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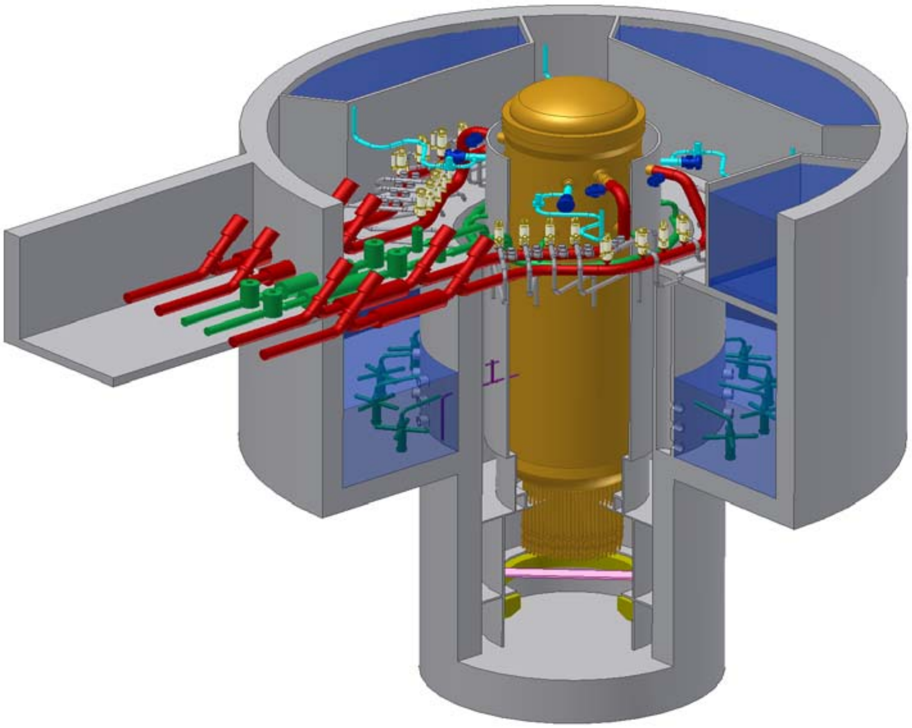

ESBWR Design Control Document

Tier 2

Chapter 9

Auxiliary Systems

(Conditional Release – pending closure of Design Verifications)

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Global Abbreviations And Acronyms List

Term	Definition
10 CFR	Title 10, Code of Federal Regulations
A/D	Analog-to-Digital
AASHTO	American Association of Highway and Transportation Officials
AB	Auxiliary Boiler
ABS	Auxiliary Boiler System
ABWR	Advanced Boiling Water Reactor
ac / AC	Alternating Current
AC	Air Conditioning
ACF	Automatic Control Function
ACI	American Concrete Institute
ACS	Atmospheric Control System
AD	Administration Building
ADS	Automatic Depressurization System
AEC	Atomic Energy Commission
AFIP	Automated Fixed In-Core Probe
AGMA	American Gear Manufacturer's Association
AHS	Auxiliary Heat Sink
AHU	Air handling unit
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AL	Analytical Limit
ALARA	As Low As Reasonably Achievable
ALWR	Advanced Light Water Reactor
ANS	American Nuclear Society
ANSI	American National Standards Institute
AOO	Anticipated Operational Occurrence
AOV	Air Operated Valve
API	American Petroleum Institute
APRM	Average Power Range Monitor
APR	Automatic Power Regulator
APRS	Automatic Power Regulator System
ARI	Alternate Rod Insertion
ARMS	Area Radiation Monitoring System
ASA	American Standards Association
ASD	Adjustable Speed Drive
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
AST	Alternate Source Term

Global Abbreviations And Acronyms List

Term	**Definition**
ASTM	American Society of Testing Methods
AT	Unit Auxiliary Transformer
ATLM	Automated Thermal Limit Monitor
ATWS	Anticipated Transients Without Scram
AV	Allowable Value
AWS	American Welding Society
AWWA	American Water Works Association
B&PV	Boiler and Pressure Vessel
BAF	Bottom of Active Fuel
BHP	Brake Horse Power
BOP	Balance of Plant
BPU	Bypass Unit
BPWS	Banked Position Withdrawal Sequence
BRE	Battery Room Exhaust
BRL	Background Radiation Level
BTP	NRC Branch Technical Position
BTU	British Thermal Unit
BWR	Boiling Water Reactor
BWROG	Boiling Water Reactor Owners Group
CAV	Cumulative absolute velocity
C&FS	Condensate and Feedwater System
C&I	Control and Instrumentation
C/C	Cooling and Cleanup
CB	Control Building
CBGAHVS	Control Building General Area
CBHVAC	Control Building HVAC
CBHVS	Control Building Heating, Ventilation and Air Conditioning System
CCI	Core-Concrete Interaction
CDF	Core Damage Frequency
CFR	Code of Federal Regulations
CIRC	Circulating Water System
CIS	Containment Inerting System
CIV	Combined Intermediate Valve
CLAVS	Clean Area Ventilation Subsystem of Reactor Building HVAC
CM	Cold Machine Shop
CMS	Containment Monitoring System
CMU	Control Room Multiplexing Unit
COL	Combined Operating License

Global Abbreviations And Acronyms List

Term	Definition
COLR	Core Operating Limits Report
CONAVS	Controlled Area Ventilation Subsystem of Reactor Building HVAC
CPR	Critical Power Ratio
CPS	Condensate Purification System
CPU	Central Processing Unit
CR	Control Rod
CRD	Control Rod Drive
CRDA	Control Rod Drop Accident
CRDH	Control Rod Drive Housing
CRDHS	Control Rod Drive Hydraulic System
CRGT	Control Rod Guide Tube
CRHA	Control Room Habitability Area
CRHAHVS	Control Room Habitability Area HVAC Sub-system
CRT	Cathode Ray Tube
CS&TS	Condensate Storage and Transfer System
CSDM	Cold Shutdown Margin
CS / CST	Condensate Storage Tank
CT	Main Cooling Tower
CTVCF	Constant Voltage Constant Frequency
CUF	Cumulative usage factor
CWS	Chilled Water System
D-RAP	Design Reliability Assurance Program
DAC	Design Acceptance Criteria
DAW	Dry Active Waste
DBA	Design Basis Accident
dc / DC	Direct Current
DCS	Drywell Cooling System
DCIS	Distributed Control and Information System
DEPSS	Drywell Equipment and Pipe Support Structure
DF	Decontamination Factor
D/F	Diaphragm Floor
DG	Diesel-Generator
DHR	Decay Heat Removal
DM&C	Digital Measurement and Control
DOF	Degree of freedom
DOI	Dedicated Operators Interface
DOT	Department of Transportation
dPT	Differential Pressure Transmitter

Global Abbreviations And Acronyms List

Term	**Definition**
DPS	Diverse Protection System
DPV	Depressurization Valve
DR&T	Design Review and Testing
DS	Independent Spent Fuel Storage Installation
DTM	Digital Trip Module
DW	Drywell
EB	Electrical Building
EBAS	Emergency Breathing Air System
EBHV	Electrical Building HVAC
ECCS	Emergency Core Cooling System
E-DCIS	Essential DCIS (Distributed Control and Information System)
EDO	Environmental Qualification Document
EFDS	Equipment and Floor Drainage System
EFPY	Effective full power years
EFU	Emergency Filter Unit
EHC	Electrohydraulic Control (Pressure Regulator)
ENS	Emergency Notification System
EOC	Emergency Operations Center
EOC	End of Cycle
EOF	Emergency Operations Facility
EOP	Emergency Operating Procedures
EPDS	Electric Power Distribution System
EPG	Emergency Procedure Guidelines
EPRI	Electric Power Research Institute
EQ	Environmental Qualification
ERICP	Emergency Rod Insertion Control Panel
ERIP	Emergency Rod Insertion Panel
ESF	Engineered Safety Feature
ETS	Emergency Trip System
FAC	Flow-Accelerated Corrosion
FAPCS	Fuel and Auxiliary Pools Cooling System
FATT	Fracture Appearance Transition Temperature
FB	Fuel Building
FBHV	Fuel Building HVAC
FCI	Fuel-Coolant Interaction
FCM	File Control Module
FCS	Flammability Control System
FCU	Fan Cooling Unit

Global Abbreviations And Acronyms List

Term	**Definition**
FDDI	Fiber Distributed Data Interface
FFT	Fast Fourier Transform
FFWTR	Final Feedwater Temperature Reduction
FHA	Fire Hazards Analysis
FIV	Flow-Induced Vibration
FMCRD	Fine Motion Control Rod Drive
FMEA	Failure Modes and Effects Analysis
FPS	Fire Protection System
FO	Diesel Fuel Oil Storage Tank
FOAKE	First-of-a-Kind Engineering
FPE	Fire Pump Enclosure
FTDC	Fault-Tolerant Digital Controller
FTS	Fuel Transfer System
FW	Feedwater
FWCS	Feedwater Control System
FWS	Fire Water Storage Tank
GCS	Generator Cooling System
GDC	General Design Criteria
GDCS	Gravity-Driven Cooling System
GE	General Electric Company
GE-NE	GE Nuclear Energy
GEN	Main Generator System
GETAB	General Electric Thermal Analysis Basis
GL	Generic Letter
GM	Geiger-Mueller Counter
GM-B	Beta-Sensitive GM Detector
GSIC	Gamma-Sensitive Ion Chamber
GSOS	Generator Sealing Oil System
GWSR	Ganged Withdrawal Sequence Restriction
HAZ	Heat-Affected Zone
HCU	Hydraulic Control Unit
HCW	High Conductivity Waste
HDVS	Heater Drain and Vent System
HEI	Heat Exchange Institute
HELB	High Energy Line Break
HEP	Human error probability
HEPA	High Efficiency Particulate Air/Absolute
HFE	Human Factors Engineering

Global Abbreviations And Acronyms List

Term	Definition
HFF	Hollow Fiber Filter
HGCS	Hydrogen Gas Cooling System
HIC	High Integrity Container
HID	High Intensity Discharge
HIS	Hydraulic Institute Standards
HM	Hot Machine Shop & Storage
HP	High Pressure
HPNSS	High Pressure Nitrogen Supply System
HPT	High-pressure turbine
HRA	Human Reliability Assessment
HSI	Human-System Interface
HSSS	Hardware/Software System Specification
HVAC	Heating, Ventilation and Air Conditioning
HVS	High Velocity Separator
HWC	Hydrogen Water Chemistry
HWCS	Hydrogen Water Chemistry System
HWS	Hot Water System
HX	Heat Exchanger
I&C	Instrumentation and Control
I/O	Input/Output
IAS	Instrument Air System
IASCC	Irradiation Assisted Stress Corrosion Cracking
IBC	International Building Code
IC	Ion Chamber
IC	Isolation Condenser
ICD	Interface Control Diagram
ICS	Isolation Condenser System
IE	Inspection and Enforcement
IEB	Inspection and Enforcement Bulletin
IED	Instrument and Electrical Diagram
IEEE	Institute of Electrical and Electronic Engineers
IFTS	Inclined Fuel Transfer System
IGSCC	Intergranular Stress Corrosion Cracking
IIS	Iron Injection System
ILRT	Integrated Leak Rate Test
IOP	Integrated Operating Procedure
IMC	Induction Motor Controller
IMCC	Induction Motor Controller Cabinet

Global Abbreviations And Acronyms List

Term	Definition
IRM	Intermediate Range Monitor
ISA	Instrument Society of America
ISI	In-Service Inspection
ISLT	In-Service Leak Test
ISM	Independent Support Motion
ISMA	Independent Support Motion Response Spectrum Analysis
ISO	International Standards Organization
ITA	Inspections, Tests or Analyses
ITAAC	Inspections, Tests, Analyses and Acceptance Criteria
ITA	Initial Test Program
LAPP	Loss of Alternate Preferred Power
LCO	Limiting Conditions for Operation
LCW	Low Conductivity Waste
LD	Logic Diagram
LDA	Lay down Area
LD&IS	Leak Detection and Isolation System
LERF	Large early release frequency
LFCV	Low Flow Control Valve
LHGR	Linear Heat Generation Rate
LLRT	Local Leak Rate Test
LMU	Local Multiplexer Unit
LO	Dirty/Clean Lube Oil Storage Tank
LOCA	Loss-of-Coolant-Accident
LOFW	Loss-of-feedwater
LOOP	Loss of Offsite Power
LOPP	Loss of Preferred Power
LP	Low Pressure
LPCI	Low Pressure Coolant Injection
LPCRD	Locking Piston Control Rod Drive
LPMS	Loose Parts Monitoring System
LPRM	Local Power Range Monitor
LPSP	Low Power Setpoint
LWMS	Liquid Waste Management System
MAAP	Modular Accident Analysis Program
MAPLHGR	Maximum Average Planar Linear Head Generation Rate
MAPRAT	Maximum Average Planar Ratio
MBB	Motor Built-In Brake
MCC	Motor Control Center

Global Abbreviations And Acronyms List

Term	Definition
MCES	Main Condenser Evacuation System
MCPR	Minimum Critical Power Ratio
MCR	Main Control Room
MCRP	Main Control Room Panel
MELB	Moderate Energy Line Break
MLHGR	Maximum Linear Heat Generation Rate
MMI	Man-Machine Interface
MMIS	Man-Machine Interface Systems
MOV	Motor-Operated Valve
MPC	Maximum Permissible Concentration
MPL	Master Parts List
MS	Main Steam
MSIV	Main Steam Isolation Valve
MSL	Main Steamline
MSLB	Main Steamline Break
MSLBA	Main Steamline Break Accident
MSR	Moisture Separator Reheater
MSV	Mean Square Voltage
MT	Main Transformer
MTTR	Mean Time To Repair
MWS	Makeup Water System
NBR	Nuclear Boiler Rated
NBS	Nuclear Boiler System
NCIG	Nuclear Construction Issues Group
NDE	Nondestructive Examination
NE-DCIS	Non-Essential Distributed Control and Information System
NDRC	National Defense Research Committee
NDT	Nil Ductility Temperature
NFPA	National Fire Protection Association
NIST	National Institute of Standard Technology
NICWS	Nuclear Island Chilled Water Subsystem
NMS	Neutron Monitoring System
NOV	Nitrogen Operated Valve
NPHS	Normal Power Heat Sink
NPSH	Net Positive Suction Head
NRC	Nuclear Regulatory Commission
NRHX	Non-Regenerative Heat Exchanger
NS	Non-seismic (non-seismic Category I)

Global Abbreviations And Acronyms List

Term	Definition
NSSS	Nuclear Steam Supply System
NT	Nitrogen Storage Tank
NTSP	Nominal Trip Setpoint
O&M	Operation and Maintenance
O-RAP	Operational Reliability Assurance Program
OBCV	Overboard Control Valve
OBE	Operating Basis Earthquake
OGS	Offgas System
OHLHS	Overhead Heavy Load Handling System
OIS	Oxygen Injection System
OLMCPR	Operating Limit Minimum Critical Power Ratio
OLU	Output Logic Unit
OOS	Out-of-service
ORNL	Oak Ridge National Laboratory
OSC	Operational Support Center
OSHA	Occupational Safety and Health Administration
OSI	Open Systems Interconnect
P&ID	Piping and Instrumentation Diagram
PA/PL	Page/Party-Line
PABX	Private Automatic Branch (Telephone) Exchange
PAM	Post Accident Monitoring
PAR	Passive Autocatalytic Recombiner
PAS	Plant Automation System
PASS	Post Accident Sampling Subsystem of Containment Monitoring System
PCC	Passive Containment Cooling
PCCS	Passive Containment Cooling System
PCT	Peak cladding temperature
PCV	Primary Containment Vessel
PFD	Process Flow Diagram
PGA	Peak Ground Acceleration
PGCS	Power Generation and Control Subsystem of Plant Automation System
PH	Pump House
PL	Parking Lot
PM	Preventive Maintenance
PMCS	Performance Monitoring and Control Subsystem of NE-DCIS
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PQCL	Product Quality Check List

Global Abbreviations And Acronyms List

Term	Definition
PRA	Probabilistic Risk Assessment
PRMS	Process Radiation Monitoring System
PRNM	Power Range Neutron Monitoring
PS	Plant Stack
PSD	Power Spectra Density
PSS	Process Sampling System
PSWS	Plant Service Water System
PT	Pressure Transmitter
PWR	Pressurized Water Reactor
QA	Quality Assurance
RACS	Rod Action Control Subsystem
RAM	Reliability, Availability and Maintainability
RAPI	Rod Action and Position Information
RAT	Reserve Auxiliary Transformer
RB	Reactor Building
RBC	Rod Brake Controller
RBCC	Rod Brake Controller Cabinet
RBCWS	Reactor Building Chilled Water Subsystem
RBHV	Reactor Building HVAC
RBS	Rod Block Setpoint
RBV	Reactor Building Vibration
RC&IS	Rod Control and Information System
RCC	Remote Communication Cabinet
RCCV	Reinforced Concrete Containment Vessel
RCCWS	Reactor Component Cooling Water System
RCPB	Reactor Coolant Pressure Boundary
RCS	Reactor Coolant System
RDA	Rod Drop Accident
RDC	Resolver-to-Digital Converter
REPAVS	Refueling and Pool Area Ventilation Subsystem of Fuel Building HVAC
RFP	Reactor Feed Pump
RG	Regulatory Guide
RHR	Residual heat removal (function)
RHX	Regenerative Heat Exchanger
RMS	Root Mean Square
RMS	Radiation Monitoring Subsystem
RMU	Remote Multiplexer Unit
RO	Reverse Osmosis

Global Abbreviations And Acronyms List

Term	**Definition**
ROM	Read-only Memory
RPS	Reactor Protection System
RPV	Reactor Pressure Vessel
RRPS	Reference Rod Pull Sequence
RSM	Rod Server Module
RSPC	Rod Server Processing Channel
RSS	Remote Shutdown System
RSSM	Reed Switch Sensor Module
RSW	Reactor Shield Wall
RTIF	Reactor Trip and Isolation Function(s)
RT_{NDT}	Reference Temperature of Nil-Ductility Transition
RTP	Reactor Thermal Power
RW	Radwaste Building
RWBCR	Radwaste Building Control Room
RWBGA	Radwaste Building General Area
RWBHVAC	Radwaste Building HVAC
RWCU/SDC	Reactor Water Cleanup/Shutdown Cooling
RWE	Rod Withdrawal Error
RWM	Rod Worth Minimizer
SA	Severe Accident
SAR	Safety Analysis Report
SB	Service Building
S/C	Digital Gamma-Sensitive GM Detector
SC	Suppression Chamber
S/D	Scintillation Detector
S/DRSRO	Single/Dual Rod Sequence Restriction Override
S/N	Signal-to-Noise
S/P	Suppression Pool
SAS	Service Air System
SB&PC	Steam Bypass and Pressure Control System
SBO	Station Blackout
SBWR	Simplified Boiling Water Reactor
SCEW	System Component Evaluation Work
SCRRI	Selected Control Rod Run-in
SDC	Shutdown Cooling
SDM	Shutdown Margin
SDS	System Design Specification
SEOA	Sealed Emergency Operating Area

Global Abbreviations And Acronyms List

Term	Definition
SER	Safety Evaluation Report
SF	Service Water Building
SFP	Spent fuel pool
SIL	Service Information Letter
SIT	Structural Integrity Test
SIU	Signal Interface Unit
SJAE	Steam Jet Air Ejector
SLC	Standby Liquid Control
SLCS	Standby Liquid Control System
SLMCPR	Safety Limit Minimum Critical Power Ratio
SMU	SSLC Multiplexing Unit
SOV	Solenoid Operated Valve
SP	Setpoint
SPC	Suppression Pool Cooling
SPDS	Safety Parameter Display System
SPTMS	Suppression Pool Temperature Monitoring Subsystem of Containment Monitoring System
SR	Surveillance Requirement
SRM	Source Range Monitor
SRNM	Startup Range Neutron Monitor
SRO	Senior Reactor Operator
SRP	Standard Review Plan
SRS	Software Requirements Specification
SRSRO	Single Rod Sequence Restriction Override
SRSS	Sum of the squares
SRV	Safety Relief Valve
SRVDL	Safety relief valve discharge line
SSAR	Standard Safety Analysis Report
SSC(s)	Structure, System and Component(s)
SSE	Safe Shutdown Earthquake
SSLC	Safety System Logic and Control
SSPC	Steel Structures Painting Council
ST	Spare Transformer
STP	Sewage Treatment Plant
STRAP	Scram Time Recording and Analysis Panel
STRP	Scram Time Recording Panel
SV	Safety Valve
SWH	Static water head
SWMS	Solid Waste Management System

Global Abbreviations And Acronyms List

Term	Definition
SY	Switch Yard
TAF	Top of Active Fuel
TASS	Turbine Auxiliary Steam System
TB	Turbine Building
TBCE	Turbine Building Compartment Exhaust
TEAS	Turbine Building Air Supply
TBE	Turbine Building Exhaust
TBLOE	Turbine Building Lube Oil Area Exhaust
TBS	Turbine Bypass System
TBHV	Turbine Building HVAC
TBV	Turbine Bypass Valve
TC	Training Center
TCCWS	Turbine Component Cooling Water System
TCS	Turbine Control System
TCV	Turbine Control Valve
TDH	Total Developed Head
TEMA	Tubular Exchanger Manufacturers' Association
TFSP	Turbine first stage pressure
TG	Turbine Generator
TGSS	Turbine Gland Seal System
THA	Time-history accelerograph
TLOS	Turbine Lubricating Oil System
TLU	Trip Logic Unit
TMI	Three Mile Island
TMSS	Turbine Main Steam System
TRM	Technical Requirements Manual
TS	Technical Specification(s)
TSC	Technical Support Center
TSI	Turbine Supervisory Instrument
TSV	Turbine Stop Valve
UBC	Uniform Building Code
UHS	Ultimate heat sink
UL	Underwriter's Laboratories Inc.
UPS	Uninterruptible Power Supply
USE	Upper Shelf Energy
USM	Uniform Support Motion
USMA	Uniform support motion response spectrum analysis
USNRC	United States Nuclear Regulatory Commission

Global Abbreviations And Acronyms List

Term	Definition
USS	United States Standard
UV	Ultraviolet
V&V	Verification and Validation
Vac / VAC	Volts Alternating Current
Vdc / VDC	Volts Direct Current
VDU	Video Display Unit
VW	Vent Wall
VWO	Valves Wide Open
WD	Wash Down Bays
WH	Warehouse
WS	Water Storage
WT	Water Treatment
WW	Wetwell
XMFR	Transformer
ZPA	Zero period acceleration

9. AUXILIARY SYSTEMS

9.1 FUEL STORAGE AND HANDLING

Upon receipt of the new fuel bundles at the reactor site, the fuel bundle containers are uncrated from the shipping crate and the fuel bundle container is raised to the refueling floor in the fuel building. The fuel bundles are removed from the container and moved to the new fuel inspection stand where the fuel bundles are inspected and the fuel channels are installed. Once the fuel bundles are assembled they are then placed in the Spent Fuel Pool or in the Inclined Fuel Transfer System (IFTS) for transfer to the Reactor Building. The now channeled fuel assemblies are then moved to the new fuel storage racks in the Reactor Building buffer pool until time to move them into the reactor.

The buffer pool can store 60% of the total core load of new fuel assemblies. The fuel assemblies are stored in underwater storage racks located adjacent to the reactor well. The racks are side loading and are accessed using the refueling bridge.

Spent fuel removed from the reactor vessel must be stored underwater. There are two locations containing spent fuel storage racks. Buffer racks in the deep pit area of the Reactor Building buffer pool are used to temporarily store discharged fuel or fuel to be returned to the rector during fuel shuffles. Spent fuel racks for long-term storage of spent fuel are located in the fuel building. These spent fuel storage racks are located at the bottom of the storage pools at a depth sufficient to provide adequate radiological shielding. The spent fuel storage pool water is processed by the Fuel and Auxiliary Pools Cooling System (FAPCS), which provides cooling to the spent fuel and maintains the spent fuel storage pool water quality. The buffer pool deep pit storage area in the Reactor Building can store up to 154 fuel assemblies. The fuel building spent fuel storage pool can store the fuel assemblies resulting from ten calendar years of operation plus one full core offload of fuel.

9.1.1 New Fuel Storage

9.1.1.1 Design Bases

Nuclear Design

The new fuel storage racks in the buffer pool are designed to assure that the fully loaded array is sub critical by at least 5% $\Delta k/k$.

Monte Carlo techniques are employed in the calculations performed to assure that k_{eff} does not exceed 0.95 under all normal and abnormal conditions.

The assumption is made that the storage array is infinite in all directions. Because no credit is taken for neutron leakage, the values reported as effective neutron multiplication factors are, in reality, infinite neutron multiplication factors.

The biases between the calculated results, experimental results, and the uncertainty in the calculation, are taken into account as part of the calculation procedure to assure that the specific k_{eff} limit is met.

Storage Design

The new fuel storage racks in the buffer pool can store up to 60% of one full core fuel load.

Mechanical and Structural Design

The new fuel storage racks contain storage space in the Reactor Building buffer pool in the reactor for 60% of the RPV core capacity of fuel assemblies (with channels) or bundles (without channels). They are designed to withstand all credible static and seismic loadings.

The racks are designed to protect the fuel assemblies and fuel bundles from excessive physical damage which may cause the release of radioactive materials in excess of 10 CFR 20 and 10 CFR 100 requirements, under normal and abnormal conditions caused by being struck by fuel assemblies, fuel bundles or other equipment.

The racks are constructed in accordance with the Quality Assurance Requirements of 10 CFR 50, Appendix B.

The racks are classified as non-safety-related and Seismic Category I. See Subsection 9.1.2.1.3 for additional discussion of design bases and analysis.

Thermal-Hydraulic Design

See Subsection 9.1.2.1.4.

Material Considerations

See Subsection 9.1.2.1.5.

Dynamic and Impact Analysis

A standard dynamic analysis, using the appropriate response spectra, shall be performed by the COL licensee to demonstrate compliance to design requirements. The input excitation for these analyses utilizes the horizontal and vertical response spectra provided in Section 3.7.

Vertical impact analysis shall be performed by the COL licensee because the fuel assembly is held in the storage rack by its own weight without any mechanical hold-down devices. See Subsection 9.1.6 for COL information requirements for Dynamic and Impact Analysis.

9.1.1.2 Facilities Description (New Fuel Storage)

Pool Storage

The new fuel storage racks in the Reactor Building buffer pool hold up to 60% of the RPV core capacity of channeled fuel assemblies. The racks have double rows of storage positions for assemblies that are side loaded into the storage racks. Because the racks are open on the side to allow side loading, the weight of the fuel assemblies placed in the storage position actuates a mechanism that restrains the assemblies in position. The racks are floor mounted.

9.1.1.3 Safety Evaluation

Criticality Control

The design of the new fuel storage racks provides for an effective multiplication factor (k_{eff}) for either normal and abnormal storage conditions equal to or less than 0.95. To ensure that design criteria are met, the following normal and abnormal new fuel storage conditions were analyzed:

- Normal positioning in the new fuel array
- Eccentric positioning in the new fuel array

The new fuel storage area accommodates fuel ($k_{inf} \leq 1.35$ at 20°C in standard core geometry) with no safety implications.

Structural Design

The new fuel storage racks are designed to meet Seismic Category I requirements. Stresses in a fully loaded rack do not exceed stresses specified by the applicable American Society Mechanical Engineers (ASME) Codes and Standards when subjected to seismic loads.

The storage rack structure is designed to withstand the impact resulting from a falling fuel assembly.

Procedural fuel handling requirements and equipment design dictate that no more than one bundle at a time can be handled over the storage racks. The structural arrangement is such that no lateral displacement of the fuel occurs; therefore, subcritical spacing is maintained. The COL licensee shall develop fuel handling procedures.

The racks are fabricated from ASTM material.

Protection Features of the New Fuel Storage Facilities

The new fuel storage racks are housed in the Reactor Building. The Reactor Building is Seismic Category I and designed for natural phenomena such as tornadoes, tornado missiles, floods and high winds.

The refueling machine is used to move fuel in the Reactor Building. It contains interlocks to prevent overloads from being applied to the fuel bail of the fuel assembly. Thus, the transfer devices used for new fuel handling to the new fuel rack cannot impose excessive uplift loads on the rack.

Should it become necessary to move major loads along or over the pools, administrative controls require that the load be moved over the empty portion of the buffer pool and avoid the area of the new fuel racks. The COL licensee shall develop administrative controls for fuel handling.

9.1.2 Spent Fuel Storage

9.1.2.1 Design Bases

9.1.2.2 Nuclear Design

A full array in the loaded spent fuel rack is designed to be subcritical by at least 5% $\Delta k/k$. Neutron-absorbing material, as an integral part of the design, is employed to assure that the calculated k_{eff}, including biases and uncertainties, does not exceed 0.95 under all normal and abnormal conditions.

Monte Carlo techniques are employed in the calculations performed to assure that k_{eff} does not exceed 0.95 under all normal and abnormal conditions.

The storage array is assumed to be infinite in all directions. No credit is taken for neutron leakage, therefore, the values reported as effective neutron multiplication factors are, in reality, infinite neutron multiplication factors.

The biases between the calculated results and experimental results, as well as the uncertainty involved in the calculations, are taken into account as part of the calculative procedure to assure that the specific k_{eff} limit is met.

9.1.2.3 Storage Design

The fuel storage racks provided in the Spent Fuel Pool in the Fuel Building provide for storage of irradiated fuel assemblies resulting from 10 calendar years of plant operation plus one full core off load. The fuel storage racks in the Reactor Building buffer pool deep pit can hold a total of 154 spent fuel assemblies.

