS Page/Party System
29	Blank	30	Blank

UPS PANEL C-0-UPS-001Y			
CKT #	**Load Description**	**CKT #**	**Load Description**
1	Control Room Work Station # 1 Receptacles	2	Control Room Work Station # 2 Receptacles
3	Control Room Work Station # 3 Receptacles	4	Control Room Work Station # 4 Receptacles
5	Control Room Work Station # 5 Receptacles	6	Control Room Work Station # 6 Receptacles
7	Control Room Ethernet Switch Panel C-0-ICS-CP-001 Receptacles	8	SPARE
9	SPARE	10	SPARE
11	SPARE	12	SPARE
13	SPARE	14	SPARE
15	SPARE	16	BLANK
17	SPARE	18	BLANK

Note: Information retrieved from D-C-0000-UPS-0090-E

4.1.1.4 *Plant Grounding and Lightning Protection*

The GLP subsystem's design assures personnel safety and investment protection. The overall design promotes safe operation and reduces potential damages to equipment within acceptable limits.

The selected plant grounding subsystem enhances the availability and proper coordination of current interrupting devices of the MPS subsystem.

The lightning protection subsystem design performs the following principal functions to provide personnel safety and investment protection:

- Maintains safe voltages across all areas of the yard during high voltage system transients
- Provides a low impedance ground fault current return path
- Maintains safe voltages within the DUF_6 Conversion Facility structures during electrical transients
- Provides surge protection for the instrumentation circuits
- Minimizes and protects against ill effects of lightning surges on equipment and structures

The design and analysis of the grounding subsystem are in conformance with the procedures and recommended practices as stated in the IEEE 142 standard. The design and installation of the lightning protection subsystem are in accordance with NFPA 780. The design also identifies the minimum requirements for application of lightning arresters and grounding electrodes and grids.

4.1.1.5 *Plant Illumination and Lighting*

The PLS subsystem provides illumination levels in the plant facility areas and inside the buildings/structures to support the safe conduct of production activities. The PLS subsystem provides the following functions:

- Provides normal lighting to meet the visual requirements of occupied and unoccupied plant areas when the normal AC power source is available
- In the event of a loss of normal AC power (via standby generator-backed power), provide limited illumination in the CCR to other areas where shutdown operations are performed, and along the access and egress routes assigned for firefighting and safe evacuation of the buildings
- In the event of a loss of both normal AC power and the standby power generator-backed AC power sources, via local battery backed emergency light units, provide essential-to-life emergency illumination in the CCR and the other building areas required for egress

4.1.1.6 *Plant Cathodic Protection (PCP)*

The PCP subsystem is provided to control external corrosion of the underground and submerged metallic piping and structures that could be subject to electrochemical galvanic action. Piping systems that may utilize below grade cathodic protection are: instrument air, service air, potable water/fire protection, sanitary sewer, and process water. Where these systems utilize non-metallic pipe, cathodic protection has not been provided.

Based on a very limited number of buried metallic objects such as metallic valve bodies and metallic pipes, cathodic protection using sacrificial anode system has been provided. This selection was based on cost effectiveness of the sacrificial anode system requiring minimal maintenance. The PCP subsystem design protects against the premature failure of the underground metallic objects and damage to buried equipment that may impact plant availability and production goals.

4.1.1.7 *Plant Communication System (PCS)*

The PCS provides an effective and diversified means of data and voice communications within the plant area and external to the plant during all modes of operation. The system consists of three subsystems: telephone/page, PABX, and wireless telephone. Each subsystem is completely independent, such that a failure of one subsystem will have no effect on the operability of the other subsystems. The wireless telephone, telephone/page, and PABX subsystems receive power from the 120 Vac UPS subsystem. The PCS system's design supports efficient personnel communications during the conduct of business operations.

The DUF_6 Conversion Facility's Communication System includes an external interface with the GDP Plant Shift Superintendent's (PSS) office for emergency services notification. This public address system allows transmitting and receiving emergency announcements between the two facilities (Portsmouth only).

4.1.2 Boundaries and Interfaces

The boundaries of the PES originate at the load side of the two 15 kV (nominal) circuit breakers in the Portsmouth GDP Switchyard #X-530 (For the Paducah DUF_6 Plant, it is Paducah GDP Switchyard # C-531), which provide two 15 kV (nominal) permanent power feeds to the DUF_6 Conversion Facility. On the LV side, the system boundaries extend down to the 480 V MCC buses and 480 V PDP buses.

The SPS subsystem boundary extends from the diesel generator output circuit breaker to the two critical load MCC buses and on to the UPS distribution panel bus.

4.1.3 Physical Location and Layout

The two 15 kV (nominal) feeders from the GDP Switchyard connect, via underground duct, to an outdoor, 15 kV nominal double-ended switchgear lineup located in close proximity to the Conversion Building. The switchgear feeders, via underground ducts, connect to four outdoor-type 13.8 kV - 480 V unit substation transformers, located adjacent to the 15 kV switchgear. The secondary sides of these transformers are connected to their respective LV switchgears via non-segregated phase bus ducts. The bus ducts penetrates the west wall of the Conversion Building to connect to the LV switchgear, located in the Conversion Building Electrical Room. Distribution from these switchgears to six 480 V MCCs in the Electrical Room is via overhead cables in tray. There is also additional distribution from these switchgears, via cable tray, to two MCCs in the HF Scrubber Room, to two 480 V PDPs in the ground floor and second floor Mechanical Rooms, and to one MCC in the KOH Regeneration Building, via cable tray and underground duct. An additional PDP in the Warehouse/Maintenance Building is fed from the switchgear via cable tray and underground duct. This PDP also sub-feeds a PDP in the Administration Building, via underground duct.

At the Paducah site, there is one additional MCC located in the Conversion Building Electrical room to provide for the fourth conversion line loads.

The standby diesel generator, located near the northwest corner of the Conversion Building, connects to an automatic transfer switch (ATS), in the Conversion Building Electrical Room, via underground duct. The load side of this switch is connected to critical load MCC (B14E). The ATS is normally aligned to 480 V Switchgear Bus 1B1. This MCC sub-feeds an additional critical load MCC (B14EA), in the HF Scrubber Room, via cable tray. MCC B14E is also the normal source for the UPS, located in the Electrical Equipment Room.

4.1.4 Principles of Operation

The MPS is supplied from two separate utility 15 kV (nominal) power feeds from the GDP X-530 (C-531) switchyard. Each of the feeders connects to the double-ended MV switchgear bus having a normally open tiebreaker. Each supply feeder is rated to carry full plant load. During normal plant operation, each feeder provides power to only half of the plant. Should any one of the 15 kV feeders lose source power, the associated 15 kV incoming breaker in the DUF_6 Conversion Facility would trip. The breaker trip signal automatically initiates tiebreaker closing. Interlock system has been provided to prevent tiebreaker closure to protect against Plant 15 kV switchgear bus fault (which is a very rare possibility). This scheme allows continued power to the operation of the Portsmouth (Paducah) plant.

The LV switchgears are arranged in A train and B train arrangement with a provision to cross feed, to facilitate maintenance of any distribution equipment without compromising plant operation.

The loads on the MCCs are organized on a conversion line basis, thus limiting operation loss to that line should any downstream distribution component become inoperable.

The standby diesel generator power source is always ready to automatically start on receipt of an undervoltage signal from the associated MCC B14E. The standby diesel generator provides power for orderly shutdown of the plant in the event both the utility power feeders experience loss of source power.

All other PES support subsystems are always in operation.

4.1.4.1 *Major Equipment*

The major equipment of the PES is listed in the Table 1, Portsmouth DUF_6 Conversion Facility Electrical Major Equipment List and Table 2, Paducah DUF_6 Conversion Facility Electrical Major Equipment List for the Portsmouth and Paducah conversion plants, respectively.

4.1.5 System Reliability Features

An engineering study completed in June 2003 (DUF6-G-E-STU-006, dated 6/23/03) evaluated the available utility power sources at the plant location, and determined the preferred electric sources. During this evaluation study, it was confirmed that at the FBP there are ready built-up reliable utility capacity available for the use of DUF_6 conversion facilities.

The DUF_6 Conversion Facility power distribution design includes two separately derived 15 kV (nominal) power supply feeders, as the normal power sources connected to a double-ended 15 kV Switchgear with a ‘normally open’ tie breaker. Each of the feeders is rated for 100% of the plant load. During normal operation, the plant receives power from both supply sources. Should one of the power sources be lost, for some reason, the corresponding incoming circuit breaker will be tripped, signaling closure of the tie breaker, thus continuing power supply to the entire plant via the healthy feeder. Protective interlocks are provided to ensure that the automatic transfer will not take place if the loss of power was caused by a bus fault.

Distribution of power within the plant is provided at 480 Vac, via four 480 V unit substations. The USS A1-A2 and USS B1-B2 pairs serve the conversion process and other peripheral equipment. Each of these pairs is connected via a normally open tie breaker. Equipment loads, affiliated with individual process lines, are aligned with a specific USS, wherever possible. This design approach helps continued plant operation with minimal impact due to equipment failures.

4.1.6 System Control Features

Refer to the section 4.1.6 for the system control features. For detailed information on automatic actions, interlocks, and alarms, refer to the Software Requirement Specification documents (BWCS-C-SRS-001/BWCS-C-SRS-002 for Paducah and BWCS-X-SRS-001 / BWCS-X-SRS-002 for Portsmouth).

4.2 OPERATIONS

4.2.1 Initial Configuration (Pre-Startup)

There is no different ‘Initial Configuration’ planned for the MPS.

4.2.2 System Startup

On completion of the electrical distribution system installation, each individual sections of the distribution system will be tested as per the Test procedures outlined in the project specification documents. On conformance, the system will be energized thru the FBP power sources to support plant start-up testing.

4.2.3 Normal Operations

Refer to Operations procedures in Attachment C

4.2.4 Off-Normal Operations

Refer to Operations procedures in Attachment C.

4.2.5 System Shutdown

Refer to Operations procedures in Attachment C.