9.1.2.4 Mechanical and Structural Design

The spent fuel storage racks in the Reactor Building buffer pool and in the Spent Fuel Pool in the Fuel Building contain storage space for fuel assemblies (with channels) or bundles (without channels). A standard dynamic analysis using the appropriate response spectra is performed to demonstrate compliance to design requirements. They are designed to withstand all credible static and seismic loadings. The racks are designed to protect the fuel assemblies and bundles from excessive physical damage which may cause the release of radioactive materials in excess of 10 CFR 20 and 10 CFR 100 requirements, under normal and abnormal conditions caused by impact from fuel assemblies, bundles or other equipment.

The Spent Fuel Pool is a reinforced concrete structure with a stainless steel liner. Fuel storage racks and pool liner embedments are designed to meet Seismic Category I requirements. The bottoms of the pool gates are higher than the minimum water level required over the spent fuel storage racks to provide adequate shielding and cooling. Pool fill and drain lines enter the pool above the safe shielding water level. Redundant anti-siphon vacuum breakers are located at the high point of the pool circulation lines to preclude a pipe break from siphoning the water from the pool and jeopardizing the safe water level.

The racks include individual solid tube storage compartments, which provide lateral restraints over the entire length of the fuel assembly or bundle. The weight of the fuel assembly or bundle is supported axially by the rack fuel support. Lead-in guides at the top of the storage spaces provide guidance of the fuel during insertion.

Materials used for construction are specified in accordance with the latest issue of applicable ASTM specifications. The racks are constructed in accordance with a quality assurance program that ensures the design, construction, and testing requirements are met.

The structural integrity of the rack is demonstrated for the loads and load combinations described below using linear elastic design methods.

The applied loads to the rack are as follows:

- Dead loads, weight of rack and fuel assemblies plus the hydrostatic loads
- Live loads—effect of lifting an empty rack during installation
- Thermal loads—the uniform thermal expansion caused by pool temperature changes
- Seismic forces
- Accidental drop of fuel assembly from maximum possible height

- Postulated stuck fuel assembly causing an upward force

The load combinations considered in the rack design are as follows:

- Live loads
- Dead loads plus SSE
- Dead loads plus fuel drop

Stress analyses are performed by classical methods based upon shears and moments developed by the dynamic method. Using the given loads, load conditions and analytical methods, stresses are calculated at critical sections of the rack and compared to acceptance criteria referenced in ASME Code Section III, Subsection NF.

9.1.2.5 Thermal-Hydraulic Design

The fuel storage racks are designed to provide sufficient natural convection coolant flow through the rack and fuel to remove decay heat without reaching excessive water temperatures (100°C; 212°F).

In the spent fuel storage pool, the bundle decay heat is removed by FAPCS recirculation flow to maintain the pool temperature below 48.9ºC (120ºF) during normal conditions.

A thermal-hydraulic analysis to evaluate the rate of naturally circulated flow and the maximum rack exit temperature will be performed. See Subsection 9.1.6 for COL information.

9.1.2.6 Material Considerations

Structural material used in the fabrication of the fuel storage racks is in accordance with the latest issue of the applicable ASTM specification at the time of equipment order. Materials are chosen for their corrosion resistance and their ability to be formed and welded with consistent quality.

The storage tube material is permanently marked with identification traceable to the material certifications. The fuel storage tube assembly is compatible with the environment of treated water and provides a design life of 60 years.

9.1.2.7 Facilities Description (Spent Fuel Storage)

There are two separate areas for storage of spent fuel assemblies. These are in a separate deep pit area in the buffer pool in the Reactor Building and in the Spent Fuel Pool in the Fuel Building.

Spent fuel storage racks in the buffer pool area provide storage in the Reactor Building Spent Fuel Pool for spent fuel received from the reactor vessel during the refueling operation. The amount to be stored is equal to a typical reload. The deep pit for the storage of spent fuel in the rack is designed such that the depth of the cavity allows the fuel to be placed in the rack with sufficient margin below the rack for natural convection cooling to occur and that the top of the active fuel remains below the top of the cavity. The spent fuel storage racks are top entry racks designed to preclude the possibility of criticality under normal and abnormal conditions.

Spent fuel storage racks in the Spent Fuel Pool area provide storage in the fuel building Spent Fuel Pool for spent fuel received from the reactor vessel resulting from ten calendar years of

operation plus one fuel core offload of fuel. The cavity for the storage of spent fuel in the rack is designed such that the depth of the cavity allows the fuel to be placed in the rack with sufficient margin below the rack for natural convection cooling to occur and that the top of the active fuel remains below the top of the cavity. The spent fuel storage racks are top entry racks designed to preclude the possibility of criticality under normal and abnormal conditions.

On a complete loss of the FAPCS active cooling capability and under the condition of maximum heat load, sufficient quantity of water is available in the Spent Fuel Pool above the top of active fuel (TAF) level to allow boiling for 72 hours and still have the TAF at least 3.0 m (10 ft) submerged under water.

9.1.2.8 Safety Evaluation

Criticality Control

The spent fuel storage racks are designed to assure that the fully loaded array is sub critical by at least 5% $\Delta k/k$.

Monte Carlo techniques are employed in the calculations performed to assure that k_{eff} does not exceed 0.95 under all normal and abnormal conditions.

The assumption is made that the storage array is infinite in all directions. Because no credit is taken for neutron leakage, the values reported as effective neutron multiplication factors are, in reality, infinite neutron multiplication factors.

The biases between the calculated results, experimental results, and the uncertainty in the calculation, are taken into account as part of the calculative procedure to assure that the specific k_{eff} limit is met.

Structural Design and Material Compatibility Requirements:

- The support structure allows sufficient pool water flow for natural convection cooling of the stored fuel and to keep rack material temperatures within limits.
- The racks include individual solid tube storage compartments, which provide lateral restraints over the entire length of the fuel assembly or bundle.
- The racks are fabricated from materials used for construction and are specified in accordance with the latest issue of applicable ASTM specifications at the time of equipment order.
- The racks are designed to withstand the impact force generated by the vertical free-fall drop of a fuel assembly from the maximum height expected during normal fuel handling.
- The rack is designed to withstand a pull-up force in the event a fuel assembly should jam.
- The fuel storage pools have adequate water shielding for the stored spent fuel. See Section 9.1.3.

NRC Regulatory Guide 1.13 is applicable to spent fuel storage facilities. The Reactor Building, which contains the fuel storage facilities, including the storage racks and pool, is designed to protect the fuel from damage caused by:

- Natural events such as earthquake, high winds and flooding; and

- Mechanical damage caused by dropping of fuel assemblies, bundles, or other objects onto stored fuel.

Summary of Radiological Considerations

By adequate design and careful operational procedures, the design bases of the spent fuel storage arrangement are satisfied. Thus, the exposure of plant personnel to radiation is maintained well below published guideline values. Further details of radiological considerations, including those for the spent fuel storage arrangement, are presented in Chapter 12.

9.1.3 Fuel and Auxiliary Pools Cooling System

9.1.3.1 System Description

9.1.3.2 System Description Summary

The Fuel and Auxiliary Pools Cooling System (FAPCS) consists of two redundant cooling and cleanup (C/C) trains, each with a pump, a heat exchanger and a water treatment unit for cooling and cleanup of various cooling and storage pools except for the Isolation Condenser and Passive Containment Cooling System (IC/PCCS) pools (refer to Figure 9.1-1). A separate subsystem with its own pump, heat exchanger and water treatment unit is dedicated for cooling and cleaning of the IC/PCCS pools independent of the FAPCS C/C train operation during normal plant operation (refer to Figure 9.1-1).

The primary design function of FAPCS is to cool and clean pools located in the containment, Reactor Building and Fuel Building (refer to Table 9.1-1) during normal pant operation. FAPCS provides flow paths for filling and makeup of these pools during normal plant operation and during post accident conditions, as necessary.

FAPCS is also designed to provide the following accident recovery functions in addition to the Spent Fuel Pool cooling function:

- Suppression pool cooling (SPC)
- Drywell spray
- Low pressure coolant injection of suppression pool water into the RPV
- Alternate Shutdown Cooling

During normal plant operation, at least one FAPCS C/C train is available for continuous operation to cool and clean the water of the Spent Fuel Pool, while the other train can be placed in standby or other mode for cooling the Gravity Driven Cooling System (GDCS) pools and suppression pool. If necessary during refueling outage, both trains may be used to provide maximum cooling capacity for cooling the Spent Fuel Pool.

Each FAPCS C/C train has sufficient flow and cooling capacity to maintain Spent Fuel Pool bulk water temperature below 48.9°C (120°F) under normal Spent Fuel Pool heat load conditions. During the maximum Spent Fuel Pool heat load conditions of a full core off-load plus irradiated fuel in the Spent Fuel Pool resulting from 10 years of plant operations, both FAPCS C/C trains are needed to maintain the bulk temperature below 60°C (140°F).

All operating modes (refer to Table 9.1-2) are manually initiated and controlled from the Main Control Room (MCR), except the SPC mode, which is initiated either manually, or automatically on high suppression pool water temperature signal. Instruments are provided for indication of operating conditions to aid the operator during the initiation and control of system operation. Provisions are provided to prevent inadvertent draining of the pools during FAPCS operation.

Containment isolation valves are provided on the lines that penetrate the primary containment. Containment isolation valves are powered from independent safety-related sources. Air-operated valves with containment isolation function are designed to close upon loss of its electric power or air supply.

The containment isolation valves that are not required to open to perform a post-accident recovery function are automatically closed upon receipt of a containment isolation signal from the Leakage Detection and Isolation System (LD&IS). The containment isolation valves on the suppression pool suction and return lines and drywell spray lines do not receive containment isolation signal to close because these valves must be able to open when FAPCS is initiated to perform an accident recovery function described above.

The FAPCS is a nonsafety-related system with the exception of piping and components required for containment isolation and refilling of the IC/PCCS pools and the Spent Fuel Pool with emergency water supplies from offsite. The FAPCS piping and components that are required to support safety-related and/or accident recovery function have Quality Group B or C and Seismic I classification (Table 9.1-3).

9.1.3.3 Detailed System Description

The FAPCS is provided with two 100% capacity cooling and cleanup (C/C) trains for redundancy. Each FAPCS train has one pump, one heat exchanger and one water treatment unit consisting of prefilter and demineralizer.

A manifold of four motor operated valves is attached to each end of the FAPCS C/C trains [refer to Figure 9.1-1]. These manifolds are used to connect the FAPCS C/C train with one of the two pairs of suction and discharge piping loops to establish the desired flow path during FAPCS operation. One loop is used for the Spent Fuel Pool and auxiliary pools, and the other loop for the GDCS pools and suppression pool and for injecting water to drywell spray sparger and reactor vessel via RWCU/SDC and feedwater pipes.

The use of manifolds with proper valve alignment and separate suction-discharge piping loops 1) allows operating of one train independent of the other train to permit on-line maintenance or dual mode operation using separate trains if necessary, 2) prevents inadvertent draining of the pool and mixing of contaminated water in the Spent Fuel Pool with cleaner water in other pools.

Each water treatment unit is equipped with a prefilter, a demineralizer and a post strainer. A bypass line is provided to permit bypass of the water treatment unit, when necessary. The prefilter and demineralizers of the water treatment units are located in shielding cells so that radiation exposure of plant personnel is within acceptable limits.

Proper physical separation is provided between the active components of the two redundant trains to assure operation of one train in the event of failure of the other train.

A reactor makeup water discharge line is provided for injecting suppression pool water to the reactor vessel via Reactor Water Cleanup/Shutdown Cooling System (RWCU/SDC) Loop B and Feedwater Loop A discharge pipes. The injection valve is prevented from opening by a high reactor pressure signal from the Nuclear Boiler System to protect the low pressure portion of FAPCS piping and components.

A drywell spray discharge line and a ring header with spray nozzles mounted on the header are provided for spraying water inside the drywell to reduce the drywell pressure 72 hours following a LOCA to assist in post accident recovery. The ring header equipped with spray nozzles is located in the drywell.

A separate cooling and cleanup subsystem completely independent of FAPCS C/C trains and their piping loop is provided for cooling and cleanup of the IC and PCCS pools to prevent radioactive contamination of these pools. The subsystem consists of one pump, one heat exchanger, and one water treatment unit .

FAPCS contains two containment isolation valves on the lines that penetrate the primary containment, except the suppression pool suction line. One isolation valve is located inside the containment and the other isolation valve is outside the containment. The suppression pool suction line is provided with only one isolation valve outside the containment because:

- The suppression pool suction line isolation valve is normally closed. It must be opened so that FAPCS can perform a post accident recovery (defense-in-depth) function. The reliability of opening only one isolation valve is higher than opening of two valves.
- FAPCS piping system outside the containment meet Quality Group B and Seismic Category I, and its design temperature and pressure are at least equal to that of the containment. Therefore, it is qualified as a closed system outside containment.
- The normally closed isolation valve is designed with fail-safe (closed) features. This isolation valve design, along with a closed system outside containment, ensures containment isolation capability, even after a single active failure. Therefore, a single active failure can be accommodated with only one isolation valve.
- An isolation valve inside the drywell would be submerged under water during severe accident conditions.

The outboard isolation valves are located as close as possible to the containment. The power-operated containment isolation valves on the GDCS pool suction and return lines are automatically closed, if open, upon receipt of a containment isolation signal from the LD&IS. The power-operated containment isolation valves on the suppression pool suction and return lines and the drywell spray line do not receive a containment isolation signal because these valves must be able to open when FAPCS is initiated to provide an accident recovery function.

Pipes equipped with normally closed manual valves are provided for establishing flow paths from off-site emergency water supplies or the Fire Protection System to refill the IC/PCCS pools and Spent Fuel Pool following a design basis loss of coolant accident.

Anti-siphoning devices are used to prevent unintended drainage of the pools. The anti-siphoning holes in the suppression pool suction line are at the elevation of minimum water level to prevent complete draining of the pool in case of a suction line break at a lower elevation.

The containment isolation valves and other equipment required for the post-accident recovery function are provided with electric power from reliable power supplies. In the event of loss of off-site power, these electric power supplies are automatically connected to the on-site power sources. The electrical power supplies, control and instrumentation of the two FAPCS trains and their supporting systems are divisionally separated. Pneumatic power assisted containment isolation valves are designed to close upon loss of its electric power or pneumatic (air or nitrogen) supply.

Provisions are provided to protect FAPCS components from fire, missile generating event, plant internal flooding, or seismic event of intensity up to and including a Safe Shutdown Earthquake (SSE) so that sufficient capability is retained for the fuel pool cooling function.

The FAPCS is designed to permit surveillance testing and in-service inspection of the safety-related components in accordance with ASME Section XI. Additionally, the FAPCS is designed to permit leak rate testing of its components required to perform containment isolation function, in accordance with 10 CFR 50 Appendix J.

9.1.3.4 System Operating Modes

FAPCS is designed to operate in operating modes listed in Table 9.1-2. The following paragraphs describe discuss the major operating modes of FAPCS:.

Spent Fuel Pool Cooling and Cleanup Mode – One of the FAPCS C/C trains is continuously operated in this mode to cool and clean the water in the Spent Fuel Pool during normal plant operation and refueling outage. This mode may be initiated following an accident to cool the Spent Fuel Pool for accident recovery. During this mode of operation, water is drawn from the skimmer surge tanks, pumped through the heat exchanger and water treatment unit to be cooled and cleaned and then returned to the Spent Fuel Pool. When necessary, a portion or all of the water may bypass the water treatment unit.

Fuel and Auxiliary Pool Cooling and Cleanup Mode - During a refueling outage, one or both FAPCS C/C trains are placed in this mode of operation to cool and clean the water in the Spent Fuel Pool and pools listed below depending on the heat load condition in these pools.

- Upper fuel transfer pool
- Buffer pool
- Reactor well
- Dryer and separator storage pool

During this mode of operation, water is drawn from the skimmer surge tanks, pumped through the heat exchanger and water treatment unit to be cooled and cleaned and then returned to these pools. When necessary, portion or all of the water may bypass the water treatment unit.

IC/PCCS Pool Cooling and Cleanup Mode –The FAPCS-IC/PCCS pool C/C subsystem is placed in this mode as necessary during normal plant operation.. During this mode of operation, water is drawn via a common suction header from IC/PCCS pools. Water is cooled and cleaned by the IC/PCC pool C/C subsystem and is then returned to the pool through a common line that branches and discharges deep in the pool.

GDCS Pool Cooling and Cleanup Mode – One train of the FAPCS C/C that is not operating in Spent Fuel Pool cooling mode is placed in this mode as necessary during normal plant operation. Water is drawn from GDCS pools A and C in this mode of operation. The water is cooled and cleaned and is then returned to GDCS pool B. The water level in the GDCS pool B rises and the water is cascaded and discharged at a submerged location in the adjacent GDCS pools A and C during this mode of operation.

Suppression Pool Cooling and Cleanup Mode – One of the FAPCS C/C trains that is not operating in Spent Fuel Pool cooling mode is placed in this mode as necessary during normal plant operation. Water is drawn from the suppression pool and is cooled and cleaned and then returned to the suppression pool in this mode of operation. This mode may be initiated following an accident to cool the suppression for accident recovery.

Low Pressure Coolant Injection (LPCI) Mode - This mode may be initiated following an accident after the reactor has been depressurized to provide reactor makeup water for accident recovery. In this mode the FAPCS pump takes suction from the suppression pool and pumps it into the reactor vessel via RWCU/SDC loop B and then Feedwater loop A.

Alternate Shutdown Cooling Mode – This mode may be initiated following an accident for accident recovery. In this mode, FAPCS operates in conjunction with other systems to provide reactor shutdown cooling in the event of loss of other shutdown cooling methods. FAPCS flow path is similar to that of LPCI mode during this mode of operation. Water is drawn from the suppression pool, cooled and then discharged back to the reactor vessel via the LPCI injection flow path. The warmer water in the reactor vessel rises and then overflows into the suppression pool via two opened safety-relief valves on the main steam lines A and B, completing a closed loop for this mode operation.

Drywell Spray Mode - This mode may be initiated following an accident for accident recovery. During this mode of operation, FAPCS draws water from the suppression pool, cools and then spays the cooled water to drywell air space to reduce the containment pressure.

9.1.3.5 Design Bases

FAPCS is a nonsafety-related system, except for the following safety-related portions of the system.

Piping and components completely separate from FAPCS pool cooling piping provide flow paths for post-accident make-up water transfer, from off-site water supply sources to the IC/PCCS pool and Spent Fuel Pool. No active valves located inside the Reactor Building are required to operate to accomplish this makeup. The piping and components are designed to meet Quality Group C and Seismic Category I requirements.

Containment isolations valves are provided on the FAPCS lines that penetrate the containment. The containment isolation valves on the GDCS suction and discharge lines that do not have post accident operation receive containment isolation signals.

FAPCS piping and components, relied upon for containment integrity, are designed to Quality Group B and Seismic Category I requirements.

9.1.3.6 Operation

FAPCS C/C trains operate continuously to cool and clean the water in the Spent Fuel Pool during normal plant operation and refueling outage. Operation of only one FAPCS C/C train is sufficient to handle the cooling requirements under the normal heat load condition in the Spent Fuel Pool. Operation with up to two FAPCS C/C trains is sufficient to handle the cooling requirement under the maximum heat load condition. At least one FAPCS C/C train is available for cooling the Spent Fuel Pool, except for a short period as long as the water temperature in the pool remains below the maximum temperature limit for normal operation.

During a refueling outage, FAPCS can be operated in the Fuel and Auxiliary Pool Cooling and Cleanup mode with both C/C trains under the maximum heat load condition in the Spent Fuel Pool.

If necessary the FAPCS can operate in a dual mode using two separated FAPCS C/C trains with separate suction and discharge piping loops. However, dual mode operation using a single train is prohibited, because it could result in redistribution of water between pools containing contaminated water and pools containing clean water.

As necessary during normal plant operation, the standby FAPCS C/C train is placed in operation to cool and clean the water in the Suppression Pool and GDCS pools. The IC/PCCS pools C/C subsystem operates as necessary to cool and clean the water in the IC/PCCS pools during normal plant operation.

The FAPCS may be operated in the following modes for post-accident recovery following an accident:

- Spent Fuel Pool Cooling
- Low Pressure Coolant Injection (LPCI)
- Suppression Pool Cooling (SPC)
- Drywell Spray
- Alternate Shutdown Cooling (ASDC)

All FAPCS lines penetrating the containment that do not have a post-accident recovery function are automatically isolated upon receipt of a containment isolation signal from Leak Detection and Isolation System (LD&IS).

The FAPCS piping provides flow paths for delivery of makeup water to IC/PCCS pools and Spent Fuel Pool from offsite emergency water supply or Fire Protection system as needed 72 hours after a design basis accident.

9.1.3.7 Safety Evaluation

The FAPCS is a nonsafety-related system except for the portions of the system that establish flow paths necessary for supply of emergency makeup water to the Spent Fuel Pool and IC/PCCS pools following an accident and the systems containment isolation function.

The FAPCS piping and components that provide the flow paths for the emergency makeup water supply are designed to meet the requirements contained in Table 9.1-3, Item 3. No active valves are required to operate for establishing emergency makeup water supply flow paths.

Two containment isolation valves are provided on the FAPCS lines that penetrate the containment, except the suppression pool suction line, which has one containment isolation valve.

The use of two containment isolation valves meets NRC GDC 56 requirement. The use of one pneumatic power assisted containment isolation valve also satisfies GDC 56 based on the allowable exception (Case 2 discussed in SRP 6.2.4).

Containment isolation provisions that differ from the explicit requirements of GDC 56 are acceptable if the basis for the difference is justified. Two exception cases are quoted in the SRP 6.2.4:

Case 1 Both valves may be located outside containment, if it is not practical to locate a valve inside the containment (e.g. the valve may be under water as a result of an accident).

Case 2 Use of a single containment isolation valve is acceptable if it can be shown that:

- the reliability of an ESF or ESF-related system is greater with only one isolation valve,
- closed system outside containment which is designed to Seismic Category I, Safety Class 2 and design temperature and pressure at least equal to that for the containment, and is protected from missiles, and
- a single active failure can be accommodated with only one isolation valve.

Case 2 is applicable to the use of only one isolation valve on the suppression pool suction line for the following reasons:

- An isolation valve inside the drywell would be submerged under water under severe accident conditions.
- The FAPCS is designed to provide post accident recovery (defense-in-depth) functions of suppression pool cooling, low pressure coolant injection drywell spray, and alternate shutdown cooling, which all take suction from the suppression pool. Because the suppression pool suction line isolation valves are normally closed, opening of the suction line isolation valve is required to perform these functions. The reliability of opening only one isolation valve is higher than opening two valves.
- FAPCS piping system outside the containment is designed to Seismic Category I and Quality Group B with design temperature and pressure at least equal to that for the containment, and is protected from missiles. Therefore, it is qualified as a closed system outside containment.
- The isolation valve is normally closed and is designed with fail-safe (closed) feature. This isolation valve design, along with a closed system outside containment, ensures containment isolation capability, even after a single active failure. Therefore, a single active failure can be accommodated with only one isolation valve.

In additional to the using a single containment isolation valve in the suppression pool suction line, manual valve control, instead of automatic valve closure, is used for the containment isolation valves on the suppression pool suction and return lines and drywell spray discharge line. This is based on the following arguments:

- These isolation valves are closed during normal plant operation.
- Opening of these valves is required when FAPCS is initiated into one of the post accident recovery operating modes (SPC, LPCI, Drywell Spray and ASDC modes).
- If SPC mode is automatically initiated on high suppression pool water temperature concurrent with a containment isolation signal, the containment isolation signal overrides the automatic SPC initiation.
- Therefore, use of a manual valve control feature to replace automatic containment isolation feature improves reliability of these valves and FAPCS for the post accident recovery.

Pneumatic power assisted containment isolation valves fail closed on loss of electric power or the air supply.

9.1.3.8 Testing and Inspection Requirements

The FAPCS is designed to permit surveillance test and in-service inspection of its safety-related components and components required to perform the post-accident recovery functions, in accordance with ASME Section XI. The FAPCS is designed to permit leak rate testing of its components required to perform containment isolation function in accordance with 10 CFR 50 Appendix J.

9.1.3.9 Instrumentation and Control

9.1.3.10 System Instrumentation

Water Levels - The skimmer surge tank level is monitored by a level detector and transmitter mounted on a local panel. The skimmer surge tank level is displayed in the MCR. In addition to level indication, this signal is used to initiate low and high water-level alarms and to operate the makeup water control valve for the skimmer surge tank.

The IC/PCCS pool has two local panel-mounted, safety-related level transmitters. Both transmitter signals are indicated on the safety-related displays and sent through the gateways for nonsafety-related display and alarms. Both signals are validated and used to control the valve in the makeup water supply line to the IC/PCCS pool.

The Spent Fuel Pool has two wide-range safety-related level transmitters that transmit signals to the MCR. These signals are used for water level indication and to initiate high/low-level alarms.

All other pools (suppression pool, upper transfer pool, buffer pool, reactor well, dryer and separator storage pool) have local, non-safety related, panel-mounted level transmitters to provide signals for high/low-level alarms in the MCR.

Water Temperatures – Water temperatures are monitored in the Fuel and Auxiliary pools (listed in Table 9.1-1) with temperature elements and local panel-mounted temperature transmitters that send signals to the MCR for water temperature indication and high-temperature alarms. In the IC/PCCS pool, each condenser vault also has temperature elements and local panel-mounted temperature transmitters that send signals to the MCR for water temperature indication and high-temperature alarms. The upstream and downstream piping of the two heat exchangers in the cooling/cleanup trains have temperature elements and local panel-mounted temperature transmitters that send signals to the MCR.

Flow and Pressure - Panel-mounted pressure transmitters for the pump suction and discharge pressure are provided locally. A pump trip signal is generated on low suction pressure to provide for pump protection. The pressure transmitters send signals to pressure indicators in the MCR. An orifice type flow element is located on the downstream side of each pump discharge check valve. A local panel-mounted flow transmitter sends the signals from these transmitters to flow indicators in the MCR.

9.1.3.11 System Controls

All FAPCS operating modes are manually initiated, except Suppression Pool Cooling (SPC) mode. The SPC mode is initiated either manually, or automatically upon receipt of a high suppression pool temperature signal from the Leak Detection and Isolation system. The automatic SPC mode initiation selects the FAPCS standby train (if available) to be initiated.

Upon receipt of a containment isolation signal from the Leak Detection and Isolation System, the following valves are signaled to close:

- GDCS pool inboard and outboard suction line isolation valves
- GDCS pool return isolation valve

FAPCS C/C train pumps are automatically tripped under the following operating conditions:

- Low water levels in skimmer surge tank
- Low water level in Suppression Pool
- Low water level in GDCS pools
- High water level in GDCS pools
- Low pump suction pressure
- Low pump discharge flow
- High pump discharge flow

The FAPCS IC/PCCS pools C/C subsystem pump is automatically tripped on low water level in IC/PCCS pools. Water level in the skimmer surge tanks is maintained by automatic open/closure of the makeup water supply isolation valve. Water level in the IC/PCCS pools is maintained by automatic open/closure of the makeup water supply isolation valve.

9.1.4 Light Load Handling System (Related to Refueling)

The reactor and fuel servicing system includes the fuel storage arrangements and the necessary facilities, special tools, and equipment required to accomplish normal fueling and refueling outage tasks.

The system is integrated with other customer provided equipment and supporting services to enhance and implement the fuel handling procedure in a safe and efficient manner.

9.1.4.1 Design Bases

The fuel handling system is designed to provide a safe and effective means for transporting and handling fuel from the time it reaches the plant until it leaves the plant after post-irradiation

cooling. Safe handling of fuel includes design considerations for maintaining occupational radiation exposures as low as reasonably achievable (ALARA).

The following subsections briefly describe the integrated fuel transfer and service system that ensures that the design bases of the fuel handling system and the requirements of Regulatory Guide 1.13 are satisfied.

Table 9.1-4 provides the design criteria for major fuel handling system equipment and lists the safety class, quality group and seismic category. Where applicable, Table 9.1-5 provides the appropriate ASME, American National Standards Institute (ANSI), Industrial and Electrical Codes are identified. Additional design criteria are described below and expanded further discussed in Subsection 9.1.4.2.

Fuel transfer from the point of receipt up to inspection, storage, and placement in the reactor core is accomplished with fuel grapples. A general purpose fuel grapple is used when fuel movement is performed by the fuel building crane on the fuel building floor prior to placement in the fuel preparation machine and transfer to the Spent Fuel Pool or buffer pool. During refueling operations, however, fuel movement is performed in the fuel building by the fuel handling machine and in the Reactor Building by the refueling machine telescoping grapples.

The refueling machine and the fuel handling machine are classified non-safety-related Seismic Category II, and are constructed in accordance with a supplemental quality assurance program to ensure compliance with applicable design, construction and test requirements.

Working loads of the platform structure are in accordance with the American Institute of Steel and Construction (AISC) Manual of Steel Construction. All parts of the hoist systems are designed to have a safety factor of at least 10, based on the ultimate strength of the material. A redundant load path is incorporated in the fuel grapples.

Both the refueling machine and the fuel handling machine have telescoping masts with integral grapples mounted from a trolley structure. They are also equipped with auxiliary hoists and jib cranes to which other grapples are attached when required. Both have redundant safety features and indicators that ensure positive engagement with fuel bundles. The fuel masts have interlocks that provide the necessary position control boundaries during deployment and limit travel during transfer of irradiated fuel. These safety provisions ensure that a safe water shielding depth is always maintained over the active fuel, while preventing physical damage to the mast.