4.2.6 Safety Management Programs and Administrative Controls

The overall site safety management plans and programs are defined in *Safety Management Program Descriptions for the DUF_6 Conversion Project*, DUF6-U-SMP-005. The following programs and plans are applicable to the PES System:

- Initial Testing, In-service Surveillance and Maintenance Programs
- Operational Safety Programs
- Procedures and Training Program
- Human Factors Process

- Quality Assurance Programs
- Emergency Preparedness Programs
- Management, Organization, and Institutional Safety Provisions

As administrative controls are developed, they will be defined in SOPs and described here.

4.3 TESTING AND MAINTENANCE

4.3.1 Temporary Configurations

Temporary configurations are non-routine and will be handled on a temporary basis.

4.3.2 TSR-Required Surveillances

Not applicable.

4.3.3 Non-TSR Inspections and Testing

Refer to Operations and Maintenance procedures.

4.3.4 Maintenance

Maintenance will be performed in accordance with the nationally recognized standards and equipment manufacturer's operations and maintenance manuals. Preventative maintenance may be adjusted based on plant experience.

4.3.4.1 *Post-Maintenance Testing*

When Post-Maintenance Testing is needed it will be described in the Maintenance Work Package.

4.3.4.2 *Post-Modification Testing*

As modification is non-routine and not predictable, the procedures and acceptance criteria for modifications are unique. As such, they will be handled on an individual basis with sufficient detail described in the design change documentation.

ATTACHMENT A, SOURCE DOCUMENTS
Page 1 of 1

DUF6-SRD-PADU	*System Requirements Document for the Depleted Uranium Hexafluoride Conversion Facility, Paducah, KY*
DUF6-SRD-PORT	*System Requirements Document for the Depleted Uranium Hexafluoride Conversion Facility, Portsmouth, OH*

ATTACHMENT B, SYSTEM DRAWINGS
Page 1 of 9

Drawing	Description
D-X-0000-GEN-0001-E	*Portsmouth DUF_6 Conversion Project Electrical Legend and Symbols Sheet 1*
D-X-0000-GEN-0002-E	*Portsmouth DUF_6 Conversion Project Electrical Legend and Symbols Sheet 2*
D-X-0000-GEN-0003-E	*Portsmouth DUF_6 Conversion Project Electrical Legend and Symbols Sheet 3*
D-X-0000-GEN-0010-E	*Portsmouth DUF_6 Conversion Project Overall Key One Line Diagram*
D-X-0000-MPS-0040-E	*Portsmouth DUF_6 Conversion Project 13.8 kV Switchgear One Line Diagram*
D-X-0000-MPS-0050-E	*Portsmouth DUF_6 Conversion Project 480 V Unit Substations One Line Diagram A1 and A2*
D-X-0000-MPS-0051-E	*Portsmouth DUF_6 Conversion Project 480 V Unit Substations One Line Diagram B1 and B2*
D-X-0000-MPS-0060-E	*Portsmouth DUF_6 Conversion Project 480 V Motor Control Center A11 One Line Diagram*
D-X-0000-MPS-0061-E	*Portsmouth DUF_6 Conversion Project 480 V Motor Control Center One Line Diagram A12*
D-X-0000-MPS-0062-E	*Portsmouth DUF_6 Conversion Project 480 V Motor Control Center A21 One Line Diagram*
D-X-0000-MPS-0063-E	*Portsmouth DUF_6 Conversion Project 480 V Motor Control Center A22 One Line Diagram*
D-X-0000-MPS-0064-E	*Portsmouth DUF_6 Conversion Project 480 V Motor Control Center A23 One Line Diagram*
D-X-0000-MPS-0065-E	*Portsmouth DUF_6 Conversion Project 480 V Motor Control Center B11 One Line Diagram*
D-X-0000-MPS-0066-E	*Portsmouth DUF_6 Conversion Project 480 V Motor Control Center B12 One Line Diagram*
D-X-0000-MPS-0067-E	*Portsmouth DUF_6 Conversion Project 480 V Motor Control Center One Line Diagram B14E & B14EA*
D-X-0000-MPS-0068-E	*Portsmouth DUF_6 Conversion Project 480 V Motor Control Center B22 One Line Diagram*
D-X-0000-SPS-0080-E	*Portsmouth DUF_6 Conversion Project Standby Power Generator One Line Diagram*
D-X-0000-UPS-0090-E	*Portsmouth DUF_6 Conversion Project UPS One Line Diagram*
D-X-0000-GEN-1301-E	*Portsmouth DUF_6 Conversion Project Electrical Area Classification Plan*
D-X-1100-GEN-1801-E	*Portsmouth DUF_6 Conversion Project Power Plan – Administration Building Ground Floor El. 100'-00"*

Attachment B, SYSTEM DRAWINGS

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Drawing	Description
D-X-1100-GEN-1802-E	*Portsmouth DUF_6 Conversion Project Power Plan – Administration Building Second Floor El. 113'-00"*
D-X-0000-GEN-1901-E	*Portsmouth DUF_6 Conversion Project 14 kV Feeder Routing Plan*
D-X-1300-GEN-1951-E	*Portsmouth DUF_6 Conversion Project Electrical Room Arrangement*
D-X-0000-GLP-3001-E	*Portsmouth DUF_6 Conversion Project Grounding Details Sheet 1*
D-X-0000-GLP-3002-E	*Portsmouth DUF_6 Conversion Project Grounding Details Sheet 2*
D-X-0000-GLP-3003-E	*Portsmouth DUF_6 Conversion Project Grounding Details Sheet 3*
D-X-0000-GLP-3102-E	*Portsmouth DUF_6 Conversion Project Grounding Plan Northeast Quadrant*
D-X-0000-GLP-3103-E	*Portsmouth DUF_6 Conversion Project Grounding Plan South East Quadrant*
D-X-0000-GLP-3104-E	*Portsmouth DUF_6 Conversion Project Grounding Plan Northwest Quadrant*
D-X-0000-GLP-3105-E	*Portsmouth DUF_6 Conversion Project Grounding Plan South West Quadrant*
D-X-1300-GLP-3106-E	*Portsmouth DUF_6 Conversion Project Grounding Plan Conversion Building Ground Floor El. 100'-0"*
D-X-1300-GLP-3107-E	*Portsmouth DUF_6 Conversion Project Grounding Plan Conversion Building Second Floor*
D-X-1300-GLP-3108-E	*Portsmouth DUF_6 Conversion Project Grounding Plan Conversion Building Roof*
D-X-1300-GLP-3133-E	*Portsmouth DUF_6 Conversion Project Grounding Plan Conversion Building Electrical Room*
D-X-1320-GLP-3134-E	*Portsmouth DUF_6 Conversion Project Grounding Plan KOH Regeneration Building*
D-X-0000-GLP-3201-E	*Portsmouth DUF_6 Conversion Project Grounding and Lightning Protection Sys Lightning Protection Plan*
D-X-0000-GLP-3202-E	*Portsmouth DUF_6 Conversion Project Lightning Protection Details*
D-X-0000-MPS-4001-E	*Portsmouth DUF_6 Conversion Project Elementary and Connection Diagram 13.8 kV Swgr Main Breaker 1AM*
D-X-0000-MPS-4002-E	*Portsmouth DUF_6 Conversion Project Elementary and Connection Diagram 13.8 kV Swgr Main Breaker 1BM*
D-X-0000-MPS-4003-E	*Portsmouth DUF_6 Conversion Project Elementary and Connection Diagram 13.8 kV Swgr Tie Breaker 1ABT*

D-X-0000-MPS-4004-E	*Portsmouth DUF_6 Conversion Project Elementary and Connection Diagram 480 V Swgr A1 Main Breaker A1M*

Attachment B, SYSTEM DRAWINGS

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Drawing	Description
D-X-0000-MPS-4005-E	*Portsmouth DUF_6 Conversion Project Elementary and Connection Diagram 480 V Swgr A2 Main Breaker A2M*
D-X-0000-MPS-4006-E	*Portsmouth DUF_6 Conversion Project Elementary and Connection Diagram 480 V Swgr A1-A2 Tie Breaker A1A2T*
D-X-0000-MPS-4007-E	*Portsmouth DUF_6 Conversion Project Elementary and Connection Diagram 480 V Swgr B1 Main Breaker B1M*
D-X-0000-MPS-4008-E	*Portsmouth DUF_6 Conversion Project Elementary and Connection Diagram 480 V Swgr B2 Main Breaker B2M*
D-X-0000-MPS-4009-E	*Portsmouth DUF_6 Conversion Project Elementary and Connection Diagram – 480 V Switchgear B1-B2 Tie Breaker B1B2T*
D-X-0000-MPS-4010-E	*Portsmouth DUF_6 Conversion Project Elementary and Connection Diagram 13.8 kV Swgr Brkr USSA1M to USS XFMR USS-XA1*
D-X-0000-MPS-4011-E	*Portsmouth DUF_6 Conversion Project Elementary and Connection Diagram 13.8 kV Swgr Bkr USSA2M to USS XFMR USS-XA2*
D-X-0000-MPS-4012-E	*Portsmouth DUF_6 Conversion Project Elementary and Connection Diagram 13.8 kV Swgr Brkr USSB1M to USS XFMR USS-XB1*
D-X-0000-MPS-4013-E	*Portsmouth DUF_6 Conversion Project Elementary and Connection Diagram 13.8 kV Swigr Bkr USSB2M to USS XFMR USS-XB2*
D-X-0000-MPS-4014-E	*Portsmouth DUF_6 Conversion Project 15 kV Switchgear ICS I/O Termination List*
D-X-0000-MPS-4015-E	*Portsmouth DUF_6 Conversion Project 480 V Switchgear ICS I/O Termination List*
D-X-0000-MPS-4016-E	*Portsmouth DUF_6 Conversion Project 15 kV AND 480 V Swgr Devices Modbus Interconnection Diagram*
D-X-0000-PLS-4021-E	*Portsmouth DUF_6 Conversion Project Elementary and Connection Diagram Lighting Control Diagram*
D-X-0000-GEN-4997-E	*Portsmouth DUF_6 Conversion Project Interconnection Diagram SPG, ATS, and ICS I/O*
D-X-0000-PLS-5001-E	*Portsmouth DUF_6 Conversion Project Lighting Fixture Schedule*
D-X-0000-PLS-5010-E	*Portsmouth DUF_6 Conversion Project Lighting Installation Details Sheet 1*
D-X-0000-PLS-5011-E	*Portsmouth DUF_6 Conversion Project Lighting Installation Details Sheet 2*