The spent fuel cask pit is intentionally located outside the areas normally confined to fuel movement. The cask and other heavy loads are not permitted to encroach within any part of any spent fuel, spent storage pool or safety-related structure.

Inadvertent cask movement by the main crane over the fuel storage pools is prevented by travel limit controls. See Section 9.1.5.

9.1.4.2 System Description

Table 9.1-6 is a listing of typical tools and servicing equipment. The following paragraphs describe the use of some of the major tools and equipment and address safety aspects of the design where applicable for light loads.

Subsection 9.1.4 provides the data that verifies the ESBWR Standard Plant heavy load handling systems and satisfies the guidelines of NUREG-0612.

9.1.4.3 Spent Fuel Cask

Not in ESBWR Standard Plant Scope

9.1.4.4 Overhead Bridge Cranes

Fuel Building Crane

The Fuel Building crane is classified as Seismic Category II to prevent structural failure with SSE loads, leading to degradation of the functioning of a Seismic Category I structure, system, or equipment to an unacceptable safety level. The crane is used for lifting large heavy components and tools up to and over the Fuel Building floor. The crane consists of two parallel girders along which the trolley traverses across its span. It is supported on its track on the fuel building wall structural columns.

Among its required light load lifting tasks during fuel handling is to lift the fuel bundle from the shipping container and place it in the new fuel inspections stand. It is also used to remove the channeled fuel assembly from the fuel inspection stand and place it in the fuel preparation machine.

The Fuel Building crane is required for lifting heavy components, fuel containers, fuel assemblies during inspection, and handling the fuel shipping cask. It also provides extensive support to general construction and operation activities in the fuel building. The principal design criteria for the fuel building crane is the same as the Reactor Building crane as contained in Subsection 9.1.5.

Reactor Building Crane

The Reactor Building crane is classified as Seismic Category II to prevent structural failure with SSE loads, leading to degradation of the functioning of a Seismic Category I structure, system, or equipment to an unacceptable safety level. The crane is used for lifting large heavy components and tools up to and over the refueling floor. The crane consists of two parallel girders along which the trolley traverses across its span.

Among its required light load lifting tasks during plant operation is to handle small tools and equipment normally used during inspection and servicing activities.

During fuel transport, the main crane is also called upon to move and store pool gates. The principal design criteria for the Reactor Building crane are contained in Subsection 9.1.5.

9.1.4.5 Refueling Equipment

Refueling Machine

The refueling machine is located in the Reactor Building and is similar to a gantry style crane and is used to transport fuel and reactor components to and from buffer pool storage, the inclined fuel transfer system, and the reactor vessel. The machine spans the buffer pool on embedded tracks in the refueling floor. A telescoping mast and grapple suspended from a trolley system is used to lift and orient fuel assemblies for placement in the core or storage rack. Control of the machine is from an operator station on the refueling machine.

A position indicating system and travel limit computer is provided to locate the grapple over the vessel core and prevent collisions with pool obstacles. Two auxiliary hoists are provided for in-

core servicing. The grapple in its retracted position provides sufficient water shielding over the active fuel during transit. The fuel grapple hoist has a redundant load path so that no single component failure will result in a fuel bundle drop. Interlocks on the machine;

- Prevent hoisting a fuel assembly over the vessel with a control rod removed
- Prevent collision with fuel pool walls or other structures
- Limit travel of the fuel grapple
- Interlock grapple hook engagement with hoist load and hoist up power
- Ensure correct sequencing of the transfer operation in the automatic or manual mode

The refueling machine is Seismic Class II. The refueling machine is designed to withstand the SSE. A standard dynamic analysis using the appropriate response spectra is performed to demonstrate compliance to design requirements. Except for hoisting speed, the fuel hoist is design to meet the requirements of NUREG-0554, Single Failure Proof Cranes. An auxiliary hoist is designed to meet the requirements of NUREG-0612, Control of Heavy Loads at Nuclear Power Plants to allow simultaneous handling of the control blade and fuel support casting with the dual function grapple. A second auxiliary hoist is provided for handling smaller lightweight tools.

Fuel Handling Machine

The fuel handling machine is similar to a gantry style crane, and is used to transport fuel and reactor components to and from the inclined fuel transfer system and the spent fuel storage and equipment storage racks. It is also used to move spent fuel to the shipping cask. The machine spans the Spent Fuel Pool on embedded tracks in the refueling floor. A telescoping mast and grapple suspended from a trolley system is used to lift and orient fuel assemblies for placement in the cask or storage rack. Control of the machine is from an operator station on the fuel handling machine.

A position indicating system and travel limit computer is provided to locate the grapple over the spent fuel racks, IFTS, and prevent collisions with pool obstacles. An auxiliary hoist is provided for additional servicing. The grapple in its retracted position provides sufficient water shielding over the active fuel during transit. The fuel grapple hoist has a redundant load path so that no single component failure will result in a fuel bundle drop. Interlocks on the machine;

- Prevent collision with fuel pool walls or other structures
- Limit travel of the fuel grapple
- Interlock grapple hook engagement with hoist load and hoist up power
- Ensure correct sequencing of the transfer operation in the automatic or manual mode

The fuel handling machine is Seismic Class II. The fuel handling machine is designed to withstand the SSE. A standard dynamic analysis using the appropriate response spectra is performed to demonstrate compliance to design requirements. Except for hoisting speed, the fuel hoist is design to meet the requirements of NUREG-0554, Single Failure Proof Cranes.

9.1.4.6 Fuel Servicing Equipment

Fuel Prep Machine

Two fuel preparation machines are mounted on the wall of the Spent Fuel Pool and are used to assist in the loading of new fuel into the spent fuel storage pool racks and for channeling and re-channeling of new and spent fuel assemblies. The machines are also used with fuel inspection fixtures to provide an underwater inspection capability.

Each fuel preparation machine consists of a work platform, a frame, and a movable carriage. The frame and movable carriage are located below the normal water level in the Spent Fuel Pool, thus providing a water shield for the fuel assemblies being handled. The fuel preparation machine carriage has an up-travel-stop to prevent raising fuel above the safe water shield level. The operator places assembled new fuel in the fuel preparation machine, the carriage is lowered and the fuel removed from the fuel preparation machine using the fuel handling machine.

New Fuel Inspection Stand

The new fuel inspection stand is vertical frame mounted in a pit that supports two fuel bundles contained in a mechanically driven inspection carriage. In the carriage the lower tie plate of each fuel bundle rests on a bearing seat and at the top each fuel assembly is supported in a separate bearing assembly. The fuel assemblies can be individually rotated about their longitudinal axis to permit viewing all sides. The fuel channel is placed on the fuel bundle in the new fuel inspection stand.

To facilitate fuel inspection, the stand is set into an inspection pit designed to allow the carriage to be lowered and raised permitting eye level viewing by inspecting personnel on the refueling floor.

Channel Bolt Wrench

The channel bolt wrench is a manually operated device approximately 3.76m (12 ft) in overall length. The wrench is used for removing or installing the channel fastener assembly that attaches the channel to the fuel assembly while the fuel assembly is held in the fuel preparation machine. The channel bolt wrench socket mates and captures the channel fastener cap-screw.

Channel Handling Tool

The channel handling tool is used in conjunction with the fuel preparation machine to install and transport fuel channels.

The tool is composed of a handling bail, lock/release knob, extension shaft, angle guides, and clamp arms that engage the fuel channel. The clamps are actuated (extended or retracted) by manually rotating a lock/release knob.

The channel handling tool is suspended by its bail from a spring balancer on the channel handling boom located on the Spent Fuel Pool periphery.

General Purpose Grapple

The general purpose grapple performs many tasks and is primarily used on the auxiliary hoist of either the refueling or fuel handling machines. It is designed to fit a standard fuel bail, which is replicated on certain tooling for handling purposes. One example is handling the underwater vacuum cleaner.

The general purpose grapple, when utilizing an extension cable, is also attached to the auxiliary hook of the fuel building crane as the need arises for handling new fuel.

9.1.4.7 Servicing Aids

General area underwater lights are provided with a suitable reflector for illumination.

Support brackets are furnished to support the lights in the reactor vessel to allow the light to be positioned over the area being serviced independent of the platform. Local area underwater lights are small diameter lights for additional illumination. Drop lights are used for illumination where needed.

Other servicing aids that are available include the following:

- A radiation-hardened portable underwater television camera for in-vessel inspection or observation of servicing activity.
- General purpose viewing aid in the form of a floatable plastic box that has brightly colored side panels for easy identification. Its purpose is to prevent surface motion of the water and alleviate image distortion of submerged objects.
- A portable, submersible underwater vacuum cleaner to help remove crud or miscellaneous loose matter from the reactor vessel or storage pools. The required pump and filter is also submersible for extended periods. The filter can be changed remotely and disposed of in standard containers after use for off-site burial.

9.1.4.8 Reactor Vessel Servicing Equipment

Table 9.1-4 lists the safety designation, QA requirements, and the seismic category. Lifting tools for lifting heavy loads are designed using a dual load path or designed for a safety factor of 10 or better with respect to the ultimate strength of the material used. NUREG-0612, Control of Heavy Loads at Nuclear Power Plants, applies to the head lifting load path. The following subparagraphs describe the equipment contained in the table.

Reactor Vessel Service Tools

These tools are used when the reactor is shut down and the reactor vessel head is being removed or reinstalled. Tools in this group are as follows:

- RPV Stud Tensioning System and RPV Head Strongback
- Stud handling tool
- Seal Surface Protector
- Stud thread protector
- Stud elongation measuring rod
- Dial indicator elongation measuring device
- Head guide cap

Steam and DPV/IC Line Plugs

Prior to refueling when the reactor water is at the refueling level, the main steam and DPV/IC line nozzles must be plugged to prevent outflow of water from the reactor.

The plugs are housed on the end of a spider structure and are lowered into the vessel and aligned with their respective nozzles, are actuated into position and their pressurized seals activated. The plug structure is constructed of corrosion resistant materials and has a factor of safety of 5 or greater.

Head Support Pedestal

Head support pedestals are mounted on the refueling floor for supporting the reactor vessel head and strongback/carousel during periods of reactor servicing.

The pedestals have dowel pins that engage three evenly spaced stud holes in the head flange. The flange surface rests on replaceable wear pads made of aluminum.

When resting on the pedestals, the head flange is sufficiently high above the floor to allow access to the seal surface for inspection and O-ring replacement.

The pedestal structure is a carbon steel weldment coated with an approved paint. It has a base with bolt holes for mounting it to the concrete floor.

A seismic analysis is used to determine the input forces imposed onto the pedestals and floor anchors. The structure is designed to withstand these calculated forces and meet the requirements of AISC.

Dryer and Chimney Head / Separator Strongback

The dryer and chimney head / separator strongback is a lifting device used for transporting the steam dryer or the chimney head with the steam separators between the reactor vessel and the storage pools. The strongback structure has a hook box with two hook pins in the center for engagement with the RB crane sister hook. The strongback has a socket with a remotely operated pin on the end of each arm for engaging it to the four lift eyes on the steam dryer or shroud head.

The strongback has been designed such that one hook pin and one main beam of the cruciform is capable of carrying the total load and no single component failure could cause the load to drop or swing uncontrollably out of an essentially level attitude. The strongback meets the requirements of NUREG-0612, Control of Heavy Loads at Nuclear Power Plants.

Head Strongback/Tensioner

The RPV head strongback stud tensioning system is an integrated piece of equipment consisting of a strongback, a four station rotating frame with stud tensioners, nut and washer handling tools, and stud cleaning tools, a nut and washer rack, and service platform.

The strongback structure has a hook box with two hook pins in the center for engagement with the reactor service crane sister hook. Extending from the center section are arms to connect to the circular monorail. The four arms have a lift rod for engagement to the four lift lugs on the RPV head. The rotating frame is connected to the strongback arms and four additional arms equally spaced between the strongback arms. The rotating frame positions the four stations of the stud tensioning and nut and washer handling tools above the stud circle of the reactor vessel

and serves to suspend stud tensioners and nut and washer handling devices. The nut and washer rack is attached to the strongback and surrounds the RPV flange. The head strongback rotating frame serves the following functions:

- Lifting of Vessel Head—the strongback, when suspended from the RB crane main hook, will transport the RPV head plus the rotating frame with all its attachments between the reactor vessel and storage on the pedestals.
- Tensioning of Vessel Head Closure—the strongback with rotating frame, when supported on the RPV head on the vessel, will carry four stations of stud Tensioners, nut and washer handling tools, its own weight, the strongback, storage of nuts, washers, and associated tools and equipment.
- Storage with RPV Head—the strongback with rotating frame, when stored with the RPV head holding pedestals, carries the same load as outlined in the second bullet above.
- Storage without RPV Head—during reactor operation, the strongback and rotating frame is stored on four separate pedestals.

The strongback, with its lifting components, is designed to meet NUREG-0612, Control of Heavy Loads at Nuclear Power Plants. After completion of welding and before painting, the lifting assembly is proof load tested and all load-affected welds and lift pins are magnetic-particle inspected.

The steel structure is designed in accordance with the Manual of Steel Construction by AISC. Aluminum structures are designed in accordance with the Aluminum Construction Manual by the Aluminum Association.

The strongback is tested in accordance with American National Standard for Overhead Hoists ANSI B30.16, Paragraph 16-1.2.2.2, such that one hook pin and one main beam of the structure is capable of carrying the total load, and so that no single component failure will cause the load to drop or swing uncontrollably out of an essentially level attitude. The ASME Boiler and Pressure Vessel Code, Section IX (Welder Qualification) is applied to all welded structures.

9.1.4.9 In-Vessel Servicing Equipment

Instrument Strongback

The instrument strongback, when attached to the Reactor Building auxiliary hoist, is used for servicing the Local Power Range Monitor (LPRM), Startup Range Neutron Monitors (SRNM), and dry tubes when they require replacement. The strongback initially supports the dry tube into the vessel. The in-core dry tube is then decoupled from the strongback and is guided into place while being supported by the instrument handling tool.

Instrument Handling Tool

The instrument handling tool is attached to the refueling platform auxiliary hoist and is used for SRNM removing and installing PRNM fixed in-core dry tubes, as well as handling the SRNM dry tubes. Dry tubes are stored in the spent fuel storage pool.

9.1.4.10 Storage Equipment

Specially designed equipment storage racks are provided. Additional storage equipment is listed in Table 9.1-6. For fuel storage racks description and fuel arrangement, refer to Subsections 9.1.1 and 9.1.2.

Defective fuel assemblies can be placed in special fuel storage containers and can stored in the equipment storage rack; both are designed for the defective fuel. These may be used to isolate leaking or defective fuel while in the fuel pool and during shipping.

9.1.4.11 Under-Vessel Servicing Equipment

The primary functions of the under-vessel servicing equipment are as follows:

- Servicing tools for maintenance of control rod drive motors packing and fine motion control rod drives (FMCRDs)
- Work platform for installation during the construction phase

Table 9.1-7 lists the equipment and tools required for servicing. Of the equipment listed, the equipment handling platform and the FMCRD handling equipment are powered electrically and pneumatically.

The FMCRD handling equipment is designed for the removal and installation of the fine motion control rod drives major components from their housings. This equipment is used in conjunction with the equipment-handling platform. It is designed in accordance with OSHA-1910.179, and American Institute of Steel Construction, AISC.

The under vessel platform provides a working surface for equipment and personnel performing work in the under vessel area. It is a polar platform capable of rotating 360°.

The under vessel servicing equipment is used in conjunction with a rail system and various carts to transport FMCRD components from outside the containment to the under vessel area.

The in-core monitoring seal flushing equipment is designed to prevent leakage of primary coolant from in-core detector housings during detector replacement. It is designed to industrial codes and manufactured from corrosion-resistant material.

9.1.4.12 Fuel Transfer System

The ESBWR is equipped with an Inclined Fuel Transfer System (IFTS). In general the arrangement of the IFTS (refer to Figure 9.1-2) consists of a terminus at the upper end in the Reactor Building buffer pool that allows the fuel to be tilted from a vertical position to an inclined position prior to transport to the Spent Fuel Pool. There is a means to lower the transport device (i.e., a carriage), means to seal off the top end of the transfer tube, and a control system to effect transfer. It has a lower terminus in the fuel building storage pool, and a means to tilt the fuel into a vertical position allowing it to be removed from the transport cart. There are controls contained in local control panels to effect transfer. There is a means to seal off the upper and lower end of the tube while allowing filling and venting of the tube.

There is sufficient redundancy and diversity in equipment and controls to prevent loss of load [carriage with fuel is released in an uncontrolled manner] and that there are no modes of operation that allow simultaneous opening of any set of valves that could cause draining of water

from the upper pool in an uncontrolled manner. The carriage and valves may be manually operated in the event of a power failure, to allow completion of the fuel transfer process.

The IFTS has sufficient cooling such that a freshly removed fuel assembly can remain in the IFTS until it is removed without damage to the fuel or excessive overheating.

The IFTS tubes and supporting structure can withstand an SSE without failure of the basic structure or compromising the integrity of adjacent equipment and structures. Therefore, the portion of the IFTS transfer tube assembly from where it interfaces with the upper fuel pool, the portion of the tube assembly extending through the building, the drain line connection, and the lower Spent Fuel Pool terminus equipment (tube, valve, support structure, and bellows) are designated as nonsafety-related and Seismic Category I. The remaining equipment is designated as non-safety-related and Seismic Category NS.

The IFTS is anchored to the bottom of the Inclined Fuel Transfer pool in the buffer pool floor in the Reactor Building. The IFTS penetrates the Reactor Building at an angle down to IFTS pit in the fuel storage pool in the Fuel Storage Building.

The IFTS terminates in a separate pit in the fuel storage pool. The lower terminus of the IFTS allows for thermal expansion (axial movement relative to the anchor point in the Reactor Building). The lower terminus allows for differential movement between the anchor point in the Reactor Building and the fuel pool terminus, and allows it to have rotational movement at the end of the tube relative to the anchor point in the Reactor Building. The lower end interfaces with the fuel storage pool with a bellows to seal between the transfer tube and the Spent Fuel Pool wall.

The IFTS carriage primarily handles nuclear fuel using a removable insert and control blades in a separate insert in the transfer cart. Other contaminated items may be moved in the carriage utilizing a suitable insert.

For radiation protection, personnel access into areas of high radiation or areas immediately adjacent to the IFTS is controlled. Access to any area adjacent to the transfer tube is controlled through a system of physical controls, interlocks and an annunciator. Specifically:

- Controls prevent personnel from inadvertently or unintentionally being left in those areas at the time the access doors are closed
- During IFTS operation or shutdown, personnel are prevented from (a) either reactivating the IFTS while personnel are in a controlled maintenance area, or (b) entering a controlled IFTS maintenance area while irradiated fuel or component are in any part of the IFTS
- Both an audible alarm and flashing red lights are provided both inside and outside any maintenance room to indicate IFTS operation
- Radiation monitors with alarms are provided both inside and outside any maintenance area
- A key-lock system of key-locks in both the IFTS main operation panel and in the control room is provided to allow access to any IFTS maintenance area

9.1.4.13 Refueling Operations

The fuel servicing system outlined in this section includes the requirements for a refueling program and the provision for tools and equipment. A general plant refueling and servicing

sequence diagram is shown on Figure 9.1-3. It depicts, in chronological order, each event and elapsed time estimates based on historical BWR fleet experience.

9.1.4.14 Arrival of Fuel at Reactor Site

Fuel bundles are packed in metal containers and then are shipped in wooden crates. Prior to moving the fuel to the Reactor Building the inner metal shipping container is removed from the outer wooden shipping box. The inner metal shipping container is moved to the floor of the fuel building using the fuel building crane. The containers must be in a vertical position before removal of the fuel, usually accomplished by the combined use of the fuel building crane auxiliary hook and the new fuel inspection stand. The fuel is inspected and channels placed over the fuel bundle. The fuel assembly is then placed in the spent storage racks.

Channeling New Fuel

Channeling of new fuel is performed on the new fuel inspection stand. With the aid of a channel handling tool, the channel is lowered over the fuel after inspection and bolted in place using a channel bolt wrench. The fuel is then transported using the fuel building crane auxiliary hook to the spent fuel storage pool, in preparation for eventual transfer to the Reactor Building for fueling the reactor.

9.1.4.15 Reactor Preparation for Refueling

The reactor is shut down and cooled down to reduce the reactor water temperature to under 50°C (120°F), so that open vessel work may take place.

Drywell Head Removal

Following drain down of the reactor well and the completion of wall cleaning, the drywell head quick disconnect pins are removed and stored for reinsertion after replacement of the drywell head.

The drywell head is lifted by the Reactor Building crane and transported to its storage area on the refueling floor. The drywell seal protection is then installed before any other activity can proceed.

Reactor Bulkhead Servicing

Following drywell head removal, penetration openings in the reactor bulkhead are sealed to prevent leakage from well flooding. The RPV head insulation frame is removed and placed in its storage area on the refueling floor.

Vessel Head Removal

Removal of the reactor vessel head is performed with the Reactor Building crane, utilizing the RPV strongback. The RB crane and RPV strongback with the RPV head stud tensioning system is used to handle the RPV head and attachments. The strongback is designed so that no single component failure will cause the load to drop or swing uncontrollably out of an essentially horizontal attitude. The RPV strongback and stud tensioning equipment is detached from the Reactor Building crane during stud de-tensioning or tensioning operations. Following stud de-tensioning operations, the Reactor Building crane is used to lift the RPV head using the previously mounted strongback with the tensioning system, nuts, and washers.

The maximum potential drop height is at the point where the head is lifted vertically from the vessel and before moving it horizontally to the head storage pedestals.

Dryer and Chimney Head / Separator Removal

Fuel Pool Gate Removal

In preparation for spent fuel movement out of the reactor core, the fuel pool and reactor well gates are removed after equalization of water levels between the fuel pool and reactor well.

Dryer Removal

The dryer-separator strongback is lowered by the RB crane and attached to the dryer lifting lugs. The dryer is lifted from the reactor vessel and transported underwater to its storage location in the D/S pit adjacent to the reactor well.

Nozzle Plugs Installation

Nozzle plug installation comprises plugging both the main steam and IC line nozzles. The installation is performed with the vessel flooded to just below the refueling floor level. Once installed, other outage tasks such as local leak rate testing, SRV or DPV replacement and main steam isolation valve (MSIV) maintenance activities can be initiated.

Chimney Head / Separator Removal

Disengagement of all chimney head bolts from the chimney head/separator flanged joint is completed and verified prior to chimney head/separator removal. The chimney head/separator is removed together as an assembly with the lifting rods attached to the separator flange.

The reactor well is then flooded and the water level is raised to the same level as the equipment storage pool. This allows the removal of the pool gate to permit passage of the chimney head/separator assembly into the storage pool.

Lifting of the dryer/separator assembly is affected by the dryer/separator strongback suspended from the main crane. The lifting pins at the ends of four cruciform beams are pneumatically actuated into the lifting eyes on the separator lifting rods.

The COL licensee shall perform load testing of the dryer/separator at 125% of rated load and take deflection measurements to verify that they are within acceptable limits. The COL licensee shall also perform random magnetic particle testing of welds after load tests to ensure structural integrity.

9.1.4.16 Refueling

Fuel movement during the refueling process is carried out by the refueling machine, the IFTS, and the fuel handling machine. The move by the refueling and fuel handling machines may be in a direct path as the resultant of both x and y vectors. Accuracy of position in either horizontal direction can be achieved at each RPV core position and at each fuel storage rack cell location.

Core Verification and Final Core Audit

The grapple camera is used to review the core location of each fuel bundle, its orientation and seating condition during each fuel move.

9.1.4.17 Vessel Closure

Following refueling, all other reactor vessel related outage activities are completed before reassembly of the reactor can begin. These may include the following:

- FMCRD maintenance and tests
- Neutron Monitoring System servicing
- SV, SRV and DPV replacement
- MSIV maintenance

The sequence of reassembly is essentially in reverse order to that of disassembly but may have some steps performed in parallel. The sequence is as follows:

- Install fuel pool gate
- Remove nozzle plugs
- Remove and store equipment storage pool gate
- Install steam dryer and chimney head / separator assemblies
- Install equipment storage pool gate
- Drain reactor cavity
- Install and tighten reactor vessel head
- Install reactor vessel insulation
- Perform in-service leak test (ISLT - Equipment is tagged out and inoperable during this test, which is a critical path item)
- Remove tags and restore valve lineups
- Install drywell head
- Flood reactor cavity
- Perform startup operations check
- Check final drywell closeout

9.1.4.18 Safety Evaluation of Fuel Handling System

Fuel servicing equipment is discussed in Subsection 9.1.4.2.4 and refueling equipment is discussed in Subsection 9.1.4.2.3. In addition, the summary safety evaluation of the fuel handling system is described in the following paragraphs.

The refueling machine and fuel handling machine are designed to prevent them from becoming unstable and toppling into pools during a SSE, and interlocks, as well as limit switches, are provided to prevent accidental movement of the grapple mast into pool walls.

The grapple on both the refueling machine and fuel handling machine is hoisted to its retracted position by redundant cables inside the mast and is lowered to full extension by gravity. The retraced position is controlled by both interlocks and physical stops to prevent raising the fuel

assembly above the normal stop position required for safe handling of the fuel. The operator can observe the exact grapple position over the core by a display screen at the operator console.

These racks requires the submittal of information pertaining to load drop analysis. See Subsection 9.1.6 for COL license information requirements under "Spent Fuel Racks Load Drop Analysis."

The fuel handling system complies with General Design Criterion 61 of 10 CFR 50 as described in Subsection 3.1.

The safety evaluation of the new and spent fuel storage is presented in Subsections 9.1.1.3.

9.1.4.19 Inspection and Testing Requirements

Inspection

The fuel storage racks and refueling machine have additional "quality requirements" that identify features that require specific QA verification of compliance to drawing requirements.

Testing

Functional tests are performed on refueling and servicing in the shop prior to the shipment of most production units and generally include electrical tests, leak tests, and sequence of operations tests.

When the unit is received at the site, it is inspected to ensure that no damage has occurred during transit or storage. Prior to use and at periodic intervals, each piece of equipment is again tested to ensure that the electrical and/or mechanical functions are operational.

Passive components, such as the fuel storage racks, are inspected periodically. Procedures for interim verification of the presence of neutron absorbing material during the life of the plant are provided.

Fuel handling and vessel servicing equipment preoperational tests are described in Subsection 14.2.8.

9.1.4.20 Instrumentation Requirements

Refueling and Fuel Handling Machines

The refueling and fuel handling machines have a position indicator system to indicate to the operator which core fuel cell the fuel grapple is accessing. Interlocks and a monitor are provided to prevent the fuel grapple from operating in a fuel cell where the control rod is not in the proper orientation for refueling.

There is also a series of mechanically activated switches and relays that provides monitor indications on the operator's console for grapple limits, hoist and cable load conditions, and confirmation that the grapple's hook is either engaged or released.

A series of load cells is installed to provide automatic shutdown whenever threshold limits are exceeded for either the fuel grapple or the auxiliary hoist units.

Fuel Grapple

Although the fuel grapple is not safety-related, it is equipped with a mounted TV camera, lighting system, and instrumentation system consisting of mechanical switches and indicator

lights. This system provides the operator with a positive indication that the grapple is properly aligned and oriented and that the grappling mechanism is either extended or retracted.

9.1.5 Overhead Heavy Load Handling Systems (OHLHS)

9.1.5.1 Design Bases

9.1.5.2 General

The equipment described in this subsection covers items considered as heavy loads that are handled under conditions that mandate critical handling compliance.

Critical load handling conditions relate to the moving of loads, the use of equipment and the performance of operations, which, by inadvertent operation or equipment malfunctions, either separately or in combination, could cause:

- A release of radioactivity
- A criticality accident
- The inability to cool fuel within the reactor vessel or within the Spent Fuel Pool
- Prevent a safe shutdown of the reactor

This includes risk assessments of spent fuel and of storage pool levels, cooling of fuel pool water, or new fuel criticality. Critical load handling therefore includes all components and equipment used for moving loads weighing more than one fuel assembly with its associated handling devices.

The Reactor and Fuel Building cranes provide a safe and effective means for transporting heavy loads including the handling of new and spent fuel, plant equipment, service tools and fuel casks. Safe handling includes design considerations for maintaining occupational radiation exposure as low as practicable during transportation and handling.

Where applicable, the appropriate seismic category, safety classification, ASME, ANSI, industrial and electrical codes have been identified (refer to Tables 9.1-4 and 9.1-5). The designs conform to the relevant requirements of General Design Criteria 2, 4, and 61 of 10 CFR 50, Appendix A.

The lifting capacity of each crane or hoist is designed to at least the maximum actual or anticipated weight of equipment and handling devices in a given area serviced. The hoists, cranes, or other lifting devices comply with the requirements of ANSI N14.6, ANSI B30.9, ANSI B30.10 and NUREG-0612 Subsection 5.1.1(4) or 5.1.1(5). Cranes and hoists are also designed to criteria and guidelines of NUREG-0612 Subsection 5.1.1(7), ANSI B30.2 and CMAA-70 specifications for electrical overhead traveling cranes, including ANSI B30.11, and ANSI B30.16 as applicable.

9.1.5.3 Applicable Design Criteria for All OHLH Equipment

All handling equipment subject to heavy loads handling criteria has ratings consistent with lifts required and the design loading will be visibly marked. Cranes/hoists or monorail hoists pass over the centers of gravity of heavy equipment that is to be lifted. In locations where a single

monorail or crane handles several pieces of equipment, the routing is such that each transported piece passes clear of other parts.