D-X-1300-PLS-5101-E	*Portsmouth DUF_6 Conversion Project Lighting and Small Power Plan Conversion Building Ground Floor Elev. 100'-0"*

Attachment B, SYSTEM DRAWINGS

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Drawing	**Description**
D-X-1300-PLS-5102-E	*Portsmouth DUF_6 Conversion Project Lighting and Small Power Plan Conversion Building Second Floor*
D-X-1300-PLS-5103-E	*Portsmouth DUF_6 Conversion Project Lighting and Small Power Conversion Building Partial Floor Plan El.134'-6"*
D-X-1300-PLS-5104-E	*Portsmouth DUF_6 Conversion Project Lighting and Small Power Plan Conversion Building Roof Plan*
D-X-1305-PLS-5105-E	*Portsmouth DUF_6 Conversion Project Lighting and Small Power Plan HF Storage Tank Enclosure*
D-X-1100-PLS-5108-E	*Portsmouth DUF_6 Conversion Project Lighting and Small Power Plan Administration Building Ground Floor El. 100'-0"*
D-X-1100-PLS-5109-E	*Portsmouth DUF_6 Conversion Project Administration Building Lighting and Small Power Plan Second Floor El.113'-0"*
D-X-1100-PLS-5110-E	*Portsmouth DUF_6 Conversion Project Lighting and Small Power Plan Administration Building Server Room*
D-X-0000-PLS-5150-E	*Portsmouth DUF_6 Conversion Project Roadway Lighting Plan*
D-X-0000-MPS-5201-E	*Portsmouth DUF_6 Conversion Project Power Distribution Panel PDP-A1-1*
D-X-0000-MPS-5202-E	*Portsmouth DUF_6 Conversion Project Power Distribution Panel PDP-B1-1*
D-X-1100-MPS-5203-E	*Portsmouth DUF_6 Conversion Project Power Distribution Panel Administration Bldg. PDP-B1-1A*
D-X-0000-MPS-5204-E	*Portsmouth DUF_6 Conversion Project Power Distribution Panel PDP-B2-1*
D-X-0000-PLS-5206-E	*Portsmouth DUF_6 Conversion Project Lighting Panels LDP-A12-1 & LDP-B14E-1*
D-X-1100-PLS-5207-E	*Portsmouth DUF_6 Conversion Project Administration Building Lighting Panels LP-B1-1A-1 & LDP-B1-1A-2*
D-X-1100-PLS-5209-E	*Portsmouth DUF_6 Conversion Project Administration Building Lighting Panels LP-B1-1A-1-1X*
D-X-1100-UPS-5210-E	*Portsmouth DUF_6 Conversion Project Uninterruptable Power Supply UPS Power Panel MP-002-1 Administration Building*
D-X-1300-MPS-5211-E	*Portsmouth DUF_6 Conversion Project Heat Tracing Panels MPS-HT-B12-1 & MPS-MP-A22-2*

D-X-1300-MPS-5212-E	*Portsmouth DUF_6 Conversion Project Conversion Bldg. Miscellaneous Power Panel MPS-MP-A22-1 & MPS-MP-A22-2*
D-X-1300-MPS-5213-E	*Portsmouth DUF_6 Conversion Project Miscellaneous Power Panels MP-A1-1-1 & MP-A1-1-2*

ATTACHMENT B, SYSTEM DRAWINGS

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Drawing	**Description**
D-X-1320-MPS-5214-E	*Portsmouth DUF_6 Conversion Project KOH Regeneration Bldg. Miscellaneous Power Panel MP-A23-3*
D-X-1300-MPS-5215-E	*Portsmouth DUF_6 Conversion Project Miscellaneous Power Panel MP-B12-1*
D-X-1300-MPS-5216-E	*Portsmouth DUF_6 Conversion Project Conversion Bldg. Miscellaneous Power Panel* MP-B11-1
D-X-0000-PCS-6001-E	*Portsmouth DUF_6 Conversion Project Communication, Fiber Optic, & Public Address Systems Riser Diagram*
D-X-0000-FPS-6002-E	*Portsmouth DUF_6 Conversion Project Fire Protection System Riser Diagram*
D-X-1100-ICS-6020-E	*Portsmouth DUF_6 Conversion Project Cable Schematic Administration Building Server Room*
D-X-0000-GEN-6021-E	*Portsmouth DUF_6 Conversion Project* Integrated Control System Block Diagram Sheet 1
D-X-0000-GEN-6022-E	Permanent Telephone Line Installation Plan
D-X-1300-PCS-6101-E	*Portsmouth DUF_6 Conversion Project* Communication and Signaling Plan Conversion Building Ground Floor EL 100’-0”
D-X-1300-PCS-6102-E	*Portsmouth DUF_6 Conversion Project* Communication and Signaling Plan Conversion Building Second Floor
D-X-1300-PCS-6103-E	*Portsmouth DUF_6 Conversion Project* Communication and Signaling Plan Conversion Building Upper Elevations
D-X-1305-PCS-6105-E	Communication and Signaling Plan – HF Storage Tank Enclosure
D-X-1100-PCS-6108-E	*Portsmouth DUF_6 Conversion Project* Communication and Signaling Plan Administration Building Ground Floor El. 100'-0"
D-X-1100-PCS-6109-E	*Portsmouth DUF_6 Conversion Project* Communication and Signaling Plan Administration Building Second Floor El. 113'-0"
D-X-1320-PCS-6115-E	Communication and Signaling Plan - KOH Regeneration Building
D-C-0000-GEN-0001-E	*Paducah DUF_6 Conversion Project* Electrical Legend and Symbols Sheet 1
D-C-0000-GEN-0002-E	*Paducah DUF_6 Conversion Project* Electrical Legend and Symbols Sheet 2