Pendant control is required for the bridge, trolley, and auxiliary hoist to provide efficient handling of fuel shipping containers during receipt and also to handle fuel during new fuel inspection. The crane control system is selected considering the long lift required through the equipment hatch as well as the precise positioning requirements when handling the RPV and drywell heads, the RPV internals, and the RPV head stud tensioner assembly. The control system provides stepless regulated variable speed capability with high empty-hook speeds. Efficient handling of the drywell and RPV heads and stud tensioner assembly require that the control system provide spotting control. Because fuel shipping cask handling involves a long duration lift, low speed, and spotting control, thermal protection features are incorporated.

Heavy load equipment is also used to handle light loads and related fuel handling tasks. Therefore, much of the handling systems and related design, descriptions, operations, and service task information of Subsection 9.1.4 is applicable here. The cross-reference for the handling operations/equipment and Subsection 9.1.4 is provided in Table 9.1-6.

Transportation routing drawings are made covering the transportation route of every piece of heavy load removable equipment from its installed location to the appropriate service shop or building exit. Routes will be arranged to prevent congestion and to assure safety while permitting a free flow of equipment being serviced. The frequency of transportation and usage of route are documented based on the predicted number of times usage either per year and/or per refueling or service outage.

9.1.5.4 System Description

9.1.5.5 Fuel Building and Reactor Building Cranes

Fuel Building Crane

The Fuel Building (FB) is a reinforced concrete structure enclosing the Spent Fuel Pool, cask handling and cleaning facility, and other equipment. The FB crane provides heavy load lifting capability for the Fuel Building floor. The main hook (150-ton capacity) is used to lift new fuel shipping containers and the spent fuel shipping cask (refer to Table 9.1-6). The orderly placement and movement paths of these components by the FB crane preclude transport of these heavy loads over the Spent Fuel Pool.

The FB crane is used during refueling/servicing as well as when the plant is on-line. Minimum crane coverage includes the FB floor laydown areas, cask wash down area, and the FB equipment hatch. During normal plant operation, the crane is used to handle new fuel shipping containers and the spent fuel shipping cask. The FB crane is interlocked to prevent movement of heavy loads over the Spent Fuel Pool.

Reactor Building Crane

The Reactor Building (RB) is a reinforced concrete structure enclosing the Reinforced Concrete Containment Vessel (RCCV), the refueling floor, the new fuel storage pools, Spent Fuel Pool, the dryer/separator, and other equipment. The Reactor Building crane provides heavy load lifting capability for the refueling floor. The main hook (150-ton capacity) is used to lift the drywell head, RPV head insulation, RPV head, dryer, separator strongback, RPV head

strongback carousel, new fuel shipping containers, and spent fuel shipping cask (refer to Table 9.1-7). The orderly placement and movement paths of these components by the RB crane preclude transport of these heavy loads over the Spent Fuel Pool or over the new fuel rack.

The RB crane is used during refueling/servicing as well as when the plant is on-line. Minimum crane coverage includes the RB refueling floor lay down areas and the RB equipment storage. During normal plant operation, the crane is used to handle new fuel shipping containers and the spent fuel shipping cask. Minimum crane coverage includes the refueling floor and the equipment hatches. The RB crane is interlocked to prevent movement of heavy loads over the fuel pools.

9.1.5.6 Other Overhead Load Handling System

Upper Drywell Servicing Equipment

The upper drywell arrangement provides servicing access for the main steam isolation valves (MSIVs), feedwater isolation valves; safety/relief valves (SRVs), depressurization valves (DPVs), Passive Containment Cooling System (PCCS) valves, Gravity-Driven Cooling System (GDCS) valves, and drywell cooling coils, fans and motors. Access to the space is from the RB through either the upper drywell personnel lock or equipment hatch. Equipment is removed through the upper drywell equipment hatch. Platforms are provided for servicing the feedwater and main steam isolation valves, safety/relief valves, and drywell cooling equipment with the objective of reducing maintenance time and operator exposure. Items such as MSIVs, SRVs, DPVs, and feedwater isolation valves weigh in excess of a fuel assembly and its handling device and therefore are considered heavy loads.

Drywell maintenance activities are only performed during a refueling outage, therefore, only the PCCS and GDCS piping and valves need to be protected from inadvertent load drops. Because the PCCS and GDCS piping and valves are spatially separated, an inadvertent load drop that breaks more than one pipe or valve of the PCCS or GDCS is not credible. In addition, a piping support structure and equipment platform separates and shields the PCCS and GDCS piping from heavy load transport paths.

This protection is such that no credible load drop can cause (a) a release of radioactivity, (b) a criticality accident, or (c) the inability to cool fuel within the reactor vessel or Spent Fuel Pool. Therefore, the upper drywell servicing equipment is not subject to the requirements of Subsection 9.1.5.

Lower Drywell Servicing Equipment

The lower drywell arrangement provides for servicing, handling and transportation operations for FMCRDs. The lower drywell OHLHS consists of a rotating equipment service platform, chain hoists, FMCRD removal equipment, and other special purpose tools.

The rotating equipment platform provides a work surface under the reactor vessel to support the weight of personnel, tools, and equipment and to facilitate transportation moves and heavy load handling operations. The platform rotates 360° in either direction from its stored or “idle” position. The platform is designed to accommodate the maximum weight of the accumulation of tools and equipment plus a maximum sized crew. The weight of tools and equipment are specified in the interface control drawings for the equipment used in the lower drywell. Special

hoists are provided in the lower drywell and Reactor Building to facilitate handling of these loads.

There are FMCRDs in the lower drywell that require servicing. There are two types of servicing operations: (1) replacement of the FMCRD drive mechanism and (2) motor and seal replacement. Separate servicing equipment is provided for each of these operations.

The FMCRD drive servicing equipment has its own mechanisms for rotating and raising FMCRD drive assemblies from a carrier on the equipment platform to their installed position. This servicing equipment interfaces with the lower drywell equipment platform and permits positioning under any one of the FMCRDs.

Separate equipment and a cart are provided for servicing FMCRD motors and seal assemblies and transporting them to the service shop located immediately outside the lower drywell equipment hatch.

There is no safety-related equipment below either component. Inadvertent load drops by the FMCRD servicing equipment cannot cause (1) a release of radioactivity, (2) a criticality accident, or (3) the inability to cool fuel within the reactor vessel or Spent Fuel Pool. Therefore, the FMCRD servicing equipment is not subject to the requirements of Subsection 9.1.5.

Main Steam Tunnel Servicing Equipment

The main steam tunnel is a reinforced concrete structure surrounding the main steam lines and feedwater lines. The safety-related valve area of the main steam tunnel is located inside the Reactor Building. Access to the main steam tunnel is during a refueling/servicing outage. At this time, MSIVs or feedwater isolation valves and/or feedwater check valves may be removed using permanent overhead monorail type hoists. They are transported by monorail out of the steam tunnel and placed on the floor below a ceiling removal hatch. Valves are then lifted through the ceiling hatch by the valve service shop monorail. During shutdown, all of the piping and valves are not required to operate. Any load drop can only damage the other valves or piping within the main steam tunnel. Inadvertent load drops by the main steam tunnel servicing equipment cannot cause (a) a release of radioactivity, (b) a criticality accident, or (c) the inability to cool fuel within reactor vessel or Spent Fuel Pool. Therefore, the main steam tunnel servicing equipment is not subject to the requirements of Subsection 9.1.5.

Other Servicing Equipment

Outside of the containment, the main steam tunnel, or the refueling floor there are no safety-related components of one division routed over any portion of a safety-related portion of another division at locations susceptible to heavy load drops capable of causing the loss of a safety-related component required to maintain the plant in a safe condition. Therefore, inadvertent load drops cannot cause (a) a release of radioactivity, (b) a criticality accident, (c) the inability to cool fuel within reactor vessel or Spent Fuel Pool, or (d) prevent the safe shutdown of the reactor. Therefore, the servicing equipment located outside the containment, the main steam tunnel, or the refueling floor is not subject to the requirements of Subsection 9.1.5.

9.1.5.7 Equipment Operating Procedures Maintenance and Service

Each item of equipment requiring servicing is described on an interface control diagram (ICD) delineating the space around the equipment required for servicing. This includes pull space for

internal parts, access for tools, handling equipment, and alignment requirements. The ICD specifies the weights of large removable parts, show the location of their centers of gravity, and describe installed lifting accommodations such as eyes and trunnions. An instruction manual describes maintenance procedures for each piece of equipment to be handled for servicing. Each manual contains suggestions for rigging and lifting of heavy parts, and identifies any special lifting or handling tools required.

Operating instruction and maintenance manuals are provided for reference and use by operations personnel for all major handling equipment components (cranes, hoist, etc.).

9.1.5.8 Operational Responsibilities

Critical heavy load handling in the plant includes the following key elements for the administration and implementation of heavy load handling systems:

- Heavy Load Handling System and Equipment Operating Procedures
- Heavy Load Handling Equipment Maintenance Procedures and/or Manuals
- Heavy Load Handling Equipment Inspection and Test Plans; NDE, Visual, etc.
- Heavy Load Handling Safe Load Paths and Routing Plans
- QA Program to Monitor and Assure Implementation and Compliance of Heavy Load Handling Operations and Controls
- Personnel Qualifications, Training and Control Program

9.1.5.9 Safety Evaluations

The arrangement of the refueling floor precludes transporting heavy loads, other than spent fuel handled by the refueling machine or fuel handling machine, over spent fuel stored in the spent fuel storage pool.

The separation (arrangement, equipment interlocks, and routing) of redundant safety-related components in relation to heavy load paths minimizes the potential to cause failure of safety-related components. Administrative procedures further minimize the potential hazard from heavy loads.

9.1.5.10 Inspection and Testing

Qualification load and performance testing, including nondestructive examination (NDE) and dimensional inspection on heavy load handling equipment, is performed. Tests may include load capacity, safety overloads, life cycle, sequence of operations, and functional performance.

When load handling equipment is received at the site, it is inspected to ensure no damage has occurred during transit or storage. Prior to use and at periodic intervals, each piece of equipment is tested again to ensure the electrical and/or mechanical functions are operational including visual inspection and, if required, NDE inspection.

Crane inspections and testing comply with ANSI B30.2.

9.1.5.11 Instrumentation Requirements

The majority of the heavy load handling equipment is manually operated and controlled by the operator based on visual observations. This type of operation does not necessitate the need for a dynamic instrumentation system.

Load cells may be installed to provide automatic shutdown whenever threshold limits are exceeded for critical load handling operations to prevent overloading.

9.1.6 COL Information

9.1.6.1 COL Applicant Information

Spent Fuel Storage Racks Criticality Analysis

The COL applicant shall provide the NRC confirmatory criticality analysis as required by *Criticality Control* (Subsection 9.1.2.3).

Spent Fuel Racks Load Drop Analysis

The COL applicant shall provide the NRC confirmatory load drop analysis as required by Subsection 9.1.4.4.

9.1.6.2 COL Licensee Information

Dynamic and Impact Analyses of New Fuel Storage Racks

The COL licensee shall provide the NRC confirmatory dynamic and impact analyses of the new fuel storage racks. Refer to Subsection 9.1.1.1, under subheading Dynamic and Impact Analysis.

The COL licensee shall confirm the fuel storage racks are designed to provide sufficient natural convection coolant flow through the rack and fuel to remove decay heat without reaching excessive water temperatures (100°C; 212°F).

Fuel Handling Procedural Control

The COL licensee shall develop fuel handling procedures and administrative controls.

Load Testing

The COL licensee shall perform load testing of the dryer/separator at 125% of rated load and take deflection measurements to verify that they are within acceptable limits. The COL licensee shall also perform random magnetic particle testing of welds after load tests to ensure structural integrity.

9.1.7 References

None

Table 9.1-1

Pools Served by FAPCS and IC/PCC

Pools Served by FAPCS C/C Subsystem	**Location**
Fuel Pools • Spent Fuel Pool • Lower Fuel Transfer Pool • Cask Pool • Cask Head Shelf Pool	Fuel Building
Auxiliary Pools • Steam Dryer and Separator Storage Pool • Reactor Well • Buffer Pool • Upper Fuel Transfer Pool	Reactor Building
GDCS Pools • GDC A pool • GDC B pool • GDC C pool	Containment
Suppression Pool	Containment
Pools Served by IC/PCCS Pool C/C Subsystem	
IC/PCCS Pools • IC Pools • PCCS Pools • Expansion (Outer) Pool	Reactor Building

Table 9.1-2

FAPCS Operating Modes

Mode	**Description**	**Plant Condition**
1	Spent Fuel Pool Cooling and Cleanup	a. Normal* b. Refueling c. Post accident**
1	Fuel and Auxiliary Pool Cooling and Cleanup	Refueling
2	IC/PCCS Pool Cooling and Cleanup	Normal*
3	GDCS Pool Cooling and Cleanup	Normal*
4	Suppression Pool Cooling and Cleanup	a. Normal* b. Post accident**
5	LPCI	Post accident**
6	IC/PCCS pool automatic makeup	Normal*
7	Reactor Well fill up	Refueling
8	Reactor Well Draining	Refueling
9	Overboarding of SP Water	Refueling
10	Post-LOCA fill-up of Spent Fuel Pool and IC/PCC pools	Post accident**
11	Alternate SDC	Post accident**
12	Drywell Spray	Post accident**

* Normal plant operation including reactor power operation and plant shutdown.

** Post accident recovery period starting at 72 hours after the accident. Cleanup function is not required during this period.

Table 9.1-3

Safety Classification, Quality Group and Seismic Category

Component	Safety Class	Quality Group	Seismic Category
1. Piping between inboard and outboard containment isolation valves for Suppression pool return line GDCS pool suction line GDCS pool return line Drywell Spray discharge line	Q	B	I
2. Piping between inboard manual valve and outboard containment isolation valve on suppression pool suction line	Q	B	I
3. Piping and components providing dedicated emergency make-up water to the IC/PCCS pools and Spent Fuel Pool from piping connections located at grade level in the reactor yard and Fire Protection System	Q	C	I
4. Interconnecting pipes between GDCS pools	Q	C	I
5. Piping and components outside containment required for SFP, SPC, LPCI and Drywell Spray modes of operation	N	B	I
6. Suppression pool suction line inside containment between the inboard manual valve and its termination point (including suction strainers)	N	C	I
7. Piping inside containment between the inboard containment isolation valve and its termination point for Suppression pool return line Drywell spray discharge line	N	C	I
8. Piping inside containment between inboard containment isolation valves and their termination points inside containment for: GDCS pool suction line GDCS pool return line	N	D	II
9. IC/PCCS Pool C/C subsystem piping	N	D	II
10. Auxiliary pools return lines between the isolation valves and terminating points	N	D	NS

Component	Safety Class	Quality Group	Seismic Category
11. Instrument Sensing lines for the following post accident monitoring instruments: IC/PCCS pool water level Spent Fuel Pool water level. Spent Fuel Pool water temperature.	Q	C/D*	I
12: Electrical Module and cables with safety-related function (containment isolation)	Q	NA	I
13: Electrical Module and cables with nonsafety-related function	N	NA	II
14. Control and Instrumentation required for fuel pool cooling. LPCI, SPC and Containment Spray modes of operation	N	NA	I
15. All other FAPCS instrumentation and controls are classified as non-Class 1E	N	NA	II

* - applicable per instrument sensing line size

Table 9.1-4

Classification of Equipment

Principle Component	Safety Designation	Location	QA Requirement	Seismic Category	Notes
Fuel Servicing Equipment	N	FB/RB	E	NS	
Miscellaneous Servicing Equipment	N	FB/RB	E	NS	
RPV Servicing Equipment	N	RB	E	NS/I	
RPV Internal Servicing Equipment	N	RB	E	NS	
Refueling Equipment					
1. Fuel Handling machine	N	FB	E	II	
2. Refueling Machine	N	RB	E	II	
3. Refueling Bellows	N	CV	E	NS	
Fuel Storage Facility					
1. Fuel Storage Racks (new and spent)	N	FB/RB	E	I	
Under RPV Servicing Equipment	N	CV	E	NS	

Table 9.1-4
Classification of Equipment (continued)

Principle Component	Safety Designation	Location	QA Requirement	Seismic Category	Notes
CRD Maintenance Facility	N	RB	E	NS	
Fuel Cask Cleaning Facility	N	RB	E	NS	
Fuel Transfer System	N	RB	E	I/NS	

Table 9.1-5

Reference Codes and Standards

Number	Title
ANS-N14.6	Standard for Special Lifting Devices for Shipping Containers Weighing (5 tons) or More for Nuclear Materials
ANSI B30.9	Slings
ANSI B30.10	Hooks
ANSI B30.2	Performance Standards for Overhead Electric Overhead Traveling Cranes
ANSI B30.16	Performance Standards for Air Wire Rope Hoists
ANSI B30.11	Overhead and Gantry Crane
CMAA70	Specifications for Electric Overhead Traveling Cranes
NUREG-0612	Control of Heavy Loads at Nuclear Power Plants

Table 9.1-6

Heavy Load Equipment Used to Handle Light Loads and Related Refueling Handling Tasks

Handling Operations/Equipment	Applicable Light Load Handling Subsection
Reactor Building Crane	9.1.4.2.2
Fuel Building Crane	9.1.4.2.3
Reactor Vessel Servicing Equipment	9.1.4.2.5
Steam Line Plugs	
Dryer/Separator Strongback	
Head Strongback/Carousel	
In Vessel Servicing Equipment	9.1.4.2.6
Refueling Equipment	9.1.4.2.7- 9.1.4.2.10
Refueling Machine	
Fuel Handling Service Tasks	
Reactor Shutdown Handling Tasks	
Drywell Head Removal	
Reactor Well Servicing	
Reactor Vessel Head Removal	
Dryer and Separator Removal	
Fuel Handling Machine	
Vessel Closure	

Table 9.1-7

Summary of Heavy Load Operations

Hardware Handling Tasks	Handling System	Handling Equipment	Location
RPV OPENING/CLOSING OPERATIONS			
Pool Seal Gates Removal, reinstallation and storage	RB	RB Crane Main or Auxiliary Hoist, Slings and Strongbacks	RF D/SP FSP
Drywell Head Removal, storage and reinstallation	RB	RB Crane Main Hoist, Drywell Head Strongbacks	RF R/W
Reactor Vessel Head Insulation Removal, storage and reinstallation	RB	RB Crane Main Hoist Lifting Sling	RF R/W
Reactor Vessel Head Removal, storage and reinstallation, includes handling stud tensioners studs, nuts, Automatic Tensioning Machine	RB	RB Crane Main Hoist Auxiliary Hoist Automatic Tensioning Machine RPV Head support Pedestal	RF RW
Steam Dryer/Separator Removal, storage and reinstallation. Includes unbolting Separator/Chimney flange joint bolts from Refueling Machine	RB	RB Crane Main Hoist Dryer/Separator Strongback	RW D/SP IRV
Steam & DPV Nozzle Plugs Remote Machine Installation and removal	RB	RB Crane Auxiliary Hoist	RF IRV

Table 9.1-7
Summary of Heavy Load Operations (continued)

Hardware Handling Tasks	Handling System	Handling Equipment	Location
REFUELING OPERATIONS:			
New Fuel:			
Receive at Grade and receipt inspect. Lift to FB floor after removing outer container.	FB	FB Crane Auxiliary Hoist	FB G/F
Remove from inner container and move fuel to new fuel inspection stand. Handle channel and place channel on new fuel bundle.	FB	FB Crane Auxiliary Hoist	NFS NFI
Move new fuel assembly from inspection stand and move load to storage pool and place in spent fuel storage racks.	FB	FB Crane Auxiliary Hoist Fuel Preparation Machine Fuel Handling Machine Auxiliary Hoists Fuel Grapples	NFS FPM FHM RF RVC
Move from pool racks and place in IFTS. Transfer fuel to Reactor Building.	FB/RB	Inclined Fuel Transfer Machine	
Spent Fuel:			
Store new fuel, refuel reactor, and remove spent fuel.	RB	Refueling Machine Auxiliary Hoists Fuel Grapple	RW FSP FCF
Fuel Cask:			
Receive, inspect, lift to fuel building floor. Lower into cask pit. Remove closure head. Move spent fuel to cask pit. Replace closure head and wash cask. Move cask to G/F for shipment.	FB	FB Crane Main Hoist Auxiliary Hoist Fuel Handling Machine Auxiliary Hoists Fuel Grapple	G/F RF FLP

Table 9.1-7
Summary of Heavy Load Operations (continued)

Hardware Handling Tasks	Handling System	Handling Equipment	Location
REACTOR SERVICE OPERATIONS:			
Control Rod Blades Replacement including moving adjacent fuel bundles, and blade guide removal and installation.	RB	Refueling Machine Auxiliary Hoists Fuel Grapple Control Rod Grapple	RVC RV
Fuel Support and Guide Tube (FSGT) (Non-routine) Removal and Replacement.	RB	Refueling Platform Auxiliary Hoists	RVC
UPPER DRYWELL AND MAIN STEAM TUNNEL SERVICING			
MSIVs, DPVs, and SRVs Servicing: SRV removal, installation, and transportation for repair and calibrations from installed location to RCCV entrance and up to special service room area and return.	UDS SRM	Monorail for servicing MSIVs, DPVs and SRVs Monorail Hoist Transportation Cart Hatchway Hoist Wall Mount	UDW RB RB SRM
	MSS	Steam Tunnel Crane Hoist Transportation Cart Hatchway Hoist Wall Mount	MST SRM

Figure 9.1-1. FAPCS Schematic Diagram

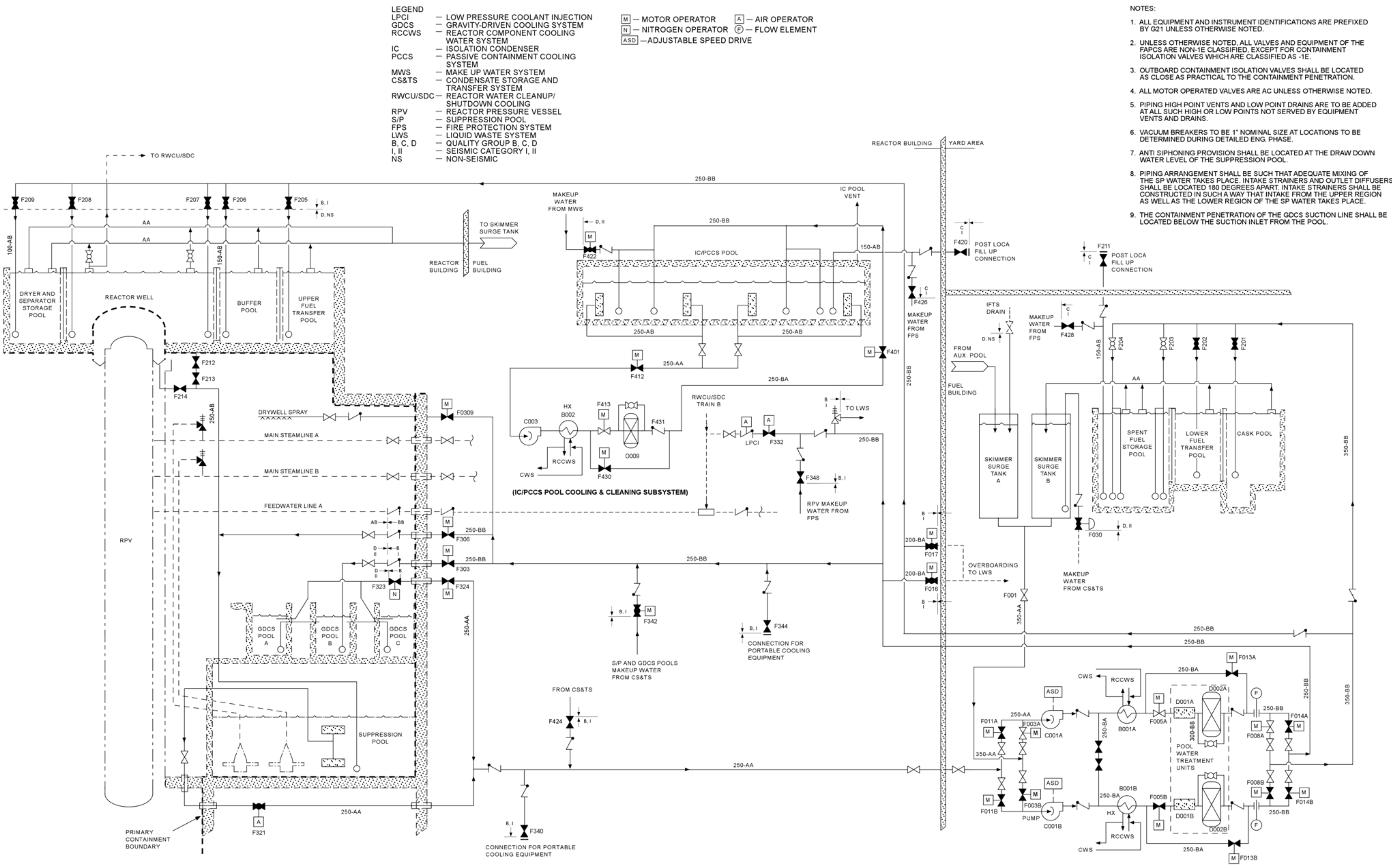


Figure 9.1-2. Inclined Fuel Transfer System

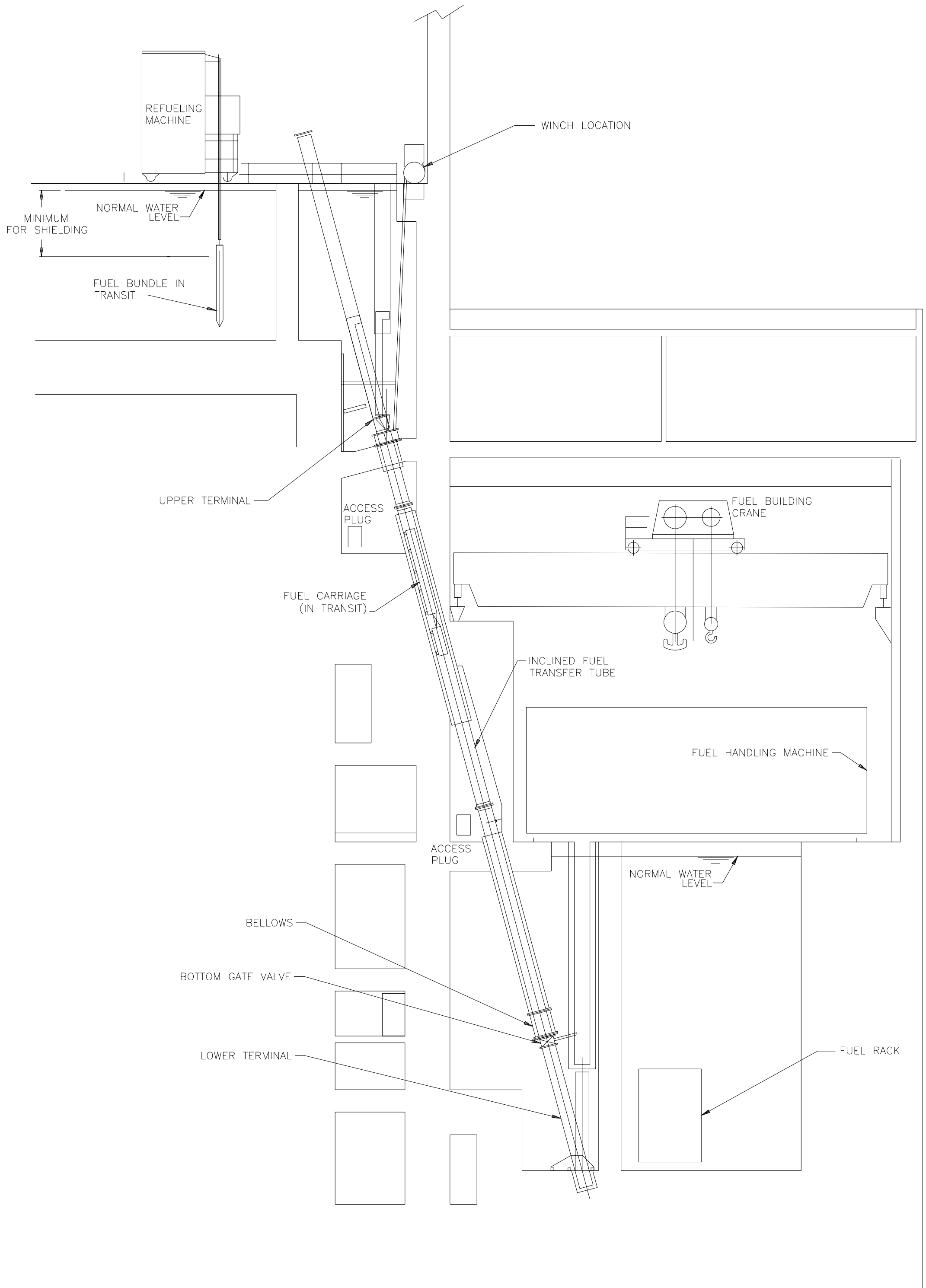
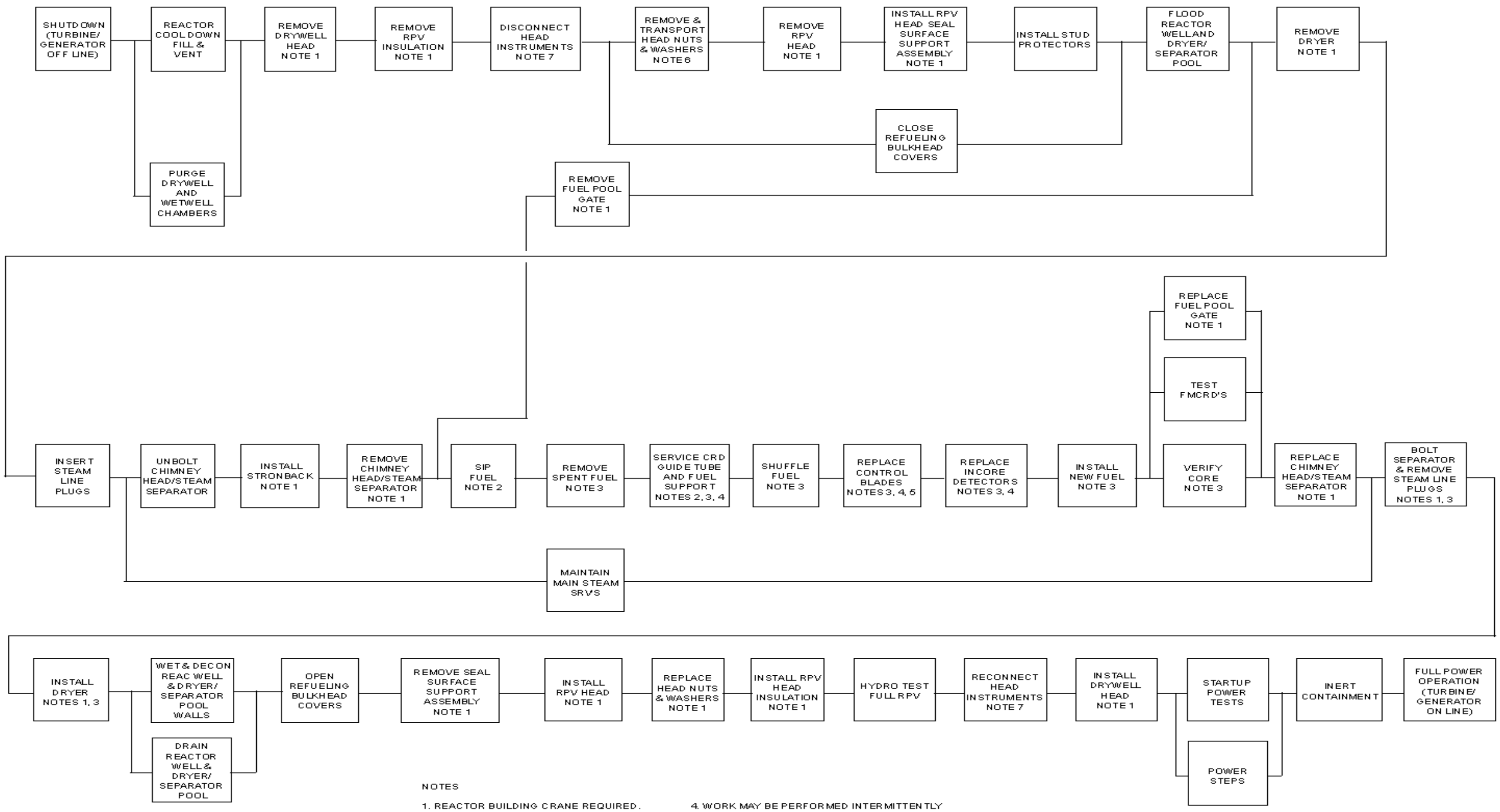


Figure 9.1-3. Refueling Sequence



NOTES

1. REACTOR BUILDING CRANE REQUIRED.
2. ADDITIONAL NON-ROUTINE OPERATION TO BE PERFORMED AS REQUIRED.
3. REFUELING MACHINE REQUIRED OVER REACTOR.
4. WORK MAY BE PERFORMED INTERMITTENTLY WITH MOVING FUEL BUT NOT SIMULTANEOUSLY.
5. TECHNICAL SPEC RESTRICTIONS APPLY.
6. NUTS AND WASHERS STORED ON RPV CAROUSEL
7. INSTRUMENTATION REQUIRED FOR FIRST CYCLE ONLY

9.2 WATER SYSTEMS

9.2.1 Plant Service Water System

9.2.1.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The Plant Service Water System (PSWS) does not perform any safety-related function. There is no interface with any safety-related component. Therefore, there is no safety design basis.