D-C-0000-GEN-0003-E	*Paducah DUF_6 Conversion Project* Electrical Legend and Symbols Sheet 3
D-C-0000-GEN-0010-E	*Paducah DUF_6 Conversion Project* Overall Key One Line Diagram

ATTACHMENT B, SYSTEM DRAWINGS

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Drawing	**Description**
D-C-0000-MPS-0040-E	*Paducah DUF_6 Conversion Project* 14.4kV Switchgear One Line Diagram
D-C-0000-MPS-0050-E	*Paducah DUF_6 Conversion Project* 480 V Unit Substations A1 AND A2 One Line Diagram
D-C-0000-MPS-0051-E	*Paducah DUF_6 Conversion Project* 480 V Unit Substations B1 AND B2 One Line Diagram
D-C-0000-MPS-0060-E	*Paducah DUF_6 Conversion Project* 480 V Motor Control Center A11 One Line Diagram
D-C-0000-MPS-0061-E	*Paducah DUF_6 Conversion Project* 480 V Motor Control Center A12 One Line Diagram
D-C-0000-MPS-0062-E	*Paducah DUF_6 Conversion Project* 480 V Motor Control Center A21 One Line Diagram
D-C-0000-MPS-0063-E	*Paducah DUF_6 Conversion Project* 480 V Motor Control Center A22 One Line Diagram
D-C-0000-MPS-0064-E	*Paducah DUF_6 Conversion Project 480 V Motor Control Center A23 One Line Diagram*
D-C-0000-MPS-0065-E	*Paducah DUF_6 Conversion Project 480 V Motor Control Center B11 One Line Diagram*
D-C-0000-MPS-0066-E	*Paducah DUF_6 Conversion Project 480 V Motor Control Center B12 One Line Diagram*
D-C-0000-MPS-0067-E	*Paducah DUF_6 Conversion Project 480 V Motor Control Center B14E & B14EA One Line Diagram*
D-C-0000-MPS-0068-E	*Paducah DUF_6 Conversion Project 480 V Motor Control Center B22 One Line Diagram*
D-C-0000-MPS-0070-E	*Paducah DUF_6 Conversion Project 480 V Motor Control Center B21 One Line Diagram*
D-C-0000-SPS-0080-E	*Paducah DUF_6 Conversion Project Standby Power Generator One Line Diagram*
D-C-0000-UPS-0090-E	*Paducah DUF_6 Conversion Project UPS One Line Diagram*
D-C-0000-GEN-1301-E	*Paducah DUF_6 Conversion Project Electrical Area Classification Plan*

D-C-1100-GEN-1801-E	*Paducah DUF_6 Conversion Project Power Plan Administration Building Ground Floor EL 100'-00"*
D-C-1100-GEN-1802-E	*Paducah DUF_6 Conversion Project Power Plan Administration Building Second Floor EL 113'-00"*

ATTACHMENT B, SYSTEM DRAWINGS

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Drawing	Description
D-C-0000-GEN-1901-E	*Paducah DUF_6 Conversion Project 15kV Feeder Routing Plan*
D-C-1300-GEN-1951-E	*Paducah DUF_6 Conversion Project Electrical Room Arrangement*
D-C-0000-GLP-3001-E	*Paducah DUF_6 Conversion Project Grounding Details Sheet 1*
D-C-0000-GLP-3002-E	*Paducah DUF_6 Conversion Project Grounding Details Sheet 2*
D-C-0000-GLP-3003-E	*Paducah DUF_6 Conversion Project Grounding Details Sheet 3*
D-C-0000-GLP-3102-E	*Paducah DUF_6 Conversion Project Grounding Plan North West Quadrant*
D-C-0000-GLP-3103-E	*Paducah DUF_6 Conversion Project Grounding Plan North East Quadrant*
D-C-0000-GLP-3104-E	*Paducah DUF_6 Conversion Project Grounding Plan South West Quadrant*
D-C-0000-GLP-3105-E	*Paducah DUF_6 Conversion Project Grounding Plan South East Quadrant*
D-C-1300-GLP-3106-E	*Paducah DUF_6 Conversion Project Grounding Plan Conversion Building Ground Floor El 100'-0"*
D-C-1300-GLP-3107-E	*Paducah DUF_6 Conversion Project Grounding Plan Conversion Building Second Floor*
D-C-1300-GLP-3108-E	*Paducah DUF_6 Conversion Project Grounding Plan Conversion Building Roof*
D-C-1300-GLP-3133-E	*Paducah DUF_6 Conversion Project Grounding Plan Conversion Building Electrical Room*
D-C-1320-GLP-3134-E	*Paducah DUF_6 Conversion Project Grounding Plan KOH Regeneration Building*
D-C-0000-GLP-3201-E	*Paducah DUF_6 Conversion Project Lighting Protection Plan*
D-C-0000-GLP-3202-E	*Paducah DUF_6 Conversion Project Lighting Protection Details*
D-C-0000-MPS-4001-E	*Paducah DUF_6 Conversion Project Elementary and Connection Diagram 14.4kV Swgr Main Breaker 1AM*