Power Generation Design Bases

The PSWS is designed to provide 100% of the required cooling to the Reactor Component Cooling Water System (RCCWS) and Turbine Component Cooling Water System (TCCWS) heat exchangers.

The PSWS is designed so that neither a single active nor single passive component failure results in a complete loss of nuclear island cooling and/or plant dependence on any safety-related system.

The PSWS is designed for ease of restoration of its function after a component failure without plant operating mode or power level change.

The PSWS is designed to operate during a Loss of Preferred Power (LOPP).

The PSWS is designed for remote operation from the main control room (MCR).

The PSWS pressure in the RCCWS heat exchangers is normally higher than that of the RCCWS to prevent RCCWS contamination of service water.

9.2.1.2 System Description

9.2.1.3 Summary Description

The PSWS rejects heat from nonsafety-related components in the reactor and turbine buildings to the environment.

9.2.1.4 Detailed System Description

The PSWS consists of two independent and 100% redundant open trains that continuously recirculate raw water through the RCCWS and TCCWS heat exchangers. The heat removed is rejected to either the normal power heat sink (NPHS) or to the auxiliary heat sink (AHS) by mechanical draft cooling towers (site specific).

In the event of a LOPP, the PSWS supports the RCCWS in bringing the plant to cold shutdown condition in 36 hours assuming the most limiting single active failure.

The PSWS design heat loads are shown on in Table 9.2-1. The PSWS component design characteristics are shown on in Table 9.2-2. The COL license information requirements for the service water basin are as stated in Section 9.2.9.

Each PSWS train consists of two 50% capacity vertical pumps taking suction in parallel from a plant service water (PSW) basin. Discharge is through a check valve, a self-cleaning duplex

strainer, and a motorized discharge valve at each pump to a common header. Each common header supplies PSW to each RCCWS and TCCWS heat exchanger train arranged in parallel. The PSW is returned via a common header to the mechanical draft cooling tower in each train. Remotely-operated isolation valves and a crosstie line permit routing of the PSW to either cooling tower. The TCCWS heat exchangers are provided with isolation valves for remote operation. Manual balancing valves are provided at each heat exchanger outlet.

The PSWS pumps are located at the plant service water basins. Each pump is sized for 50% of the train flow requirement for normal operation. The pumps are low speed, vertical wet–pit designs with allowance for increase in system friction loss and impeller wear.

Normally, the pumps in each train are powered from redundant electrical buses. During a LOPP, the pumps are powered from the two nonsafety-related standby diesel-generators.

Valves are provided with hard seats to withstand erosion caused by raw water. The valves are arranged for ease of maintenance, repair, and in-service inspection. During a LOPP, the motor-operated valves are powered from the two nonsafety-related standby diesel-generators.

The PSWS cooling towers and PSWS basins are located inside the plant security protected area. Each PSWS train is provided with a separate, multi-celled mechanical draft cooling tower with 50% of the cell fans supplied by one of the redundant electrical buses. During a LOPP, the fans are powered from the two nonsafety-related standby diesel-generators. The adjustable-speed, reversible motor fan units can be controlled for cold weather conditions to prevent freezing in the basin. The mechanical and electrical isolation of the cooling towers allows maintenance, including complete disassembly, during full power operation. The Station Water System provides makeup for blowdown, drift, and evaporation losses fromto the basin. Provision for anti-fouling treatment of the PSWS is provided.

Blowdown from the PSWS basins is by gravity into the main cooling tower basin or directly to the plant waste effluent system.

Operation

During normal operation the primary source of cooling water for the PSWS is the cooling tower makeup pumps, with the PSWS pumps serving as a backup. Heat removed from the RCCWS and TCCWS is rejected to the main cooling tower basin when the cooling tower makeup pumps are in operation. If the PSWS pumps are in operation, the PSWS mechanical draft cooling towers are used to reject the heat removed from RCCWS and TCCWS.

During periods when the required make-up water for the main cooling tower basin is reduced (e.g. winter months) or when the cooling tower makeup pumps are unavailable, the PSWS pumps are the source of cooling water for the RCCWS and TCCWS heat exchangers.

Operation of any two of the four cooling tower makeup or PSWS pumps is sufficient for the design heat load removal in any normal operating mode with the exception of the normal cooldown mode, when three pumps are initially required.

During a LOPP, the running PSWS pumps restart automatically using power supplied by the nonsafety-related standby diesel-generators.

9.2.1.5 Safety Evaluation

The PSWS has no safety-related function. Failure of the system does not compromise any safety-related system or component, nor does it prevent safe shutdown of the plant.

9.2.1.6 Testing and Inspection Requirements

Initial testing of the system includes performance testing of the heat exchangers, cooling towers and pumps for conformance with design heat loads, water flows, and heat transfer capabilities. An integrity test is performed on the system upon completion.

Provision is made for periodic inspection of components to ensure the capability and integrity of the system. The pumps are tested in accordance with standards of the Hydraulic Institute. Testing is performed to simulate all normal modes of operation to the greatest extent practical. Transfer between normal and standby power source is included in the periodic tests.

Motor-operated valves are in-service tested and inspected to improve plant availability.

9.2.1.7 Instrumentation Requirements

The PSWS is operated and monitored from the MCR. The PSWS can also be operated from the remote shutdown panels.

When both pumps in a PSWS train are operating, a low-pressure signal in that train automatically starts both pumps in the redundant train. Motor failure of an operating pump automatically starts the pumps in the redundant train.

Automatically starting one or both pumps in a PSWS train opens a flow path to the RCCWS side of the associated RCCWS heat exchangers.

Loss of electric power to an operating PSWS pump automatically starts the redundant pump in the same train.

The pump discharge strainers have remote manual override features for their automatic cleaning cycle. Pressure drop across the strainer is locally indicated and a high pressure drop is annunciatedalarmed in the control room. Venturi type flow elements are used in the return headers to minimize pressure losses. These flow elements are used to monitor PSWS flow locally and in the MCR and can be used to assist in leak detection.

Supply and return header temperatures and supply header pressure are indicated in the MCR.

9.2.2 Reactor Component Cooling Water System

9.2.2.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The Reactor Component Cooling Water System (RCCWS) does not perform any safety-related function. Therefore, the RCCWS has no safety design basis.

Power Generation Design Bases

The RCCWS is designed to provide cooling water to plant auxiliary equipment during normal power operation, plant cooldown, and shutdown operations. The temperature limits for the cooling water cold leg supplied for equipment cooling are shown in Table 9.2-4.

The RCCWS is designed so that neither a single active nor credible single passive component failure results in a complete loss of active nuclear island cooling and/or plant dependence on any safety-related system.

The RCCWS is designed for ease of restoration after a single component failure without plant operating mode or power level change.

The RCCWS is designed to operate during a Loss of Preferred Power (LOPP).

The RCCWS is designed to limit leakage of radioactive contamination to the environment.

9.2.2.2 System Description

9.2.2.3 Summary Description

The RCCWS provides cooling water to nonsafety-related components in the Reactor Building and provides a barrier against leakage of radioactive contamination of the PSWS.

9.2.2.4 Detailed System Description

The RCCWS consists of two 100% capacity independent and redundant trains.

RCCWS cooling water is continuously circulated through various auxiliary equipment heat exchangers and rejects the heat to the PSWS. The RCCWS heat loads are shown on Table 9.2-3. The RCCWS component design characteristics are shown on Table 9.2-4.

In the event of LOPP, the RCCWS supports the FAPCS and the RWCU/SDC in bringing the plant to cold shutdown condition in 36 hours if necessary assuming the most limiting single active failure. In addition, RCCWS provides cooling water to the Standby On Site Power System Diesel Generators.

Each RCCWS train consists of parallel pumps, parallel heat exchangers, one surge tank, connecting piping, and instrumentation. Both trains share a chemical addition tank. The two trains are normally connected by crosstie piping during operation for flexibility, but may be isolated for individual train operation or maintenance of either train.

The pumps in each train discharge through check valves and butterfly valves to a common header leading to the RCCWS heat exchangers' header. Crosstie lines between each train are provided up and downstream of the heat exchangers; at the pump suction and discharge headers; and downstream of the Radwaste Building cooling water supplies. The heat exchanger outlet isolation valves are automatic. The heat exchanger flow control valves, bypass temperature control valves, and cross-tie isolation valves are pneumatically operated.

RCCWS cooling water is supplied to the following major users:

- Chilled Water System (CWS) Nuclear Island chiller-condenser (Subsection 9.2.7)
- RWCU/SDC non-regenerative heat exchanger (Subsection 5.4.8)

- FAPCS heat exchanger (Subsection 9.1.3)
- Standby On Site AC Power Supply Diesel Generators
- Radwaste Building Equipment

The flow paths to heat exchangers and coolers are provided with flow balancing features that may be fixed orifice plates and/or control or manual valves, which can also be used for isolation. The major heat exchangers and coolers have motor-operated isolation valves for operator convenience.

The RCCWS pumps and heat exchangers are located in the Turbine Building.

RCCWS pumps' and heat exchangers' sizes, capacities, and types are shown in Table 9.2-4. Normally, the pumps in each train are powered from independent buses. During a LOPP, the pumps in either train can be powered from the Standby On Site AC Power System.

The RCCWS utilizes plate type heat exchangers. Leakage through holes or cracks in the plates is not considered credible based on industry experience with plate type heat exchangers. In addition, the heat exchangers are designed such that any gasket leakage from either RCCWS or PSWS will drain to the Equipment and Floor Drain System. This design prevents the potential for cross-contamination of RCCWS by PSWS or PSWS by RCCWS. Pressure and air relief valves are provided as necessary.

Surge tanks provide a constant pump suction head and allow for thermal expansion of the RCCWS inventory. The tanks are located above the highest point in the system. Makeup to the RCCWS inventory is from the Makeup Water System (MWS) through an automatic level control valve. A manual valve provides a backup source of makeup from the Fire Protection System.

System Operation

The RCCWS operates during startup, normal power, hot standby, normal and extended cooldown, shutdown, and LOPP.

RCCWS pump and heat exchanger configuration during each operational mode is shown in Table 9.2-5.

If any of the redundant users requires cooling in addition to the primary users, additional pumps may need to be started.

RCCWS heat exchanger operation is coordinated with PSWS flow. RCCWS cooling water flow through a RCCWS heat exchanger is only allowed if there is a corresponding PSWS water flow to absorb the heat load.

9.2.2.5 Safety Evaluation

The RCCWS has no safety-related function. Failure of the system does not compromise any safety-related system or component, nor does it prevent a safe shutdown of the plant.

There is no interface with the Class 1E electrical system.

9.2.2.6 Testing and Inspection Requirements

All major components are tested and inspected as separate components prior to installation and as an integrated system after installation to ensure design performance. Additional testing details of RCCWS are described in Subsection 14.2.8.1.24.

Provision is made for periodic inspection of major components to ensure the continued capability and integrity of the system. Indicators are provided for vital parameters required for testing and inspection. Provisions for grab sampling of RCCWS cooling water are provided for chemical and radiological analyses.

9.2.2.7 Instrumentation Requirements

The RCCWS is operated and monitored from the Main Control Room (MCR). Major system parameters (loop flow rate, heat exchanger outlet temperature and pressure) are indicated in the MCR. Low pump discharge header pressure, high or low head tank level, and excessive makeup valve opening time are alarmed/annunciated in the MCR.

Local temperature, pressure and level indicators provide additional component performance information.

The RCCWS heat exchanger isolation valves open automatically upon start of the corresponding PSWS flow. Failure of a RCCWS pump automatically starts the standby pump. Failure of one of the electrical buses automatically starts the standby pump(s) in the unaffected train.

9.2.3 Makeup Water System

9.2.3.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The Makeup Water System (MWS) is a nonsafety-related system, and has no safety design basis other than provision for safety-related containment penetrations and isolation valves. As discussed below, if available, the MWS can be used to provide makeup water to the Isolation Condenser / Passive Containment Cooling (IC/PCC) pools following an anticipated operational occurrence (AOO). However, this MWS function is not assumed or modeled in any safety analysis.

Power Generation Design Bases

The MWS is designed to supply demineralized water to the equipment and components shown in Table 9.2-6, and meets the water quality requirements shown in Tables 9.2-7 and 9.2-8. The MWS equipment sizes are shown in Table 9.2-9. The system consists of the following:

- A piping and valve distribution system to deliver demineralized water
- Two makeup water transfer pumps
- A demineralization subsystem
- A demineralized water storage tank

9.2.3.2 System Description

The MWS consists of two subsystems: (1) the demineralization subsystem and (2) the storage and transfer subsystem. The demineralization subsystem is a reference design that is dependent on the site-specific water quality of the available source water. The storage and transfer subsystem is a standard design applicable to any site. The makeup water transfer pumps and the demineralization subsystem are sized to meet the demineralized water needs of all operation conditions except for shutdown/refueling. During the shutdown/refueling mode, the increases in plant water consumption require a temporary demineralization subsystem and temporary makeup water transfer pumps to be used in place of the permanent fixtures.

In the reference design, the MWS major equipment is housed entirely in the Service Water/Water Treatment Building except for the demineralized water storage tank (which is outdoors and adjacent to this building) and the distribution piping to the interface systems. Based on local weather conditions, freeze protection is provided for the demineralized water storage tank and piping exposed to freezing conditions.

The MWS equipment and associated piping in contact with demineralized water are fabricated from corrosion resistant materials such as stainless steel to prevent contamination of the makeup water.

Table 9.2-9 lists the major MWS components.

Demineralization Subsystem

Feedwater to the demineralization subsystem is provided by the pretreatment components of the Station Water System. Production of demineralized water by the demineralization subsystem can be initiated and shut down either manually or automatically based on the demineralized water storage tank level. A chemical addition system is located upstream of the cartridge filters to provide treatment to the pretreated water supplied by the Station Water System. One of the Reverse Osmosis (RO) high-pressure pumps provides the pressure required for flow through the RO unit membranes. The second high-pressure pump is a backup. The RO unit reject flow is sent to the cooling tower blowdown facility. Because of the pressure drop across the RO membranes, product water is temporarily stored in the catch tank before being pumped by one of the forwarding pumps to the mixed bed demineralizer unit. Operation of the RO high-pressure pumps is interlocked with that of the forwarding pumps. The mixed bed demineralizer consists of both strong cation and anion resins in the same vessel that polishes the RO product water. The mixed bed unit effluent is monitored for water quality. This effluent is automatically recirculated to the pretreated source water storage tank until the water quality requirements are met. Makeup water is then delivered to the MWS demineralized water storage tank. The modular design of the RO unit and the mixed bed unit allows continuous demineralized water production. Cleaning, back flushing, or module removal are manual operations based on elevated differential pressure across the module or total flow through the system. No regeneration of mixed bed modules is performed on-site.

Storage and Transfer Subsystem

The flow path of the storage and transfer subsystem of the MWS is from the MWS demineralized water storage tank, through a MWS transfer pump, to the interface systems. One

pump operates continuously to maintain the system pressure. Increased demand or primary transfer pump failure automatically starts the second transfer pump.

9.2.3.3 Safety Evaluation

The MWS does not have any safety-related functions except for containment isolation. Failure of the MWS does not compromise any safety-related system or component nor does it prevent a safe shutdown. If available, MWS can be used to provide makeup water to the IC/PCC pools following an AOO. However, this MWS function is not assumed or modeled in any safety analysis.

9.2.3.4 Testing and Inspection Requirements

Initial preoperational acceptance testing of the MWS is performed to demonstrate proper system and component functioning. MWS operability is continuously demonstrated during normal plant operation. MWS containment isolation components are designed to meet the in-service inspection requirements of ASME Section XI.

9.2.3.5 Instrumentation Requirements

Instrumentation provided for the MWS includes pressure, flow, level, conductivity, silica, chloride, and sodium. These parameters are monitored and recorded at the appropriate locations in the system. Monitoring and control of the MWS operation are provided on a local panel. Monitoring of storage tank water level is provided in the MCR.

Controls and interlocks are provided for the maintenance of MWS water quality and system equipment protection. Demineralizer effluent water quality and quantity is monitored and recorded. Out-of-specification water is automatically recirculated back to the source water storage tank and alarmed on the local control panel. Pumps are protected by a low tank level alarm on the suction side and minimum flow recirculation piping on the discharge side. Automatic controls are provided with manual backup.

9.2.4 Potable and Sanitary Water Systems

This is beyond the ESBWR Standard Plant Scope. Refer to Subsection 9.2.9 for COL license information requirements of Potable and Sanitary Water Systems.

9.2.5 Ultimate Heat Sink

In the event of an accident, the UHS is the atmosphere with the Isolation Condenser / Passive Containment Cooling System (IC/PCCS) pools providing the heat transfer mechanism. Subsection 6.2.2 provides a discussion of the Passive Containment Cooling System. If one individual IC or PCCS pool compartment is not available, the remaining IC/PCCS compartments and expansion pools have reserve capacity for 72 hours of passive heat removal without makeup. External resources, through safety-related emergency makeup water piping, provide makeup water for long-term heat removal. Sufficient reserve capacity is maintained on-site to extend the safe shutdown state from 72 hours through 7 days. The external connection and emergency makeup water piping are part of the Fuel and Auxiliary Pool Cooling System. Subsection 9.1.3.2 provides a description of this piping. The external water source is site dependent and will

described by the COL applicant. Refer to Subsection 9.2.9 for COL information concerning the external water supply.

9.2.6 Condensate Storage and Transfer System

9.2.6.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The Condensate Storage and Transfer System (CS&TS) does not perform or ensure any safety-related function, and thus, has no safety design basis.

Power Generation Design Bases

The Condensate Storage and Transfer System is designed to:

- Operate during plant startup, power operation, and normal shutdown. The system is not required to operate following loss of power or during any design basis event.
- Provide managed storage capacities in the condensate storage tank.
- Provide a distribution system to supply condensate quality water to equipment.
- Provide one transfer pump sized to meet the requirements for filling the Condensate and Feedwater System in approximately 16 hours plus recirculation of a minimum of 25% of the pump capacity.
- Provide a 100% redundant backup transfer pump.
- Provide the capability to maintain the water quality requirements in the Condensate Storage Tank (CST) by pumping tank contents to the Liquid Radwaste System when the Condensate Purification System is not operating.
- Provide an enclosed area to retain any tank overflow or leakage until an appropriate disposal action is taken.
- Provide sampling of the retention area sump prior to disposal to determine if the activity of the sump contents is within 10 CFR 20 limits.

9.2.6.2 System Description

The CS&TS consists of two independent and 100% redundant transfer pumps that take suction from the CST and provide water to interface systems as required. The CST provides storage capacity for condensate rejected from the Condensate and Feedwater System, for condensate quality Liquid Waste Management System effluent during normal operation, and for Condensate and Feedwater System and condenser hotwell inventory during system maintenance outages. The CST also provides a minimum storage capacity for the Control Rod Drive System (CRDS) as a reserve water source for Reactor Pressure Vessel (RPV) makeup following a Nuclear Steam Supply System (NSSS) isolation event. The CS&TS equipment and associated piping are fabricated from stainless steel to prevent contamination of the system water.

Condensate Storage Tank

The CST is the normal source of water for make up to selected plant systems. The condensate transfer pumps take their suction from the CST and provide makeup water for various services in the Reactor Building, the Turbine Building, Fuel Building, and the Radwaste Building.

The makeup water transfer pumps supply makeup to the CST. The CST also acts as surge capacity for the condensate system by receiving rejected condensate from and making up water to the steam makeup-feedwater cycle. The tank overflows to the enclosed retention area. The tank nozzle location for the CRD pumps suction is located at a lower elevation than the nozzles for the condensate transfer pumps and the hotwell makeup line to ensure availability of the water volume reserved for the CRD System. Other water volumes generated during normal, refueling, and maintenance operations, shown in Table 9.2-10, are accommodated through management of the CST water level.

Freeze protection is provided for the CST if required. A basin surrounding the tank is designed to prevent uncontrolled runoff in the event of a tank failure. The enclosed space is sized to contain the total tank capacity. Tank overflow is also collected in this space. A sump is provided inside the retention area with provisions for sampling collected liquids and routing them to the Liquid Waste Management System or the storm sewer as appropriate.

Condensate Transfer Pumps

There are two 100% redundant condensate transfer pumps. One of the two transfer pumps runs continuously to provide condensate quality water as required. Minimum flow recirculation is provided for pump protection.

9.2.6.3 Safety Evaluation

The CS&TS does not perform or ensure any safety-related function. Failure of the system does not compromise any safety-related system or component, nor does it prevent safe shutdown of the plant.

9.2.6.4 Testing and Inspection Requirements

Initial preoperational acceptance testing of the CS&TS is performed to demonstrate proper system and equipment functioning. CS&TS operability is demonstrated by continuous use during normal plant operation. CST grab samples are periodically taken and analyzed to monitor water quality.

9.2.6.5 Instrumentation Requirements

The redundant CS&TS pumps are interlocked to automatically start the standby pump on low discharge header pressure and the trip of an active pump is annunciated in the MCR. High discharge pressure stops the standby pump. Insufficient discharge pressure or low tank level initiates an alarm in the MCR. Level transmitters actuate a MCR alarm and shut off the condensate transfer pumps when the tank level reaches a minimum volume reserved for the CRD system shown on Table 9.2-10. The makeup water control valve level transmitters control the CST water level. An alarm is initiated if the CST level decreases below the level that opens the makeup water valve. An alarm actuates in the MCR if the CST water level increases above the

level that isolates makeup water to the tank. This alarm point is lower than the overflow level. CST level indication is provided in the MCR.

The operating status of the CS&TS components, including CST level and pump header discharge pressure is monitored and indicated locally.

9.2.7 Chilled Water System

The Chilled Water System (CWS) consists of the Nuclear Island Chilled Water Subsystem (NICWS) and the Balance of Plant Chilled Water Subsystem (BOPCWS).

9.2.7.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The Chilled Water System (CWS) does not perform or ensure any safety-related function, and thus, has no safety design basis, except for the containment and isolation valves.

Power Generation Design Bases

The CWS is designed to provide chilled water at 7°C (44.6°F) to the plant facilities equipment at maximum demand. This is based on 35°C (95°F) or less RCCWS and TCCWS cooling water available to the NICWS and BOPCWS condensers respectively.

The CWS is designed to remain functional and capable of supporting normal plant operation when supplied with RCCWS and TCCWS cooling water of up to 37°C (100°F).

The NICWS is designed to operate during a Loss of Preferred Power (LOPP) and can receive power from the on-site diesel-generators.

The CWS is designed to Seismic Category II criteria when located in Seismic Category I buildings to preclude damage to safety-related equipment in a seismic event, except for the containment penetrations and containment isolation valves that are designed to Seismic Category I.

9.2.7.2 System Description

9.2.7.3 Summary Description

The CWS consists of two independent but interconnected subsystems: the NICWS and the BOPCWS. The CWS provides chilled water to the cooling coils of air conditioning units and other coolers in the Reactor Building, Control Building, Turbine Building, Radwaste Building, Service Building, Electrical Building, Fuel Building, Technical Support Center and Hot Machine Shop. The chilled water absorbs the rejected heat from these coolers and is pumped through the chiller-evaporators where the heat is transferred to RCCWS and TCCWS. The CWS consists of four identical chiller units of at least 100% of NICWS capacity.

The CWS component design characteristics are listed in Table 9.2-11. The CWS simplified diagram is shown in Figure 9.2-2 and a more detailed figure is shown in Figure 9.2-3.

9.2.7.4 Detailed NICWS Description

The NICWS consists of two 100% capacity redundant and independent loops (Train A and Train B loops) with crossties between their chilled water piping. The motor operated double isolation valves in the crosstie lines upstream and downstream of the evaporators are normally open. Each loop consists of a chiller unit, including a local control panel, chilled water circulating pump, a surge tank, an air separator, startup strainer, piping, valves, and instrumentation. A bypass line with a flow control valve is provided parallel to the loads. A common chemical feed tank for both loops is installed in parallel with the loads for corrosion inhibitor addition to the chilled water. Each loop is powered from separate buses.

The following units are cooled by the NICWS

- Fuel Building HVAC air handling conditioning units
- Control Building HVAC air handling units
- Reactor Building HVAC air handling units and building supply air units
- Drywell Air Coolers
- RCCWS equipment room HVAC fan coil units in Turbine Building
- Instrument air compressors room HVAC fan coil units in Turbine Building
- NICWS chillers room HVAC fan coil units in Turbine Building, and
- Diesel Generator Switchgear Rooms,
- Diesel Generator Control Room
- Technical Support Center in Electrical Building.

Each NICWS loop consists of a dual centrifugal compressor chiller with pump out unit, oil pump and oil heater. A temperature sensor in the chilled water outlet regulates the output capacity of the chiller by adjusting the compressor inlet guide vanes and/or by turning one of two compressors on or off. The NICWS bypasses chilled water through a flow control valve in response to reduced demand by the air conditioning units. The NICWS condensers are cooled by the RCCWS.