D-C-0000-MPS-4002-E	*Paducah DUF_6 Conversion Project* Elementary and Connection Diagram 14.4kV Swgr Main Breaker 1BM
D-C-0000-MPS-4003-E	*Paducah DUF_6 Conversion Project* Elementary and Connection Diagram 14.4kV Swgr Tie Breaker 1ABT

ATTACHMENT B, SYSTEM DRAWINGS

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Drawing	**Description**
D-C-0000-MPS-4004-E	*Paducah DUF_6 Conversion Project* Elementary and Connection Diagram 480V Swgr A1 Main Breaker A1M
D-C-0000-MPS-4005-E	*Paducah DUF_6 Conversion Project* Elementary and Connection Diagram 480V Swgr A2 Main Breaker A2M
D-C-0000-MPS-4006-E	*Paducah DUF_6 Conversion Project* Elementary and Connection Diagram 480V Swgr A1-A2 Tie Breaker A1A2T
D-C-0000-MPS-4007-E	*Paducah DUF_6 Conversion Project* Elementary and Connection Diagram 480V Swgr B1 Main Breaker B1M
D-C-0000-MPS-4008-E	*Paducah DUF_6 Conversion Project* Elementary and Connection Diagram 480V Swgr B2 Main Breaker B2M
D-C-0000-MPS-4009-E	*Paducah DUF_6 Conversion Project* Elementary and Connection Diagram 480V Swgr B1-B2 Tie Breaker B1B2T
D-C-0000-MPS-4010-E	*Paducah DUF_6 Conversion Project* Elementary and Connection Diagram 14.4kV Swgr - Brkr USSA1M to USS XFMR USS-XA1
D-C-0000-MPS-4011-E	*Paducah DUF_6 Conversion Project* Elementary and Connection Diagram 14.4kV Swgr - Brkr USSA2M to USS XFMR USS-XA2
D-C-0000-MPS-4012-E	*Paducah DUF_6 Conversion Project* Elementary and Connection Diagram 14.4kV Swgr - Brkr USSB1M to USS XFMR USS-XB1
D-C-0000-MPS-4013-E	*Paducah DUF_6 Conversion Project* Elementary and Connection Diagram 14.4kV Swgr Brkr USSB2M to USS XFMR USS-XB2
D-C-0000-MPS-4014-E	*Paducah DUF_6 Conversion Project* 15kV Switchgear ICS I/O Termination List
D-C-0000-MPS-4015-E	*Paducah DUF_6 Conversion Project* 480 V Switchgear ICS I/O Termination List
D-C-0000-MPS-4016-E	*Paducah DUF_6 Conversion Project* 15kV AND 480 V SWGR Devices Modbus Interconnection Diagram
D-C-0000-PLS-4021-E	*Paducah DUF_6 Conversion Project* Elementary and Connection Diagram Lighting Control Diagram
D-C-0000-GEN-4997-E	*Paducah DUF_6 Conversion Project* ICS Alarms Interconnection Diagram
D-C-0000-PLS-5001-E	*Paducah DUF_6 Conversion Project* Lighting Fixture Schedule

D-C-0000-PLS-5010-E	*Paducah DUF_6 Conversion Project Lighting Installation Details Sheet 1*
D-C-0000-PLS-5011-E	*Paducah DUF_6 Conversion Project Lighting Installation Details Sheet 2*

ATTACHMENT B, SYSTEM DRAWINGS

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Drawing	Description
D-C-1300-PLS-5101-E	*Paducah DUF_6 Conversion Project Lighting and Small Power Plan Conversion Building Ground Floor El. 100'-0"*
D-C-1300-PLS-5102-E	*Paducah DUF_6 Conversion Project Conversion Building Lighting and Small Power Second Floor Plan*
D-C-1300-PLS-5103-E	*Paducah DUF_6 Conversion Project Lighting and Small Power Conversion Building Partial Floor Plan at El.134'-6" and Partial Floor Plan at El. 126'-0"*
D-C-1300-PLS-5104-E	*Paducah DUF_6 Conversion Project Conversion Building Lighting and Small Power Roof Plan*
D-C-1305-PLS-5105-E	*Paducah DUF_6 Conversion Project Lighting and Small Power Plan HF Storage Tank Enclosure*
D-C-1100-PLS-5108-E	*Paducah DUF_6 Conversion Project Lighting and Small Power Plan Administration Building Ground Floor El. 100'-0"*
D-C-1100-PLS-5109-E	*Paducah DUF_6 Conversion Project Lighting and Small Power Plan Administration Building Second Floor El.113'-0"*
D-C-1100-PLS-5110-E	*Paducah DUF_6 Conversion Project Lighting and Small Power Plan Administration Building Server Room*
D-C-0000-PLS-5150-E	*Paducah DUF_6 Conversion Project Roadway Lighting Plan*
D-C-0000-MPS-5201-E	*Paducah DUF_6 Conversion Project Power Distribution Panel PDP-A1-1*
D-C-0000-MPS-5202-E	*Paducah DUF_6 Conversion Project Power Distribution Panel PDP-B1-1*
D-C-1100-MPS-5203-E	*Paducah DUF_6 Conversion Project Administration Building Power Distribution Panel PDP-B1-1A*
D-C-0000-MPS-5204-E	*Paducah DUF_6 Conversion Project Power Distribution Panel PDP-B2-1*
D-C-0000-PLS-5206-E	*Paducah DUF_6 Conversion Project Lighting Panels LDP-A12-1 & LDP-B14E-1*
D-C-1100-PLS-5207-E	*Paducah DUF_6 Conversion Project Administration Building Lighting Panels LP-B1-1A-1 & LDP-B1-1A-2*
D-C-1100-PLS-5209-E	*Paducah DUF_6 Conversion Project Administration Building Lighting Panels LP-B1-1A-1X*
D-C-1100-UPS-5210-E	*Paducah DUF_6 Conversion Project Administration Bldg. UPS Power Panel MP-002-1*

Attachment C, System Procedures

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DUF6-X/C-OPS-0503 *Plant Electrical System*

DUF6-X/C-OPS-0625 *Main Power System (MPS) Alarm Response*

DUF6-X/C-OPS-0508 *Operation of the Standby Diesel Generator*

ATTACHMENT D, OTHER DESIGN OUTPUT DOCUMENTS
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Technical Specifications

Specification #	Title / Description
DUF6-G-SPC-161250	*DUF_6 Conversion Facilities KOH Building Electrical System Requirements*
DUF6-G-SPC-163110	*DUF_6 Conversion Facilities LV Unit Substations*
DUF6-G-SPC-163460	*DUF_6 Conversion Facilities MV Metalclad Switchgear*
DUF6-G-SPC-164800	*DUF_6 Conversion Facilities Low Voltage Motor Control Centers*
DUF6-G-SPC-165611	*DUF_6 Conversion Facilities Electrical Equipment Furnished with Mechanical Equipment.*
DUF6-G-SPC-166100	*DUF_6 Conversion Facilities Uninterruptible Power Supplies*
DUF6-G-SPC-166200	*DUF_6 Conversion Facilities Standby Diesel Generator*
DUF6-G-SPC-166298	*DUF_6 Conversion Facilities Motors below 2300 Volts*
DUF6-G-SPC-169500	*DUF_6 Conversion Facilities Electrical Testing and Calibration*
DUF6-G-SPC-161024	*DUF_6 Conversion Facilities Warehouse/Maintenance Building Electrical System Requirements*
DUF6-G-SPC-161025	*DUF_6 Conversion Facilities Administration Building Electrical System Requirements*
DUF6-X-SPC-160000	*Portsmouth DUF_6 Conversion Facilities Electrical Installation*
DUF6-X-SPC-160000S	*Portsmouth DUF_6 Conversion Facilities Electrical Installation (Site Package)*
DUF6-C-SPC-160000	*Paducah DUF_6 Conversion Facilities Electrical Installation*
DUF6-C-SPC-160000S	*Paducah DUF_6 Conversion Facilities Electrical Installation (Site Package)*

Attachment D, OTHER DESIGN OUTPUT DOCUMENTS

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Calculations

Calculation #	Calculations
02562-102-EE-001	*Electrical Heat Load Calculation for Electrical Room*
02562-102-EE-002	*Medium Voltage Power Cable Sizing*
02562-102-EE-003	*Low Voltage Power Cable Sizing*
02562-102-EE-004	*UPS Sizing Calculation*
02562-102-EE-005	*Short Circuit Calculation*
02562-102-EE-006	*Voltage Drop and Load Flow Calculations*
02562-102-EE-007	*Protection Relay Setting Calculation*
02562-102-EE-009	*Grounding System Calculation*
02562-102-EE-010	*Lightning Protection Risk Assessment*
02562-102-EE-011-1	*Lighting Calculations- Administration Bldg Ground Floor*
02562-102-EE-011-2	*Lighting Calculations- Administration Bldg Second Floor*
02562-102-EE-011-3	*Lighting Calculations- Conversion Bldg Ground Floor*
02562-102-EE-011-4	*Lighting Calculations- Conversion Bldg Second Floor*
02562-102-EE-011-5	*Lighting Calculations- Roadway*
02562-102-EE-011-6	*Lighting Calculations- HF Storage Tank Enclosure*
02562-102-EE-013	*Standby Generator Sizing*
02562-102-EE-014	*Temporary (Construction) Power Transformer Sizing*
02562-102-EE-015	*13.8 kV Overhead Line Sag and Tension Calculations*
02562-102-EE--018	*Cable De-rating based on Conduit Fill*
02562-102-EE-019	*Arc Flash Analysis*

END OF DOCUMENT