9.2.7.5 Detailed BOPCWS Description

The BOPCWS subsystem consists of one 100% capacity independent loop with crossties between the BOPCWS chilled water piping and both of the NICWS loops. The motor operated double isolation valves in the crosstie lines upstream and downstream of the evaporators are normally open. BOPCWS consists of two water chiller units, including two (one per chiller) local control panel, two chilled water circulating pumps (one per chiller), a surge tank, an air separator, startup strainer, piping, valves, instrumentation, and separate chemical feed tank. The chemical feed tank is installed in parallel to the loads for corrosion inhibitor addition to the chilled water. Each BOPCWS water chiller unit is powered from a separate buses. BOPCWS water chiller units are powered from separate buses than the NICWS water chiller units.

The following units are cooled by the BOPCWS:

- Turbine Building HVAC air handling units, fan coil units, Offgas cooler condenser and building supply air units
- Radwaste Building HVAC air handling units
- Electrical Building HVAC air handling units, and
- Hot Machine Shop HVAC air handling units

The BOPCWS loop consists of two dual centrifugal compressor chillers with pump out unit, oil pump and oil heater. A temperature sensor in the chilled water outlet regulates the output capacity of each chiller by adjusting the compressor inlet guide vanes and/or by turning one of two compressors on or off. The BOPCWS bypasses chilled water through two flow control valves, one per pump/chiller set, in response to reduced demand by the air conditioning units. The BOPCWS condensers are cooled by the TCCWS.

To facilitate control of the BOPCWS, a closed system cooled by the BOPCWS, the Turbine Building Intermediate Chilled Water Subsystem, is installed. This subsystem is comprised of two intermediate heat exchangers (plate type), two intermediate circulating pumps and one surge tank. The Turbine Building Intermediate Chilled Water Subsystem provides chilled water to several Turbine Building HVAC fan coil units.

The components of both chilled water subsystems have the same design features. The following applies to both subsystems:

- The chiller units are packaged designs, including compressor, condenser, evaporator, refrigerant piping, relief valve, instrumentation, controls, and control panel.
- The chiller units lower the chilled water inlet temperature to 7°C (44.6°F). They are capable of operating at partial capacity; varying from less than 25% to 100%.

The surge tanks provide a constant pump suction head and allow for thermal expansion/contraction of the chilled water inventory. The tanks are located a minimum of three feet above the highest system point. Makeup to the chilled water inventory is from the Makeup Water System through an automatic level control valve to the surge tanks.

The BOPCWS loop has an air separator in the chilled water recirculation pump suction with a vent to the surge tank.

System Operation

The CWS remains functional during startup, normal, and shutdown operations. At least one chiller unit is in operation with the others on standby.

The four chiller units come into operation in a staggered manner based on the actual chilled water flow required for the plant as a whole.

The CWS is designed so that failure or malfunction of one loop does not affect system operability. In case of failure the system automatically generates loop isolation signal.

The following actions are required in case of loop isolation signal:

- Closing cross-tie isolation valves
- Startup the chillers and pumps on standby

- Startup air conditioning units of NICWS scope
- Startup the second fans in the Drywell Cooling System

The following events require the automatic loop isolation signal:

- Chilled water leakage exceeding makeup capacity; system leakages are detected by low level signals in surge tanks
- Loss of Preferred Power (LOPP). LOPP signal generates isolation between NICWS loops and BOPCWS loop
- Any other event in the BOPCWS loop that compromises the NICWS loops operability, or vice versa. A loop malfunction is detected by high chilled water flow signal in the other loops

During LOPP, the NICWS is automatically powered from two nonsafety-related on-site diesel generators.

9.2.7.6 Safety Evaluation

The CWS is classified as a nonsafety-related system except for its RCPB and containment isolation functions. Refer to Subsection 6.2.4 for containment isolation valves and to Subsection 7.3.3 for containment isolation instrumentation.

9.2.7.7 Testing and Inspection Requirements

Initial testing of the system includes performance testing of the chillers, pumps and coils for conformance with design heat loads, water flows, and heat transfer capabilities. An integrity test is performed on the system upon completion.

Provision is made for periodic inspection of major components to ensure the capability and integrity of the system. Local display devices are provided to indicate all vital parameters during testing and inspections.

The chillers are tested in accordance with American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Standard 30 (Methods of Testing for Rating Liquid Chilling Packages). The pumps are tested in accordance with standards of the Hydraulic Institute.

The functional capabilities of the containment isolation valves are testable in-place in accordance with the inservice inspection requirements. Such leak test connections are isolatable by two valves in series. Periodic leak testing of the containment isolation valves is prescribed in the Technical Specifications (refer to DCD Chapter 16) and described in Subsection 6.2.6.

Samples of chilled water may be obtained for chemical analyses. The chilled water is not expected to become radioactive.

9.2.7.8 Instrumentation Requirements

The CWS status indications, control instrumentation, alarms and annunciators are located in the MCR to provide the operator sufficient data for remote operation of standby units. The plant-wide multiplexing system provides data communication and control.

The chillers and pumps automatically startup and shutdown according to chilled water flow required by the plant. They can also be manually started from the MCR or from the local chiller control panels. The local control panels display the active component operating status and system parameters including flows, temperatures, and pressures.

Chiller package protective controls and monitoring instruments indicate high and low oil pressure, condenser pressure, high and low chilled water temperature and flow, high and low condenser water temperature, and unit diagnostics.

A CWS standby chiller unit starts automatically upon failure of an operating unit. Loss of chilled water or RCCWS/TCCWS cooling water flow automatically stops the chiller unit and associated chilled water recirculating pump.

The chilled water temperature is automatically controlled.

Protective interlocks prevent chiller start if there is no flow through the evaporator or if the RCCWS/TCCWS flow through the NICWS/BOPCWS condenser is out of range. An anti-recycle timer prevents successive compressor starts.

CWS system containment penetration line isolation valves automatically close on a LOCA signal to control the NICWS flow into and out of the containment (refer to Subsection 6.2.4).

The surge tanks are provided with level controlled demineralized water makeup valves and high/low level alarms in the MCR.

9.2.8 Turbine Component Cooling Water System

9.2.8.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The Turbine Component Cooling Water System (TCCWS) performs or ensures no safety-related function, and thus, has no safety design basis.

There are no connections between the TCCWS and any safety-related systems.

Power Generation Design Bases

The TCCWS provides corrosion-inhibited, demineralized cooling water to all turbine island auxiliary equipment listed in Table 9.2-12.

During power operation, the TCCWS operates to provide a continuous supply of cooling water, at a maximum temperature of 35°C (95°F), to the turbine island auxiliary equipment.

The TCCWS is designed to permit the maintenance of any single active component without interruption of the cooling function.

Makeup to the TCCWS is designed to permit continuous system operation with design failure leakage and to permit expeditious post-maintenance system refill.

The TCCWS includes an atmospheric surge tank located such that the water level in the tank is above any other component in the system.

The TCCWS is designed to have a higher pressure than the power cycle heat sink water to ensure leakage is from the TCCWS to the power cycle heat sink in the event a tube leak occurs within the TCCWS heat exchanger.

9.2.8.2 System Description

9.2.8.3 Summary Description

The TCCWS is a single loop system and consists of one surge tank, one chemical addition tank, two pumps, two heat exchangers connected in parallel, associated coolers, piping, valves, controls and instrumentation. System parameters are shown in Table 9.2-12 and the system configuration is shown in the Figure 9.2-4. Heat is removed from the TCCWS and transferred to the nonsafety-related Plant Service Water System (PSWS) (Subsection 9.2.1).

A TCCWS sample is periodically taken for analysis to assure that the water quality meets chemical specifications.

9.2.8.4 Detailed Description

The system is designed in accordance with Quality Group D specifications.

The chemical addition tank is located in the turbine building in close proximity to the TCCWS pumps.

The TCCWS pumps are 100% capacity each and are constant speed electric motor driven, horizontal centrifugal pumps. The two pumps are connected in parallel with common suction and discharge lines.

The TCCWS heat exchangers are 100% capacity each. The surface area is based on the normal heat loads.

The surge tank is an atmospheric carbon steel tank located at the highest point in the TCCWS. The surge tank is provided with a level control valve to control makeup water addition. The surge tank is located at the highest point in the system and connected to the TCCWS pumps suction header.

System Operation

During normal power operation, one of the two 100% capacity TCCWS pumps circulate corrosion-inhibited demineralized water through one side of one of the two 100% capacity TCCWS heat exchangers in service. The heat from the TCCWS is rejected to the PSWS that circulates water on the other side of the parallel plate TCCWS heat exchangers.

The standby TCCWS pump is automatically started on detection of low TCCWS pump discharge pressure. The standby TCCWS heat exchanger is placed in service manually.

Flow control valves regulate the cooling water flow to the electro-hydraulic control coolers, the turbine lube oil coolers, and the generator hydrogen cooler. Control valves in the cooling water side of these components are throttled in response to temperature signals from the fluid being cooled.

Individual throttling valves located on the cooling water outlet from each unit manually regulate the flow rate of cooling water to all of the other coolers.

The surge tank provides a reservoir for small amounts of leakage from the system and for the expansion and contraction of the cooling fluid with changes in the system temperature. The surge tank is connected to the system in the pump suction lines to ensure that adequate NPSH for the TCCWS pumps is available.

A level control valve that is actuated by sensing the surge tank level automatically controls demineralized makeup water to the TCCWS. A corrosion inhibitor is manually added to the system by means of the chemical addition tank.

9.2.8.5 Safety Evaluation

The TCCWS has no safety design basis and does not perform any safety-related function. Failure of the TCCWS does not affect any safety-related systems or components.

9.2.8.6 Tests and Inspections

All major components are tested and inspected as separate components prior to installation and as an integrated system after installation to ensure design performance.

The components of the TCCWS and associated instrumentation are accessible during plant operation for visual examination. Periodic inspections during normal operation are made to ensure operability and integrity of the system. Inspections include measurements of cooling water flows, temperatures, pressures, water quality, corrosion-erosion rate, control positions, and setpoints to verify the system condition.

9.2.8.7 Instrumentation Application

Pressure and temperature indicators are provided as required for testing and balancing the system. Flow indicator taps are provided at strategic points in the system for initial balancing of the flows and verifying flows during plant operation.

Surge tank high and low level and TCCWS discharge pressure alarms are transmitted to the MCR from the TCCWS local control panels.

Makeup flow to the TCCWS surge tank is initiated automatically on low surge tank level and is continued until the normal level is reestablished.

Provisions for taking TCCWS water samples are included.

9.2.9 COL Information

9.2.9.1 Cooling Water Systems

The design of the ESBWR Reference Plant cooling water systems is based on bounding ambient environmental conditions as defined in Chapter 2.0 as well as generic BWR water quality requirements. Based on actual site conditions, the COL applicant will provide the design of all of the cooling water systems, including, but not limited to, the following parameters:

- Main Condenser configuration (once through versus series water boxes)
- System configurations (once through versus closed loop) and materials
- Heat rejection facilities (natural draft versus mechanical cooling towers)

- Heat removal capacities of cooling water systems
- Performance characteristics of cooling water system components
- Cooling system makeup and blowdown capacities
- Service water basin, or other site-specific water supply.

The reference plant required cooling capacity is provided in Subsection 9.2.1. The required capacity for fire protection is provided in Subsection 9.5.1.

9.2.9.2 Station Water System

The COL applicant will provide the design of a station water system to provide makeup for the Cooling Water Systems, Makeup Water System and Potable Water System.

9.2.9.3 Ultimate Heat Sink Water Source

The COL applicant will identify the external water resource and procedures to use the resource as an emergency makeup water supply to the IC pools and fuel pools following an accident.

9.2.9.4 Potable and Sanitary Water System

The COL applicant will provide the design of the potable and sanitary water system that provides sufficient supply is designed to provide a minimum of 12.6 l/s (200 gpm) of potable water during peak demand periods.

9.2.9.5 Sanitary Waste Discharge Systems

The COL applicant will provide design of wastewater effluent systems that properly disposes of cooling system tower blowdown, and sanitation wastes.

9.2.10 References

None.

Table 9.2-1

PSWS Heat Loads

Normal Operation		
Trains A and B		
RCCW System:	30.8 MW	1.05 x 10^8 Btu/h
TCCW System:	54.0 MW	1.84 x 10^8 Btu/h
Total Trains A and B:	84.8 MW	2.90 x 10^8 Btu/h
Normal Cooldown		
Trains A and B		
RCCW System:	85.8 MW	2.93 x 10^8 Btu/h
TCCW System:	26.0 MW	8.88 x 10^7 Btu/h
Total Trains A and B:	111.8 MW	3.82 x 10^8 Btu/h

Table 9.2-2

PSWS Component Design Characteristics

PSWS Pumps	
Type	Vertical, wet-pit, centrifugal turbine
Quantity	4
Capacity Each	1.262 m^3/s (20000 gpm)
Total Discharge Head	As required by the system design layout
Motor Size	As required by the system design layout
PSWS Cooling Towers and Basins (Conceptual Design Only –– Site Specific Portion of PSWS)	
Type	Mechanical draft, multi-cell, redundant dual speed, reversible fans
Quantity	2
Heat Load Each*	88 MW (3.20 x 10^8 BTU/h)
Flow Rate (Water)	2.524 m^3/s (40000 gpm)
Ambient Wet Bulb Temperature	27.2°C (81°F)
Approach Temperature	3.9°C (7°F)
Cold Leg Temperature	31.1°C (88°F)
Strainers	
Type	Automatic cleaning, duplex, basket
Quantity	4

* - This worst-case heat load occurs during a Single Train Failure with a Loss of Preferred Power.

Table 9.2-3

RCCWS Nominal Heat Loads

Table 9.2-3

RCCWS Nominal Heat Loads

Normal Operation		
Nominal Heat Load Contributions		
RWCU/SDC:	9.6 MW	32.8 MBtu/h
FAPCS:	8.6 MW	29.4 MBtu/h
CWS:	8.6 MW	29.4 MBtu/h
Radwaste Building	2.1 MW	7.2 MBtu/h
Diesel Generator	0 MW	0 MBtu/hr
Other:	1.9 MW	6.6 MBtu/h
Total Trains A & B:	30.8 MW	105 MBtu/h
Normal Cooldown		
Nominal Heat Load Contributions (Train A)		
RWCU/SDCS:	28 MW	95.6 MBtu/h
FAPCS:	8.6 MW	29.4 MBtu/h
CWS:	8.6 MW	29.4 MBtu/h
Radwaste Building	2.1 MW	7.2 MBtu/h
Diesel Generator A	0 MW	0 MBtu/hr
Total Train A:	47.3 MW	161 MBtu/h
Nominal Heat Load Contributions (Train B)		
RWCU/SDC:	28 MW	95.6 MBtu/h
FACPS	8.6 MW	29.4 MBtu/h
Diesel Generator B	0 MW	0 MBtu/hr
Total Train B:	36.6 MW	125 MBtu/h
Other:	1.9 MW	6.6 MBtu/h
Total Train A&B:	85.8 MW	293 MBtu/h
Cooldown with LOPP		
Nominal Heat Load Contributions (Train A)		
RWCU/SDC:	28 MW	95.6 MBtu/h
FAPCS:	8.6 MW	29.4 MBtu/h

Table 9.2-3

RCCWS Nominal Heat Loads

CWS:	8.6 MW	29.4 MBtu/h
Radwaste Building	2.1 MW	7.2 MBtu/h
Diesel Generator A	14.3 MW	48.8 MBtu/hr
Total Train A:	61.6 MW	210 MBtu/h
Nominal Heat Load Contributions (Train B)		
RWCU/SDC:	28 MW	95.6 MBtu/h
FACPS	8.6 MW	29.4 MBtu/h
Diesel Generator B	14.3 MW	48.8 MBtu/hr
Total Train B:	50.9 MW	174 MBtu/h
Other:	1.9 MW	6.6 MBtu/h
Total Train A&B:	114 MW	390 MBtu/h
Single Failure Cooldown (Extended Cooldown)		
Nominal Heat Load Contributions (Train A or B)		
RWCU/SDC:	36 MW	123 MBtu/h
FAPCS:	8.6 MW	29.4 MBtu/h
CWS:	8.6 MW	29.4 MBtu/h
Radwaste Building	2.1 MW	7.2 MBtu/h
Diesel Generator	0 MW	0 MBtu/hr
Other:	1.9 MW	6.5 MBtu/h
Total Train A or B:	57.2 MW	195 MBtu/h
Single Failure Cooldown w/ LOPP		
Nominal Heat Load Contributions (Train A or B)		
RWCU/SDC:	36 MW	123 MBtu/h
FAPCS:	8.6 MW	29.4 MBtu/h
CWS:	8.6 MW	29.4 MBtu/h
Radwaste Building	2.1 MW	7.2 MBtu/h
Diesel Generator	14.3 MW	48.8 MBtu/hr
Other:	1.9 MW	6.5 MBtu/h
Total Train A or B:	71.5 MW	244 MBtu/h

Table 9.2-4

RCCWS Component Design Characteristics

Pumps	
Type	Horizontal, split case, single stage, centrifugal
Quantity	6
Capacity each	1,250 m^3/h (5,504 gpm)
Total Discharge Head	As required by the system design and layout
Motor Size	186 kW (250 hp)
Heat Exchangers	
Type	Horizontal Plate
Quantity	6
Cooling Capacity (Nominal)	30.56 MW (104.3 MBtu/h)
RCCWS Flow per Unit	1,250 m^3/h (5,504 gpm)
Maximum Operating RCCWS Cold Leg Supply Temperature	35°C (95°F)
Minimum Operating RCCWS Cold Leg Supply Temperature	15°C (59°F)
Maximum Operating PSWS Cold Leg Temperature	31.1°C (88°F)
Material (Plates)	Titanium or Stainless Steel*

*Site specific water quality is used to determine the material portion of Heat Exchangers

Table 9.2-5

RCCWS Configuration by Mode

Operation Mode	No. Train A Pumps Used	No. Train B Pumps Used	No. Train A HX Used	No. Train B HX Used	Total No. Pumps Used	Total No. HX Used	Total Cooling Water Flow
Normal Operation	1	1	1	1	2	2	11,007 gpm (2,500 m^3/hr)
Normal Cooldown	2	2	2	2	4	4	22,014 gpm (5,000 m^3/hr)
Cooldown w/ Single Failure of Train A	0	2	0	2	2	2	11,007 gpm (2,500 m^3/hr)
Cooldown w/ Single Failure of Train B	2	0	2	0	2	2	11,007 gpm (2,500 m^3/hr)
Cooldown w/ Single Failure of Train A w/ LOPP	0	3	0	3	3	3	16,511 gpm (3,750 m^3/hr)
Cooldown w/ Single Failure of Train B w/ LOPP	3	0	3	0	3	3	16,511 gpm (3,750 m^3/hr)
Normal Cooldown w/ LOPP	3	3	3	3	6	6	33,022 gpm (7,500 m^3/hr)

Table 9.2-6

Makeup Water System Supplied Equipment

The Makeup Water System provides water for the following:	
1	CST makeup
2	Standby Liquid Control System makeup
3	Liquid Waste System chemical addition and line flushing
4	Solid Waste System for line flushing
5	Reactor Component Cooling Water System makeup
6	Turbine Component Cooling Water System makeup
7	Chilled Water System makeup
8	Process Sampling System process use
9	Auxiliary Boiler System makeup
10	Post Accident Sampling Station flushing
11	HVAC makeup
12	Miscellaneous uses
13	IC/PCC Pool normal makeup water

Table 9.2-7

Makeup Water System Demineralized Water Storage Tank Nominal Water Quality Requirements

Water Quality Parameter		**Operating Target**	**System Design**	**Maximum Value**
Chloride (PPB as Cl)		2.5	4.0	25.0
Sulfate (PPB as SO_4)		2.5	4.0	25.0
Conductivity* at 25°C (µS/cm)		0.080	0.095	1.0
Dissolved Oxygen (PPB as O_2)		5.0	10.0	20.0
Silica (PPB as SiO_2)		5.0	10.0	50.0
pH at 25°C	Minimum	6.7	6.5	6.0
	Maximum	7.3	7.5	8.0
Corrosion Product Metals				
Iron (PPB as Fe)		8.0	8.0	80.0
Copper (PPB as Cu)		1.0	1.0	10.0
All Other Metals (PPB as the metal)		1.0	1.0	10.0
Total Metals (PPB as the metal)		10.0	10.0	100.0
Organic Impurities** (equivalent ΔK (µS/cm)		0.2	0.4	2.0

* Does not include an incremental conductivity value of 0.8 µS/cm at 25°C caused by carbon dioxide from air in water stored in tanks open to the atmosphere.

** Organic impurity values apply to fresh makeup water stored in the makeup water storage tank.

Table 9.2-8

Makeup Water System Demineralizer Effluent Nominal Water Quality Requirements

Water Quality Parameter		Operating Target	System Design	Maximum Value
Demineralizer Effluent				
Chloride (PPB as Cl)		1.0	2.0	10.0
Sulfate (PPB as SO_4)		1.0	2.0	10.0
Conductivity at 25°C (µS/cm)		0.065	0.075	0.20
Dissolved Oxygen (PPB O_2)		5.0	10.0	20.0
Silica (PPB as SiO_2)		1.0	2.0	10.0
pH at 25° C	Minimum	6.7	6.5	6.0
	Maximum	7.3	7.5	8.0
Corrosion Product Metals				
Iron (PPB as Fe)		4.0	8.0	40.0
Copper (PPB as Cu)		0.5	1.0	5.0
All Other Metals (PPB as the metal)		0.5	1.0	5.0
Total Metals (PPB as the metal)		5.0	10.0	50.0
Organic Impurities (Equivalent ΔK (µS/cm)		0.2	0.4	2.0

Table 9.2-9

Major Makeup Water System Components

Two 5-micron cartridge filters, each rated 1,999 l/min (528 gpm).
Two reverse osmosis (RO) high-pressure pumps, each rated at 1,999 l/min (528 gpm).
One RO unit rated at 1,499 l/min (396 gpm). This unit consists of multiple modules.
One chemical treatment system that provides pretreatment and membrane cleaning specific to the RO membrane type.
One RO product water catch tank with two 1,499 l/min (396 gpm) product forwarding pumps.
One 1,499 l/min (396 gpm) mixed bed demineralizer unit consisting of multiple modules.
One 950 m^3 (250,963 gal) demineralized water storage tank.
Two 1,249 l/min (330 gpm) makeup water transfer pumps.

Table 9.2-10

Capacity Requirements for the Condensate Storage Tank

Function	Capacity Required	Time Period
Storage capacity to drain the Condensate and Feedwater System and the condenser	2,960 m^3 (781,950 gal)	Maintenance outages
Condensate quality water reclaimed from LWS	270 m^3/day (71,326 gal per day)	Normal operations; Maintenance outages
Dedicated volume for Control Rod Drive System following a NSSS isolation event*	948 m^3 (250,435 gal)	Normal operations
Total CST capacity	4885 m^3 (1,290,480 gal)	N/A

* The alarm level volume includes the volume required for transients and for the Control Rod Drive System following a NSSS isolation event.

Table 9.2-11

Chilled Water System Component Design Characteristics

CWS Chiller Units	
Quantity	4
Cooling capacity (each)	~7.8 x 10^6W (26.62 x 10^6 Btu/h) *
Condensers	
Flow Rate	1700 m^3/hr (7500 gpm)
Inlet Water Temperature	35°C (95°F)
Outlet Water Temperature	40°C (104°F)
Evaporators	
Flow Rate	960 m^3/hr (4200 gpm)
Inlet Water Temperature (CW)	7°C (44.6°F)
Outlet Water Temperature (CW)	14°C (57.2°F)
Compressors	
Type	Centrifugal, dual, electric motor driven
Power	2 x 850 kW (2.9 x 10^6 Btu/hr)
Circulating Pumps	
Quantity	4
Type	Centrifugal
Flow	1000 m^3/hr (4400 gpm)
Head	60 m (196 ft)
Motor horsepower	280 kW (0.96 x 10^6 Btu/hr)
Surge tanks	
Quantity	3
Type	Vertical, cylindrical
Piping	
Material (NICWS)	Carbon Steel
Material (BOPCWS)	Carbon Steel

Table 9.2-11
Chilled Water System Component Design Characteristics (continued)

Turbine Building Intermediate Chilled Water Subsystem		
Intermediate Circulating Pumps		
	Quantity	2
	Type	Centrifugal
	Flow	1200 m^3/hr (5300 gpm)
	Head	50 m (160 ft)
	Motor horsepower	300 kW (1.0 x 10^6 Btu/hr)
Intermediate Heat Exchangers		
	Quantity	2
	Type	Plate and frame
	Duty	11,500 kW (3.9 x 10^6 Btu/hr)
Intermediate Surge Tank		
	Quantity	1
	Type	Vertical, cylindrical
Intermediate Subsystem Piping		
	Material	Carbon Steel

*. The CWS cooling capacity and other CWS component design characteristics are site dependent. The chiller unit cooling capacity and other CWS component design characteristics are indicative and correspond to CWS chilled water load of 18,275 kW.

Table 9.2-12

Turbine Component Cooling Water System Heat Loads

The TCCWS removes heat from the following components:		
–	Balance of Plant chiller condensers	
–	Generator stator cooling water heat exchangers, Generator hydrogen coolers, Hydrogen seal oil coolers and Exciter coolers	
–	Main turbine lube oil coolers	
–	Mechanical vacuum pump cooler	
–	Iso-phase bus cooler	
–	Electro-hydraulic control system coolers	
–	Reactor feed pump motor coolers and ASD feed pump	
–	Condensate pump motor coolers	
–	Service air compressor intercoolers and aftercoolers	
System parameters*		
	Heat removal capacity	54 MW (184.3E6 BTU/hr)
	System flow	2.6 m^3/s (41210 gpm)

* System parameters are site dependent. Values quoted above are for reference purposes only.

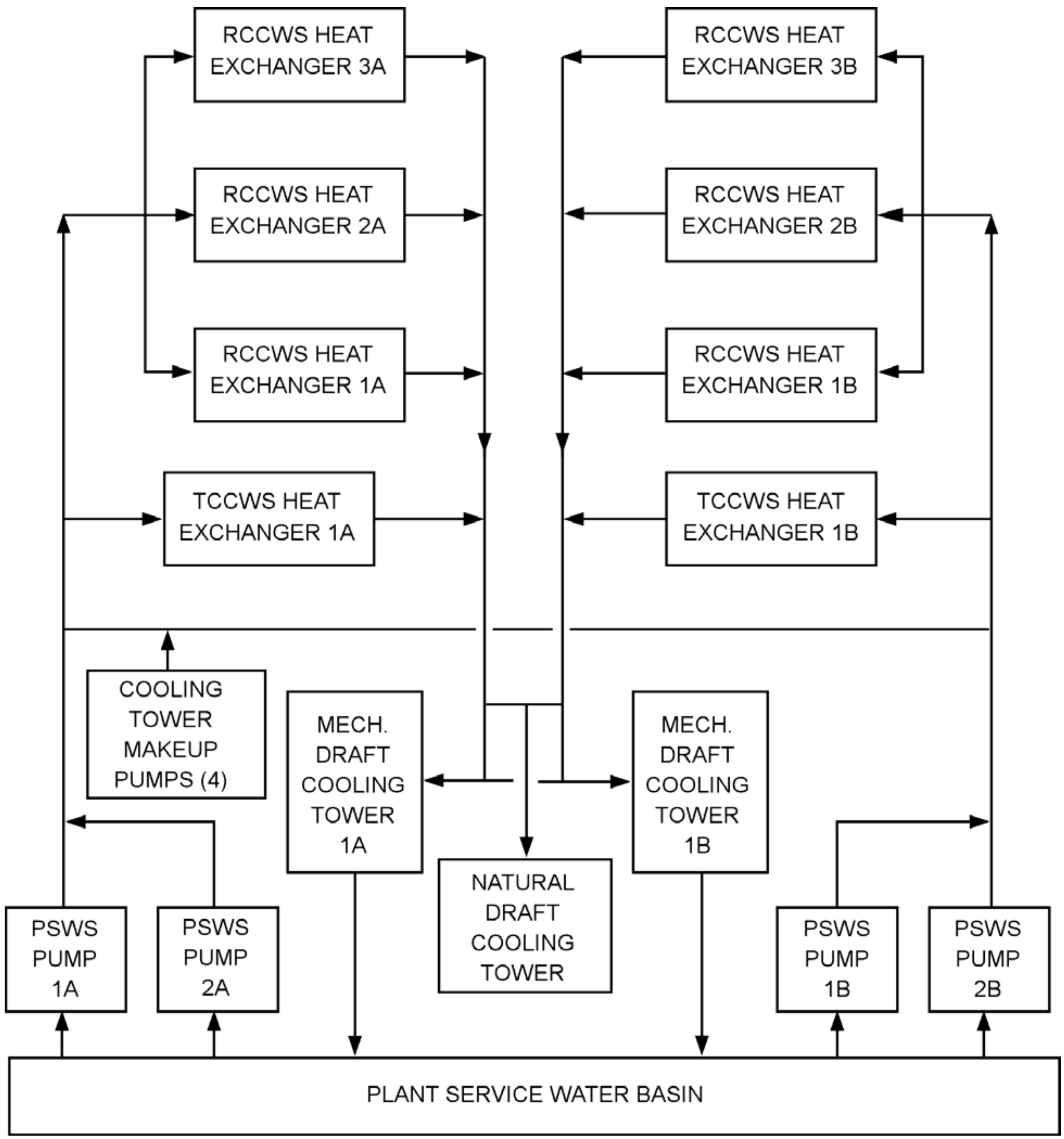


Figure 9.2-1. Plant Service Water System Simplified Diagram

Figure 9.2-2. Chilled Water System Simplified Diagram

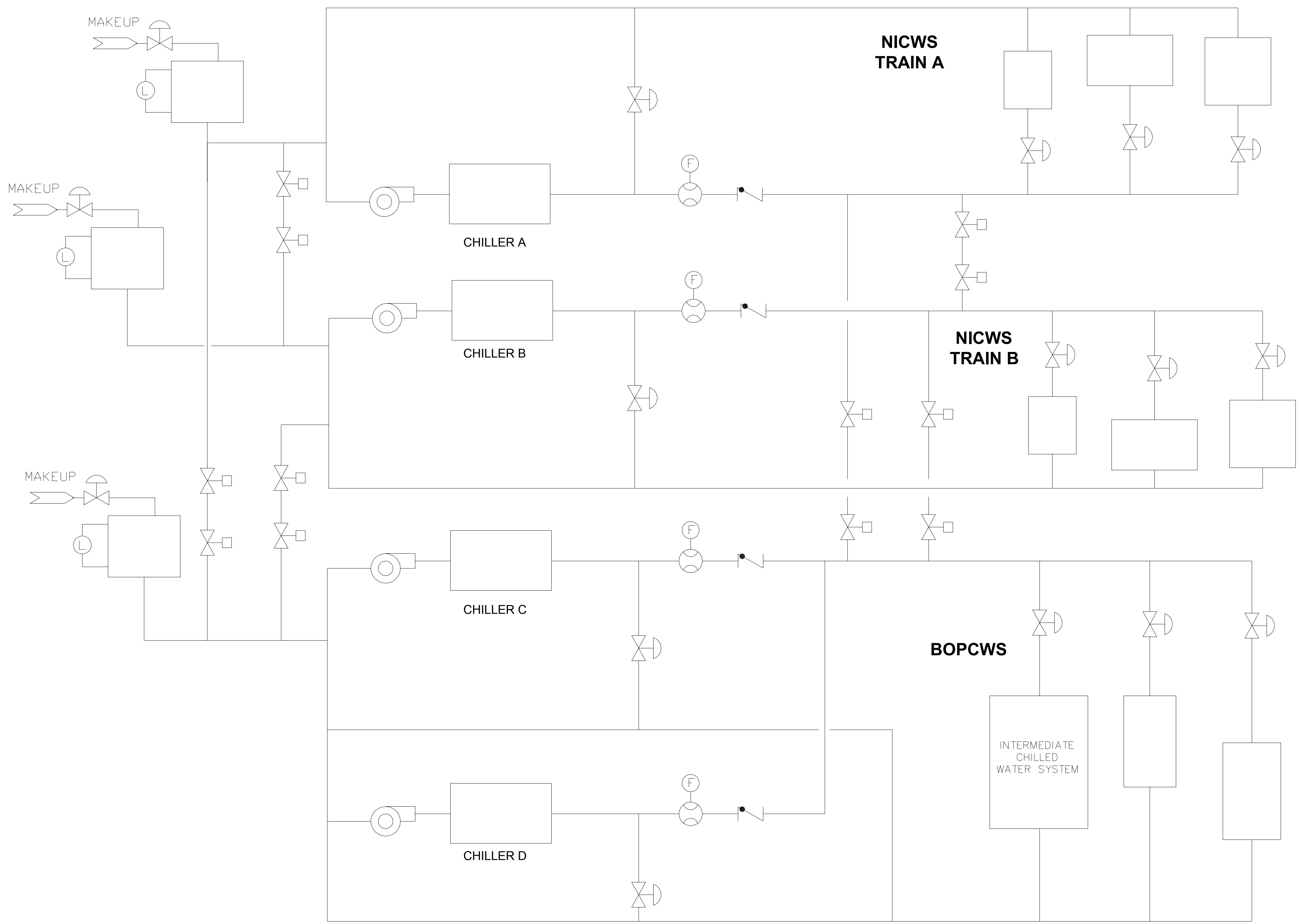


Figure 9.2-3. Chilled Water System Sheet 1 of 6

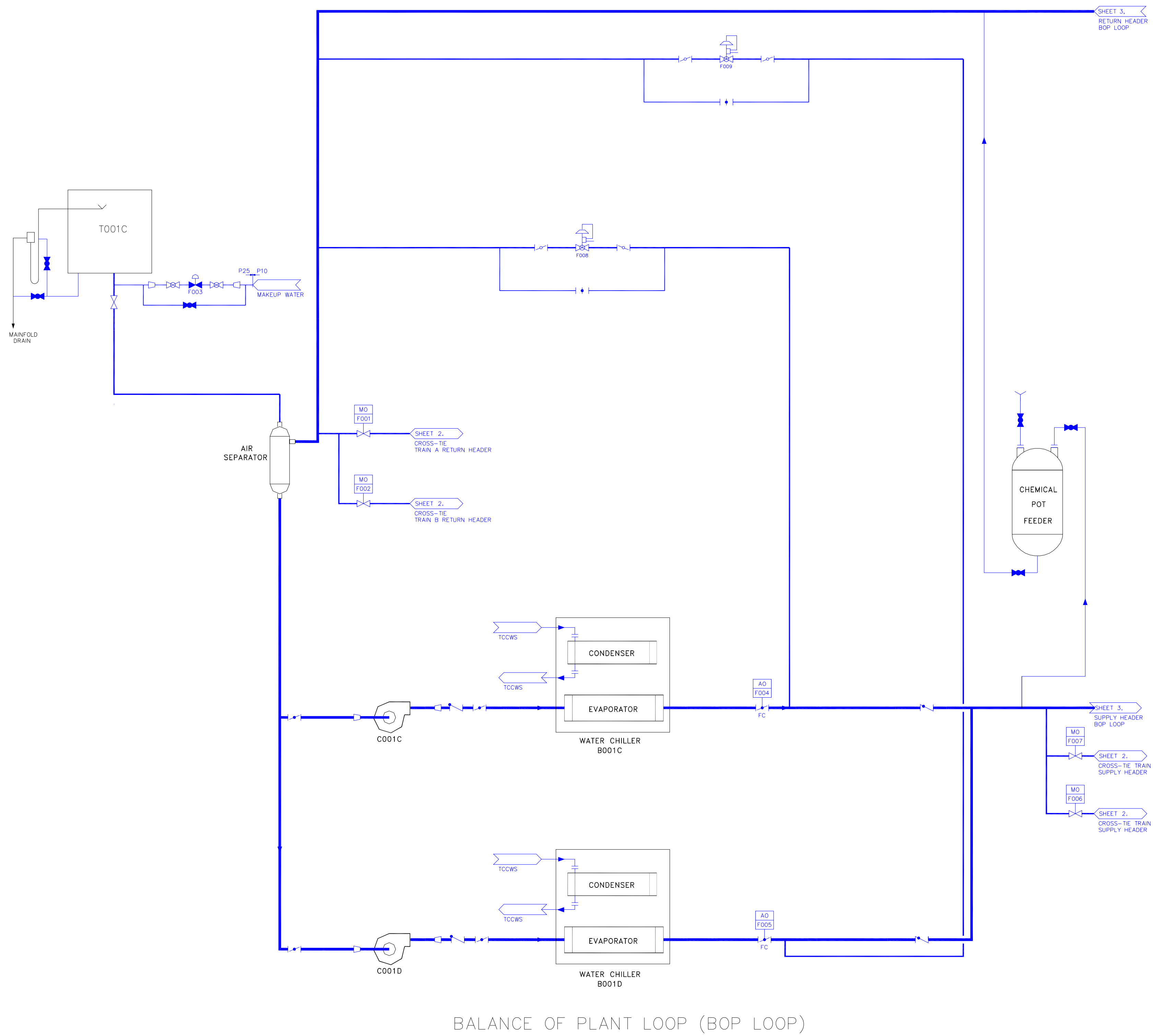


Figure 9.2-3. Chilled Water System Sheet 2 of 6

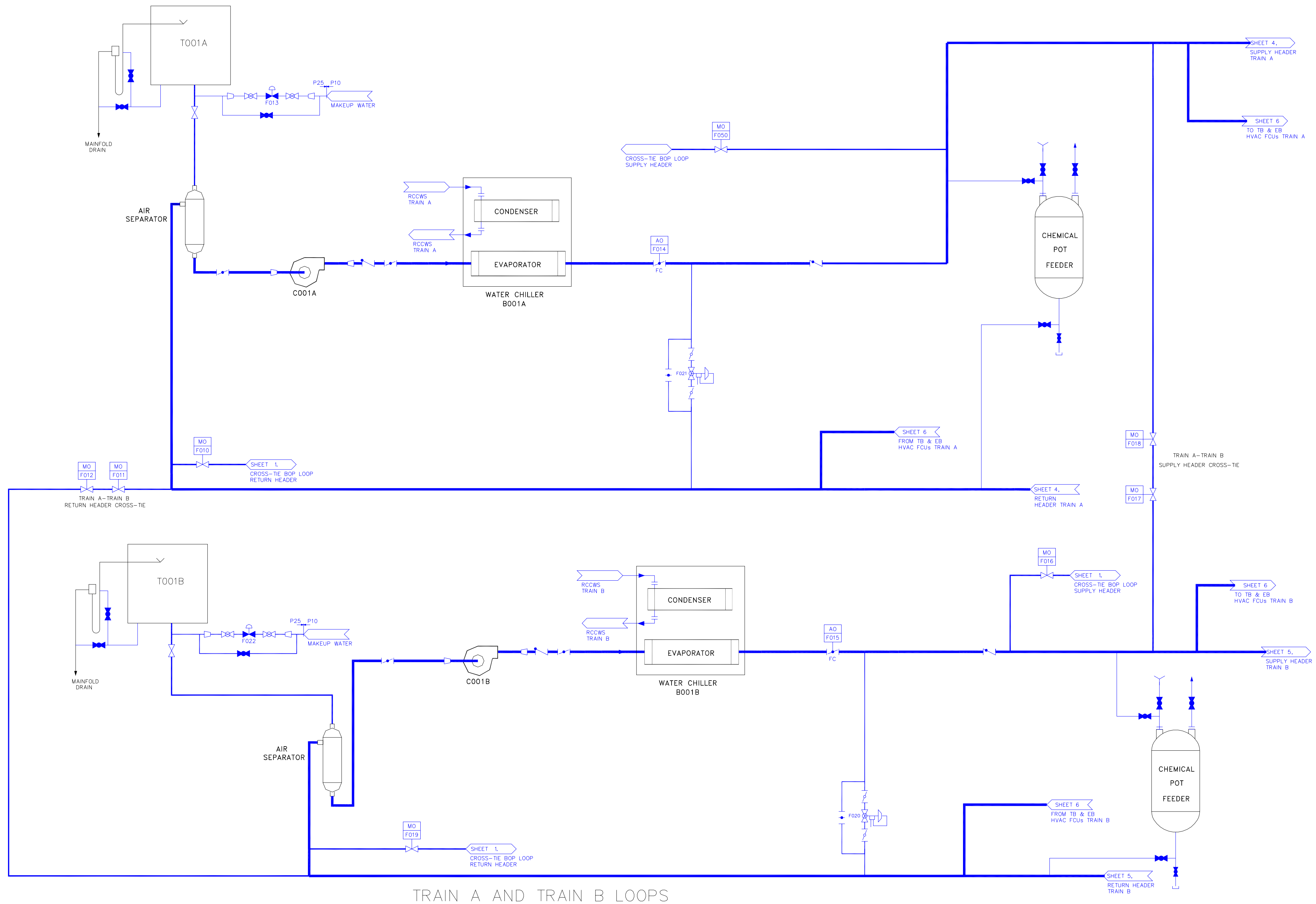


Figure 9.2-3. Chilled Water System Sheet 3 of 6

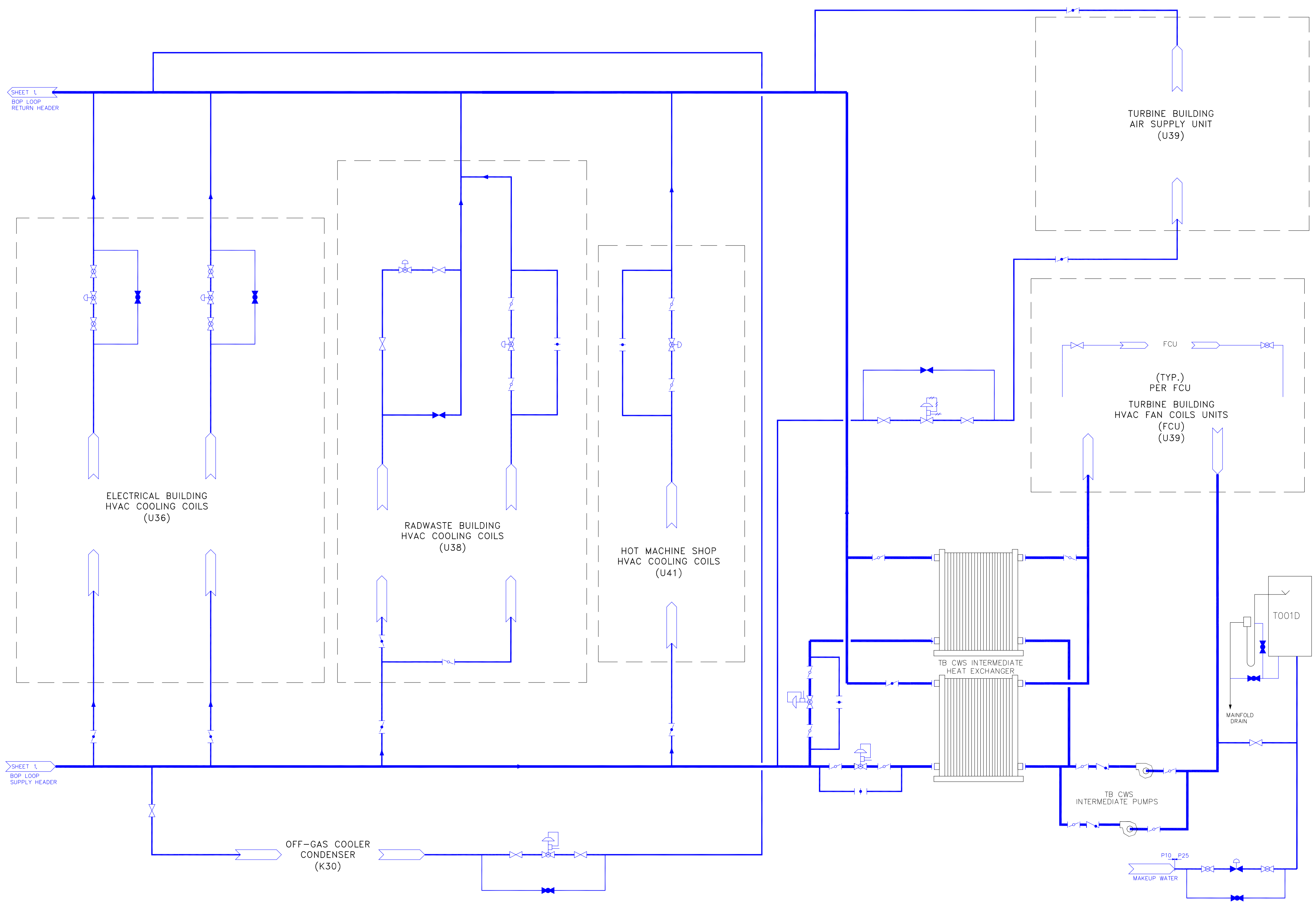


Figure 9.2-3. Chilled Water System Sheet 4 of 6

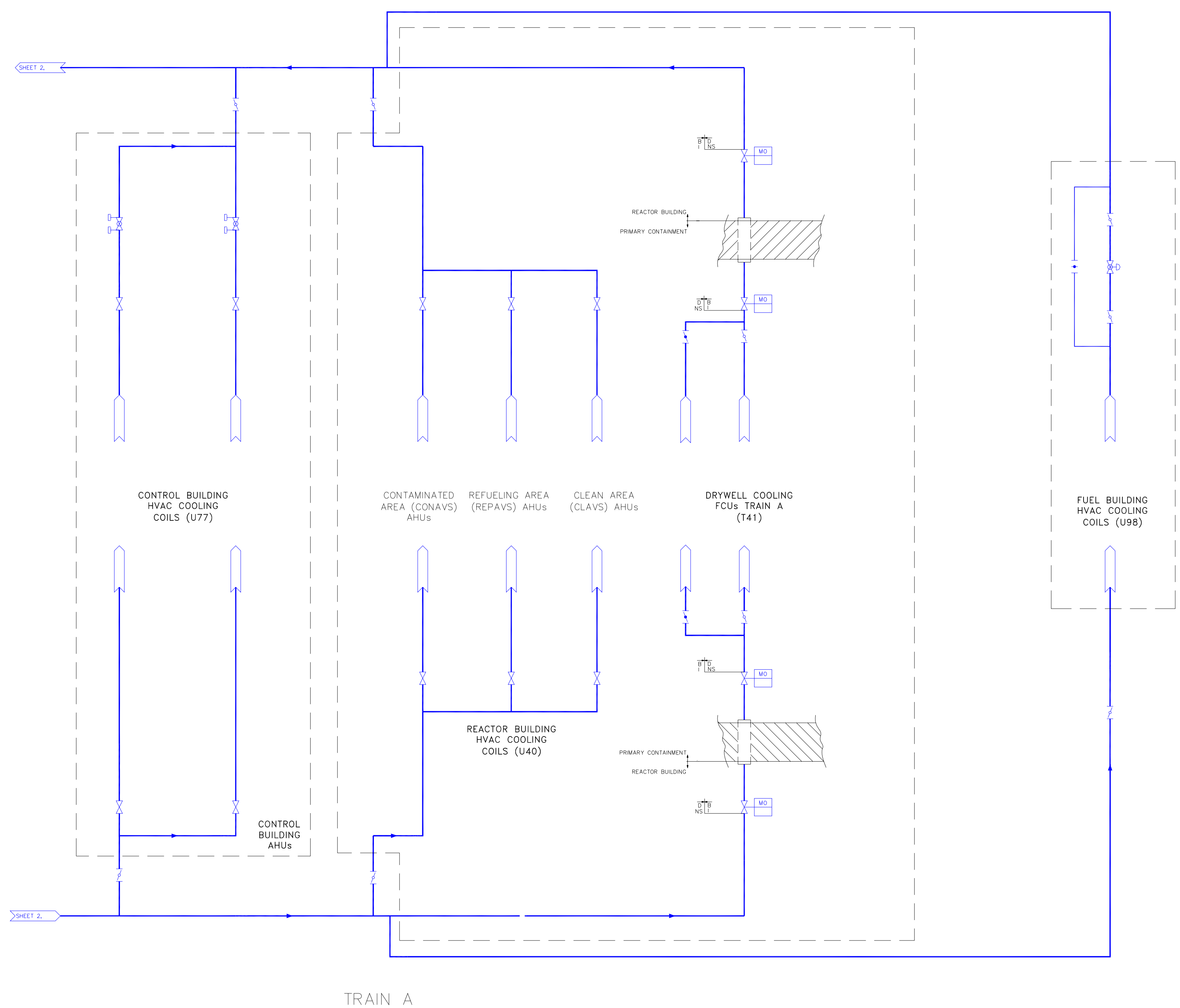


Figure 9.2-3. Chilled Water System Sheet 5 of 6

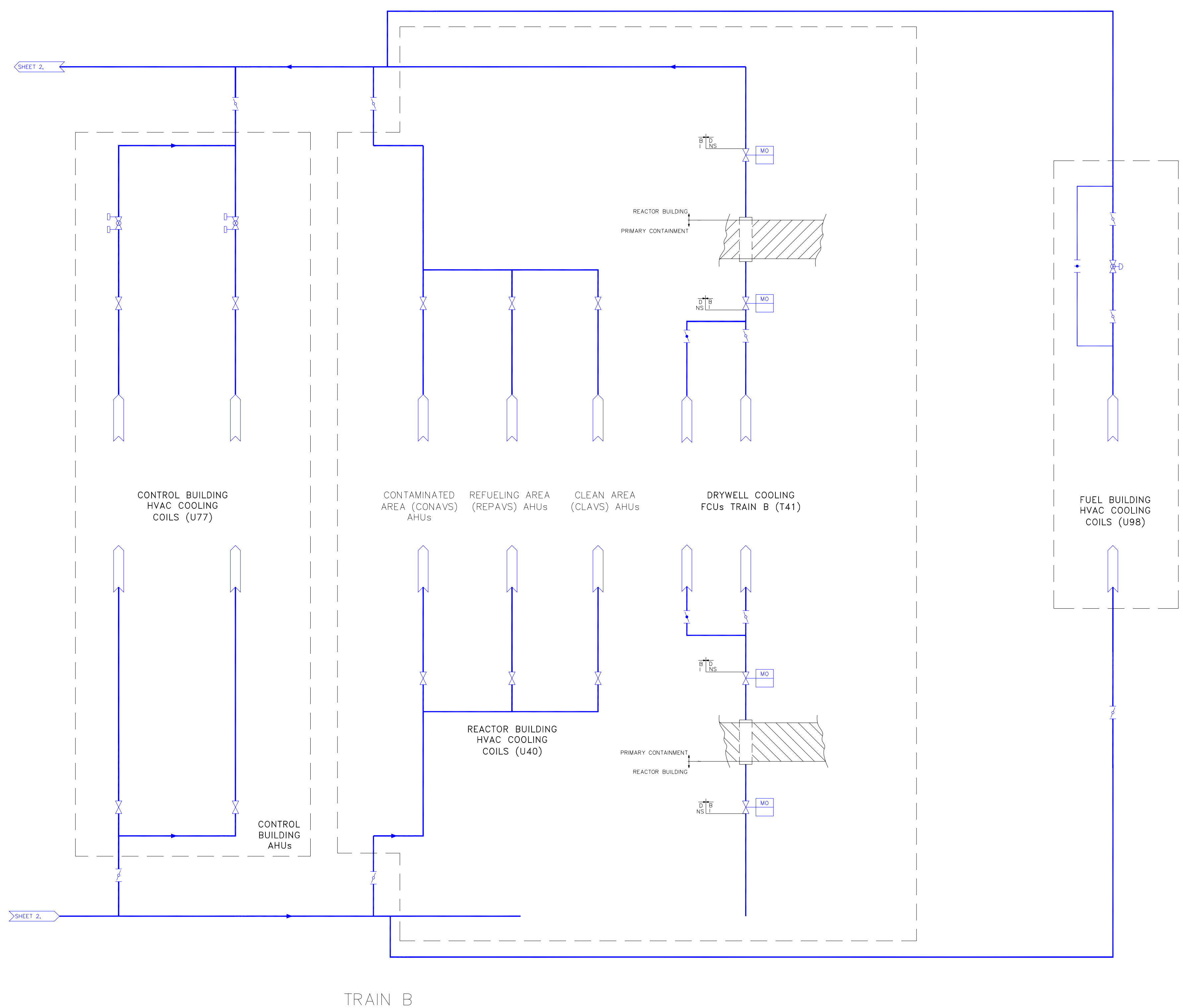


Figure 9.2-3. Chilled Water System Sheet 6 of 6

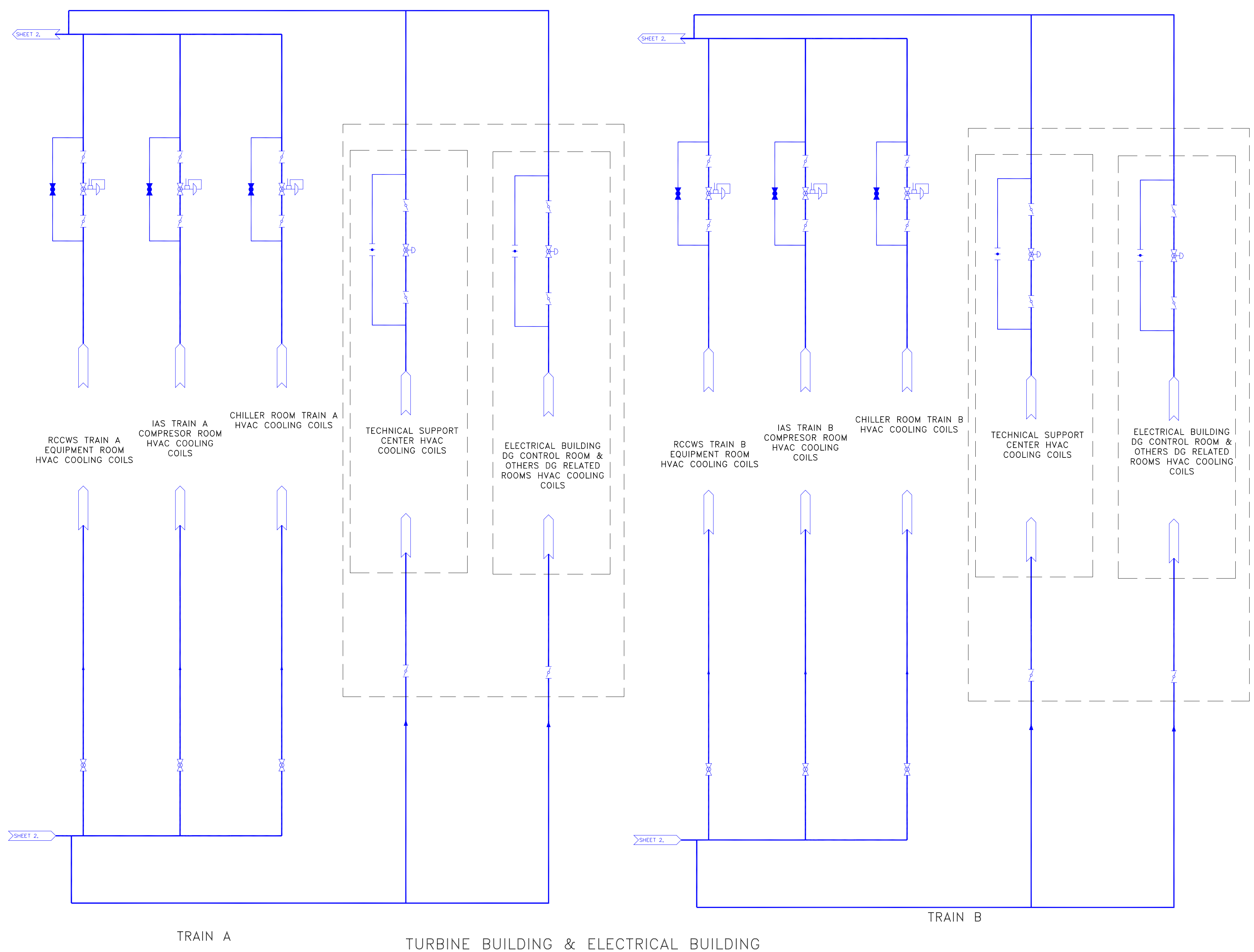
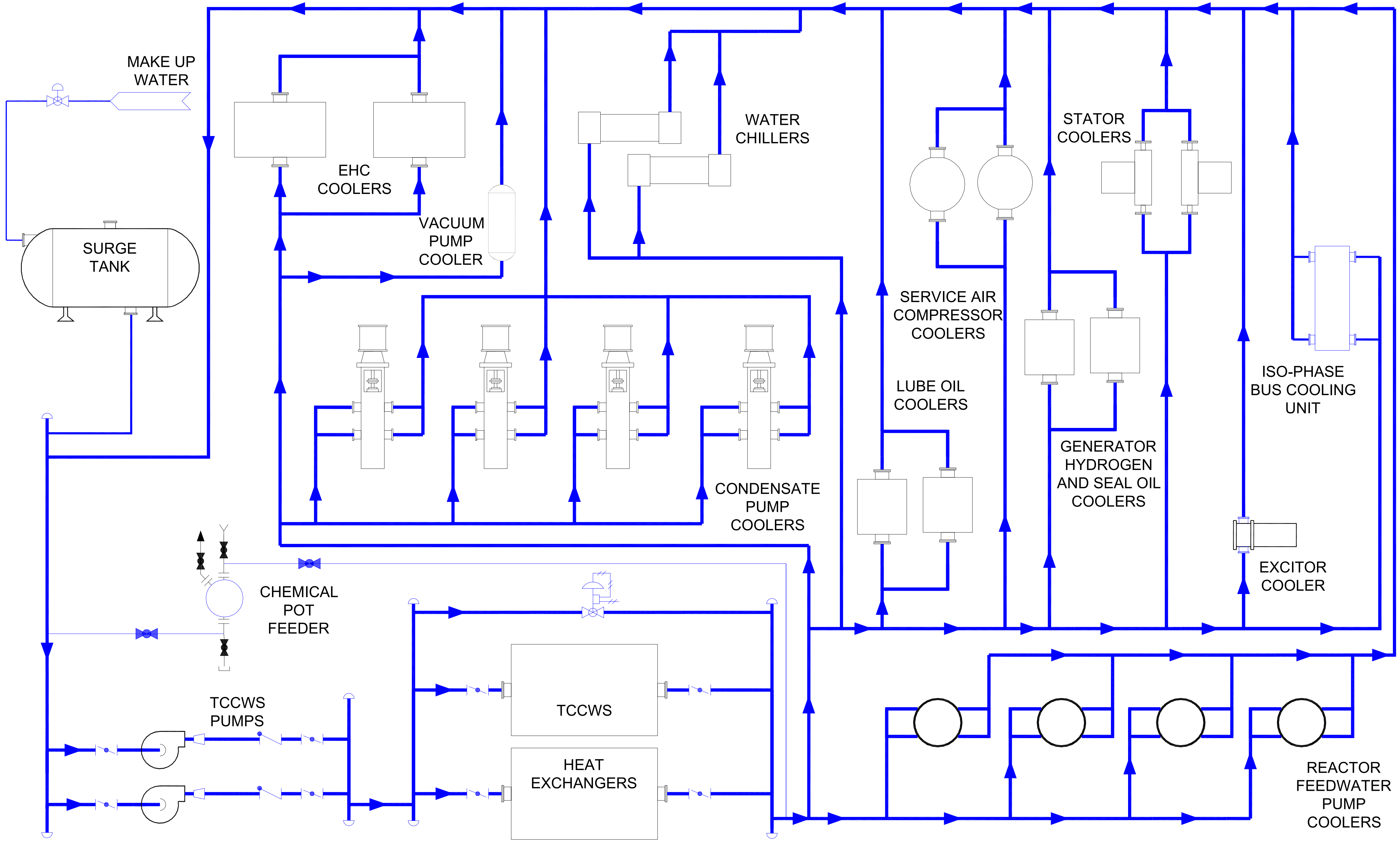


Figure 9.2-4. Turbine Component Cooling Water System Configuration



9.3 PROCESS AUXILIARIES

9.3.1 Compressed Air Systems

Compressed air systems include the Instrument Air System (IAS), the Service Air System (SAS), the Containment Inerting System (CIS) and the High Pressure Nitrogen Supply System (HPNSS). The IAS is discussed in Subsection 9.3.6; the SAS is discussed in Subsection 9.3.7. The Containment Inerting System and the HPNSS are described in Subsections 9.4.9 and 9.3.8, respectively. The CIS and the HPNSS provide nitrogen gas for instruments and valve operators within the inerted containment.

9.3.2 Process Sampling System

9.3.2.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The Process Sampling System (PSS) does not perform or ensure any safety-related function. Therefore, this system has no safety-related design basis. The Post Accident Sampling System is a subsystem of the Containment Monitoring System and is described in Section 7.5.2.

Power Generation Design Bases

The Process Sampling System (PSS) collects representative liquid samples for analysis and provides the analytical information required to monitor plant and equipment performance and changes to operating parameters.

The PSS is designed to function during all plant operational modes under individual system requirements. Design guidelines related to PSS capabilities, the attainment of representative samples, and safety are described in the following paragraphs and in Table 9.3-1.

9.3.2.2 System Description

9.3.2.3 Summary Description

The PSS provides sampling of all principle fluid process streams associated with plant operation. The PSS consists of:

- Permanently installed sample lines
- Sampling panels with analyzers and associated sampling equipment
- Provisions for local grab sampling
- Permanent shielding

Table 9.3-1 provides a list of the sample points and analyzed parameters. Additional parameters may be added depending on site location and the actual equipment used. The COL applicant shall determine if additional sampling points are required.

Provisions for Obtaining Representative Samples

Where practical, sample connections are located in turbulent flow zones to ensure adequate mixing.

Connection is made on the side of horizontal process pipe runs.

Sampling lines are sized to maintain turbulent flow and to minimize purge time. Routing is as short and as straight as possible. Large radius bends are used to avoid traps and dead legs.

Sampling lines and associated valves and fittings are fabricated from stainless steel.

Heat tracing of sampling lines is provided as necessary to prevent crystallization or solidification of contents.

Cooling capabilities are provided for temperature control of the samples as required.

Sampling equipment is designed with flushing and blowdown capability in order to remove sediment deposits, air and gas pockets. Provisions are made to purge sample lines in the stations. All flushing fluids are either returned to appropriate process streams or sent to the radwaste system, except as noted.

9.3.2.4 Detailed System Description

Continuous sample flows are routed from select locations in the process streams to the sampling stations. The sample flows enter the sample stations where pressure, temperature, and flow adjustments are made as necessary. Facilities for grab sampling and special monitoring are provided. Continuous samples are diverted to continuous monitoring equipment. The continuous monitoring equipment transmits signals to the plant computer located in the Main Control Room (MCR). Alarms are provided for indicating off-normal conditions. The parameters monitored for each process stream are described in Table 9.3-1. The sample stations' effluents are returned to an appropriate process stream or to the radwaste drain headers through a common return line.

Reactor Building Sample Station

The Reactor Building Sample Station processes samples from the following systems for analysis:

- Reactor Water Cleanup/Shutdown Cooling System (RWCU/SDC)
- Control Rod Drive System
- Fuel and Auxiliary Pool Cooling System (FAPCS)

Auxiliary pools, including the Suppression Pool, Gravity-driven Cooling System pools and Isolation Condenser pools, are monitored during the cooling and cleanup modes of FAPCS.

Typical process stream sample parameters for the Reactor Building Sample Station are outlined in Table 9.3-1. Grab sample facilities are also provided at the Reactor Building Sample Station.

Turbine Building Sample Station

The Turbine Building Sample Station is located in the Turbine Building. Process samples from the following systems are routed to this panel for monitoring:

- Condensate and Feedwater System
- Moisture Separator Reheater System
- Heater Drain and Vent System

- Generator Cooling System
- Turbine Main Steam System

Typical process stream sample parameters for the Turbine Building Sample Station are outlined in Table 9.3-1. Grab sample facilities are also provided at the Turbine Building Sample Station.

Condensate Polishing Sample Station

The Condensate Polishing Sample Station is located in the Turbine Building. Process samples from the following systems are routed to this panel for monitoring:

- Condensate and Feedwater System
- Condensate Purification System

Typical process stream sample parameters for the Condensate Polishing Sample Station are outlined in Table 9.3-1. Grab sample facilities are also provided at the Condensate Polishing Sample Station.

Condenser Sample Station

The Condenser Sample Station is located in the Turbine Building. Process samples from the Main Condenser and Auxiliaries are routed to this panel for analysis.

Typical process stream sample parameters for the Condenser Sample Station are outlined in Table 9.3-1. Grab sample facilities are also provided at the Condenser Sample Station.

Radwaste Building Sample Station

The Radwaste Building Sample Station is located in the Radwaste Building. This sample station maintains continuous conductivity monitoring of the equipment and floor drain inputs. Additional grab samples are drawn from selected locations in the Radwaste System. Fume hoods and ventilation exhausts are provided for grab samples as necessary.

Auxiliary Boiler Building Sample Station

The Auxiliary Boiler Building Sample Station is located in the Auxiliary Boiler Building. This station is used to monitor the water quality of the Auxiliary Boiler System. Process samples from the Auxiliary Boiler System are routed to this panel for analysis.

Typical process stream sample parameters for the Auxiliary Boiler Building Sample Station are outlined in Table 9.3-1. Grab sample facilities are also provided at the Auxiliary Boiler Building Sample Station.

Local Grab Sampling Stations

Local grab sampling points are located throughout the plant to monitor process streams requiring intermittent sampling. Local grab sampling points are provided for the following systems:

- Reactor Component Cooling Water System
- Turbine Component Cooling Water System
- Plant Service Water System
- Chilled Water System

- Circulating Water System
- Standby Liquid Control System

Grab sample stations are used when the operating conditions of the process stream being sampled are suitable for operator handling without any conditioning.

Sample Piping Design

Sample lines are routed to be as short as possible, avoiding traps, dead legs and dips upstream of the sample stations. Lines are sized to maintain turbulent flow at the minimum required flow for each sample line.

The seismic design and quality group classifications of sample lines and their components conform to the classification of the system to which they are connected, up to and including the block valve (or valves). Sample lines downstream of the block valves are in conformance with ASME B31.1, Power Piping Code.

All sampling lines have the process isolation block valves located as close as practical to the process taps. These valves may be closed if sample line rupture occurs downstream of the valves.

9.3.2.5 Safety Evaluation

The operation of the PSS is not required for any of the following:

- Integrity of the reactor coolant pressure boundary
- Capability to shut down the reactor and maintain it in a safe shutdown condition or
- Ability to prevent or mitigate the consequences of accidents that can result in potential off-site exposures comparable to the guideline exposures of 10 CFR 100

However, the system incorporates features that improve operator safety. The sampling stations are closed systems and the grab samples taken at the sampling stations have a chemical fume hood to preclude the exposure of operating personnel to contamination hazards. A constant air velocity is maintained through the working face of the hoods to ensure that airborne contamination does not escape to the room under operating conditions.

In the event of a loss of cooling water to the sample cooler or sample flow in excess of sample cooler capacity, the sampling system valves are interlocked to prevent high-temperature water flow through the lines.

Safety/relief valves, vented to the drain headers, are provided in the stations for high-pressure process streams.

9.3.2.6 Tests and Inspections

The sample stations are in continuous use during normal plant operation, therefore PSS operability is continuously demonstrated during normal plant operation. The sample stations are tested and calibrated at frequencies in accordance with the sample station supplier’s operation and maintenance requirements.

9.3.2.7 Instrumentation Application

PSS instrumentation is provided in each sample station for the following:

- Provisions are made to stop sample flow upon detection of high-temperature sample flow leaving the sample cooler.
- Pressure and temperature indication is provided for all high-pressure and high-temperature samples, respectively.
- Process conditions are measured and recorded for each sample flow.
- Alarms are provided for necessary measurement indications
- Provisions are made for sample flow to be indicated.

Additional monitoring equipment is provided within the panels to meet the process stream monitoring conditions listed in Table 9.3-1.

9.3.3 Equipment and Floor Drainage System

The Equipment and Floor Drainage System (EFDS) consists of the Clean (nonradioactive) Drain Subsystem and the following five potentially contaminated subsystems:

- Low Conductivity Waste (LCW) Drain Subsystem
- High Conductivity Waste (HCW) Drain Subsystem
- Detergent Drain Subsystem
- Chemical Waste Drain Subsystem and
- Reactor Component Cooling Water System (RCCWS) Drain Subsystem.

These five subsystems collect liquid drainage from various plant areas and transfer them to the radwaste system.

9.3.3.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The EFDS does not perform any safety-related function. Therefore, EFDS has no safety design basis, other than provision for safety-related containment penetrations and isolation valves, as described in Subsection 6.2.4.

Power Generation Design Bases

The EFDS collects waste liquids from their point of origin and transfers them to a suitable processing or disposal system.

Drainage systems are designed to accommodate the maximum anticipated normal volumes of liquid without overflowing; including such inputs as the anticipated water flow from a fire hose and other fire suppression water discharges to the area floor drains without impacting the safety function of any safety-related component or system.

To preclude inadvertent transfer of radioactive liquids to non-radioactive systems, the radioactively contaminated or potentially contaminated liquids are collected by completely separate systems (e.g. no cross connections) from those that collect non-radioactive liquids.

Redundant sump pumps are included to increase the reliability, availability, and maintainability of the EFDS.

Systems are designed and arranged to minimize flooding of multiple compartments.

9.3.3.2 System Description

Summary Description

The EFDS includes sumps, motor-driven pumps, isolation valves, and instrumentation for pump operation, and interconnecting piping. Separate subsystems collect clean (nonradioactive) drains, low conductivity waste (LCW) drains, high conductivity waste (HCW) drains, detergent drains, chemical, and RCCWS drain wastes.

The Clean Drain Subsystem collects and transfers liquid wastes by gravity from the clean nonradioactive equipment and floor drains to sumps and pumps these wastes to an appropriate disposal system.

The LCW Drain Subsystem collects liquid wastes from equipment drains in potentially contaminated systems. These liquids gravity drain to sumps located in the drywell and other areas. The drywell LCW drain, which is monitored for activity, is pumped to the LCW collection tank. The drywell drain line is provided with redundant containment isolation valves. The liquid wastes collected in the LCW sumps are also pumped to the LCW collection tank.

The HCW Drain Subsystem collects liquid wastes from floor drains in potentially contaminated areas. These liquids gravity drain to sumps located in the drywell and other areas. The drywell HCW drain, which is monitored for activity, is pumped to the HCW collection tank. The drywell drain line is provided with redundant containment isolation valves. Liquids collected in the HCW sumps are also pumped to the HCW collection tank.

The Detergent Drain Subsystem collects potentially contaminated wastes from the personnel decontamination stations, laundry, and shower facility drains and transfers them to the detergent drain collection tank.

The Chemical Waste Drain Subsystem collects liquid wastes containing potentially contaminated chemicals and corrosive substances from washdown areas, laboratory drains, hot maintenance shop, and other miscellaneous sources in the plant. These liquid wastes are transferred to the chemical drain collection tank.

Safety divisions are provided with a separate drain line connecting to the main drainage piping and leading to an appropriate sump in the Reactor Building. Each drain line is provided with a normally open isolation valve, which is automatically closed to prevent flooding of multiple safety divisions due to backflow. Watertight walls, floors, and doors on safety-related compartments also prevent flooding of multiple safety-related compartments.

Detailed System Description

The system includes the major equipment listed in Table 9.3-2.

The EFDS equipment is primarily located in the areas where the drains are collected. Capability is provided to sample the liquids collected in each sump.

Containment isolation valves and piping, designated safety area drain line isolation valves, and limit switches are classified as safety-related. All other EFDS equipment and components are nonsafety-related.

The EFDS interfaces with numerous systems from which drains are collected. The collected liquids are discharged to the clean waste system or the Liquid Radioactive Waste Management System, as appropriate.

The COL applicant shall determine the final size of the drywell sump.

System Operation

Liquid wastes from various floors and equipment drains gravity drain to the appropriate sumps. Drywell sumps transfer collected liquids by pumping to the LCW or HCW collection tanks in the Radwaste Building. Each sump has two pumps. One pump operates as required and the other is in standby. The lead sump pump starts automatically when the liquid reaches a predetermined level in the sump and stops at a predetermined low level. Both pumps operate simultaneously if one pump cannot accommodate the rate of accumulation of liquids in the sump. Contaminated or potentially contaminated liquids are transferred to the Liquid Radioactive Waste Management System for processing.

9.3.3.3 Safety Evaluation

The EFDS does not have any safety-related function, other than containment and designated safety division isolation functions.

Failure of the EFDS does not prevent safety-related equipment from performing their safety-related functions. Section 3.4, Water Level (Flood) Design, presents analyses demonstrating that safety-related equipment in areas drained by the EFDS is not affected by drain or flood water backing up in the drainage system because of malfunction of active components, blockage, or the probable maximum flood.

9.3.3.4 Testing and Inspection Requirements

The EFDS is designed to permit periodic inspection and testing of important components, such as valves, motor operators, and piping, to verify their integrity and capability. Equipment layout provides easy access for inspection and maintenance.

Drainage piping is hydrostatically tested prior to embedment in concrete. Potentially radioactive drainage piping is tested to gage pressure of 518,000 Pa (75 psig) in accordance with ASME B31.1. The EFDS components are tested periodically by normal operation of the equipment.

9.3.3.5 Instrumentation Requirements

Instrumentation and controls for the EFDS are located at local panels, and appropriate signals are duplicated and sent to the MCR. These indications and controls include the following:

- On/off switches for pumps
- Sump level alarms and

- Valve position indicators and controls

The EFDS can be controlled manually or can be automatically operated as described below.

High and low level transmitters on each sump start and stop the sump pump automatically. A separate high-high level switch starts the second sump pump and actuates an alarm in the MCR. Components within the safety divisions are provided with level switches to close the drain line isolation valves to preclude flooding of compartments not affected by the flood. Manual switches in the MCR can also close these valves. Closure of an isolation valve annunciates an alarm in the MCR.

Leaks in the drywell are detected by monitoring the rate of increase of the sump level. Leak detection in other areas is accomplished by monitoring the frequency and duration of sump pump operation.

9.3.4 Chemical and Volume Control System

Not applicable to ESBWR.

9.3.5 Standby Liquid Control System

9.3.5.1 Design Bases

Safety (10 CFR 50.2) Design Bases

Although the Standby Liquid Control System (SLCS) performs no design basis safety-related functions, it is classified as safety-related and is designed as a Seismic Category I system. The SLCS meets the following safety design bases:

The SLCS provides a diverse backup capability for reactor shutdown, independent of normal reactor shutdown provisions.

The SLCS provides makeup water to the RPV to mitigate the consequences of loss of coolant accident (LOCA).

The SLCS has full capacity for reducing core reactivity between the steady-state rated operating condition of the reactor with voids and the reactor cold shutdown condition, including shutdown margin, to ensure complete shutdown from the most reactive conditions at any time in core life.

The time required for actuation and effectiveness of the SLCS is consistent with the nuclear reactivity rate of change corresponding to the normal reactor rate of cooldown and depressurization and the accompanying influence of xenon decay. A fast scram of the reactor or operational control of fast reactivity transients is not specified for the SLCS.

Means are provided to ensure the capability of the SLCS to respond to an initiation demand by confirming an adequate accumulator pressure and adequate solution level and initiating circuit continuity and proper valve positions. Additional measures are capable of being taken during plant shutdown to confirm injection valve operability through in-position or in-laboratory firing tests. Provisions are made to confirm an absence of obstructions in the flow path, and to confirm adequacy of the solution concentration during plant operation.

The SLCS employs a neutron absorber solution, to be injected at multiple locations into the core bypass region at high velocity to ensure adequate mixing and total injection is such as to ensure reactor shutdown. The injection geometry ensures balancing of reaction forces.

The system is reliable to a degree consistent with its role. The potential for unintentional or accidental shutdown of the reactor by this system is minimized.

Power Generation Design Bases

None.

9.3.5.2 System Description

Summary Description

The SLCS (Figure 9.3-1) is manually initiated for its shutdown function described in Subsection 9.3.5.1. In addition, the SLCS is automatically initiated for events beyond the safety design basis, such as an Anticipated Transient Without Scram (ATWS) and LOCA events.

Detailed System Description

The SLCS system contains two identical and separate trains. Each train provides 50% injection capacity. All components of the SLCS in contact with the boron solution are constructed of, or lined with, stainless steel. The safety-related portion of each train of the SLCS is comprised of the components and groups of components listed in Table 9.3-3.

The SLCS requires support from the safety-related systems listed in Table 9.3-4.

The SLCS also includes the following nonsafety-related subsystem: nitrogen charging subsystem including a liquid nitrogen tank, vaporizer, and high-pressure pump for initial accumulator charging and makeup for the normal system losses during normal plant operations.

Support is required from the following nonsafety-related readiness function:

Control of the equipment compartment temperature and humidity conditions to ensure proper equipment operation and avoidance of solute precipitation in the accumulator or injection line, thereby ensuring proper system operation. This system readiness function is nonsafety-related.

The major components of SLC, which are necessary for injection of Sodium Pentaborate Solution (SPBS) into the reactor, are located within the Reactor Building. The nonsafety-related high-pressure cryogenic nitrogen equipment is located outside the Reactor Building at grade elevation. The bulk of the safety-related SLCS equipment is located within two divisionally separated compartments of the Reactor Building except for a portion of the injection line(s) that leads to the RPV and therefore passes through containment. The nonsafety-related nitrogen poison solution charging and makeup equipment is located in the Auxiliary Building.

The sparger system is located within the reactor vessel and those portions of the SLCS injection line downstream of the squib valve contain only cold stagnant reactor water.

Electrical heating of the accumulator tank and the injection line is not necessary because the saturation temperature of the solution is less than 15.5°C (60°F) and the equipment room temperature is maintained above than that value at all times when SLCS injection is required to be operable. Adiabatic expansion of the cover gas can lead to temperatures less than the saturation temperature, the low rate of heat transfer between the cover gas and the solution and

the rapid rate of injection of the solution ensure that neither precipitation nor freezing affect the solution injection process or its effectiveness.

System Operation

The SLCS can be manually initiated from the MCR to inject a boron neutron absorber solution into the reactor if the operator determines the reactor cannot be shutdown or kept shutdown using the control rods. Once the operator decision for initiation of the SLCS is made, the design intent is to simplify the manual process by providing dual, protected switches. This prevents inadvertent injection of neutron absorber by the SLCS.

The dual manual initiation switches in the MCR are of a recessed, spring-loaded, rotate and push type and have a protective switch cover. Actuation requires simultaneous depression of the switches, and the switches are located such that a single operator can readily initiate the system. Procedural controls govern operation of these initiation switches.

The SLCS is only required to shutdown the reactor and keep the reactor from going critical again during cooldown. The SLCS is only needed in the improbable event that insufficient control rods can be inserted in the reactor core to accomplish shutdown and cooldown in the normal manner.

The SLCS is also designed to provide makeup water to the RPV during a LOCA event by injecting the boron solution from both accumulators. The emergency core cooling system (ECCS) and the SLCS are designed to flood the core during a LOCA event to provide the required core cooling. By providing core cooling following a LOCA, the ECCS and SLCS, in conjunction with the containment, limits the release of radioactive materials to the environment following a LOCA.

The shutdown functional performance requirements of the SLCS are bounded by the ATWS event performance requirements shown in Table 9.3-5.

Upon completion of injecting the boron solution, redundant accumulator level measurement instrumentation using 2 out of 4 logic closes the injection line shut-off valve in each SLCS train. Closure of this valve prevents injection of nitrogen from the accumulator into the reactor vessel that could interfere with Isolation Condenser System operation. Failure to close this valve, however, does not necessarily have any important detrimental effect. Operation of the accumulator vent could quickly reduce accumulator pressure and limit the amount of nitrogen injected into the reactor vessel. Any nitrogen injected into the reactor vessel would eventually be purged from the reactor by operation of safety/relief valves or the high pressure Isolation Condenser vent system for purging the noncondensable gases, depending on equipment status and operator response actions. The initial amount of nitrogen injected into the reactor vessel in the event of failure to close the shut-off valve would be minimal in the event that reactor pressure is controlled by operation of the high-pressure Isolation Condensers. As the reactor absolute pressure decreases to about 6.9 MPa (1000 psia), the injected nitrogen would be transported to the Isolation Condensers where it would be vented to the suppression pool.

Failure of the Isolation Condenser vent or limitations in its capacity would only inhibit the rate of heat removal in the Isolation Condenser so that the rate of reactor depressurization would become limited by the rate of decrease in the decay heat. Such limits would provide ample time for operation of the accumulator vent.

For ATWS events, the failure of control rods to insert in response to a valid trip demand is assumed. The SLCS automatically initiates by the Average Power Range Monitor (APRM) not downscale (≥ 6%) and one of the following conditions persisting for at least 3 minutes:

- High reactor dome gauge pressure of ≥ 7.76 MPa (≥ 1125 psig); and
- Low reactor vessel water level (≤ Level 2).

SLCS injection initiation ensures a timely accomplishment of hot shutdown with subsequent injections as the reactor depressurizes to ensure that cold shutdown can be achieved with no further occurrence of critical conditions. Refer to Section 15.5 for SLCS performance in the evaluation of ATWS events.

9.3.5.3 Safety Evaluation

The SLCS is mainly a reactivity control system that is maintained in an operable status whenever the reactor is critical. Because of the large number of independent control rods are available to shutdown the reactor and the redundant and diverse methods to insert the control rods, at any time in core life, the use of the SLCS for safety reasons is not expected over the life of the plant.

Availability of the SLCS is ensured by redundancy in the injection valves. Adequate functioning of the system is ensured if one of the two injection valves open in each train. No other function is required for proper system operation. Addition of nitrogen to recover gas pressure after initial injection is not necessary for adequate functioning of the system. Protection against inadvertent premature operation of the shut-off valve is ensured by use of redundancy in the initiation signal for this function.

The system is designed to bring the reactor from rated power to a cold shutdown condition at any time in core life. The reactivity compensation provided reduces reactor power from rated to zero and allows cooling of the nuclear system to less than the cold shutdown temperature with the control rods remaining withdrawn in the rated power pattern. These conditions (hot shutdown and cold shutdown) include, where applicable, the reactivity gains that result from complete decay of the rated power xenon. They include the positive reactivity effects from eliminating steam voids, changing water density from hot to cold, reduced Doppler effect in uranium, reducing neutron leakage from boiling to cold, and decreasing control rod worth as the moderator cools.

The minimum uniformly mixed equivalent concentration of natural boron required in the reactor core to provide adequate cold shutdown margin after operation of the SLCS is 7600 ppm. Calculation of the minimum quantity of isotopically enriched sodium pentaborate to be injected into the reactor is based on the required 7600 ppm equivalent natural boron concentration in the reactor coolant at 20°C (68°F) and reactor water level conservatively taken at the elevation of the bottom edge of the main steam lines. This result is then increased by a factor of 1.25 to provide a 25% general margin to discount potential non-uniformities of the mixing process within the reactor. This result is then increased by a factor of 1.15 to provide a further margin of 15% to discount potential dilution by the RWCU/SDC System in the shutdown cooling mode.

Cooldown of the nuclear system requires a minimum of several hours to remove the thermal energy stored in the reactor, reactor water, and associated equipment. The limit for the reactor vessel cooldown is 55.6°C/h (100°F/h) and the normal operating temperature is approximately

288°C (550°F). Use of the main condenser and the shutdown cooling systems normally requires 10 to 24 hours to decrease the reactor vessel temperature to 20°C (68°F). Although hot shutdown is the condition of maximum reactivity, cold shutdown condition is associated with the largest total water mass in which the particular shutdown concentration must be established and therefore, this condition determines the total mass of neutron absorber solution to be injected.

The extremely rapid initial rate of isotopically enriched boron injection ensures that hot shutdown boron concentration are achieved within several minutes of SLCS initiation based on initial reactor water inventory. Maintaining normal water level with the voids collapsed causes some dilution of this concentration but does not cause hot shutdown concentrations to be violated. As the reactor cools and begins to depressurize, completion of all neutron absorber solution injection occurs long before cold shutdown conditions are reached. The high injection velocity of the injection spargers and the natural circulation flow within the reactor vessel ensures efficient mixing and distribution of the boron throughout the reactor vessel.

The SLCS equipment essential for injection of neutron absorber solution into the reactor is designed as Seismic Category I for withstanding the specified earthquake loadings (refer to Section 3.7). The system piping and equipment are designed, installed, and tested in accordance with the requirements stated in Section 3.9.

The safety functions of the SLCS are powered from the Class 120 VAC and 250 VDC electrical systems. The SLCS does not require AC power for operation. Only Class 1E 250 VDC power is required. Environmental conditions to prevent precipitation of solute do not require operation of the Reactor Building HVAC systems during the time that SLCS operation is required.

The initial accumulator tank inventory of compressed nitrogen is adequate to ensure full injection of the solution inventory at a reactor pressure of 6.9 MPa (1000 psia).

Direct effects of nitrogen injection or reduction in heat removal capability of the Isolation Condensers caused by noncondensables cannot cause reactor vessel overpressurization because of the operation of the shut-off valve or the operation of SRVs, should the shut-off valve fail. Interference with Isolation Condenser operation by nitrogen injection into the reactor vessel is overcome by operation of the SRVs and the Isolation Condenser venting system that ensures recovery of the Isolation Condenser function.

The SLCS is evaluated against the applicable General Design Criteria (GDC) as follows:

The SLCS is designed to conform to the GDC of 10 CFR 50. The overall requirements (Section I) of the GDC are applicable to the SLCS, and system equipment has been designed and installed in conformance with the presentations in Chapter 3. Other related GDCs are presented individually below:

Criterion 26, Reactivity Control System Redundancy and Capability: The FMCRD system is the intended means for normal operational control of reactivity. Anticipated operational occurrences initiate the hydraulic scram function and rapidly insert all rods to ensure a safe limit on reactivity changes. These systems are capable of safely accommodating all reactivity changes from the normal power range (including xenon influences) to cold shutdown conditions. The SLCS is redundant to these functions and represents a diverse means for reactor shutdown to ensure the ability to bring and maintain

the core to such critical conditions for the full range of reactor conditions from hot shutdown to cold shutdown.

Criterion 27, Combined Reactivity Control Systems Capability: Operation of the SLCS is not required to meet the intent of this criterion. The SLCS could, for many conditions exceeding the design basis of the plant, provide additional reactor shutdown capability to ensure achieving shutdown conditions.

Criterion 28, Reactivity Limits: This criterion applies only to the reactivity control systems intended for normal operation.

The SLCS is evaluated against the applicable regulatory guides as follows:

Regulatory Guide 1.26, Quality Group Classifications and Standards: Because the SLCS is a defense-in-depth beyond design basis shutdown system, all mechanical components required for boron injection are at least Quality Group B. Those portions that are part of the reactor coolant pressure boundary are Quality Group A.

Regulatory Guide 1.29, Seismic Design Classification: All components of the SLCS necessary for injection of the neutron absorber into the reactor are Seismic Category I.

ASB 3-1 and MEB 3-1: Because the SLCS is located within its own compartment inside the Reactor Building, it is adequately protected from flooding, tornadoes, and internally/externally generated missiles. SLCS equipment is protected from pipe break by providing adequate distance between the Seismic Category I and non-seismic SLCS equipment, where such protection is necessary. In addition, appropriate distance is provided between the SLCS and other high energy piping systems.

This system is only required for extremely low probability event, where all of the control rods are assumed to be inoperable while the reactor is at normal full power operation. Therefore, the protection provided is greater than required to meet the intent of ASB 3-1 and MEB 3-1.

This system is used in ATWS events, presented in Section 15.5. The ATWS events are extremely low probability non-design basis postulated events.

Testing and Inspection Requirements

The SLCS is a system requiring firing of only one of two squib valves in each trainloop and no dynamic equipment for operation under design conditions. Assurance that design conditions are maintained is accomplished by critical parameter alarms and periodic surveillances.

Critical parameters (accumulator level and pressure) are alarmed and recorded in the MCR.

Valves, including the injection valves, shut-off valves, the vent valves, and the relief valves, are periodically tested to ensure operability.

The SLCS preoperational test to demonstrate adequate system performance is described in Subsection 14.2.8.

During scheduled plant shutdowns, the pyrotechnic charges are replaced in the injection line squib valves. Replacement is done without any opening of the reactor coolant pressure boundary (RCPB). Subsequently in the laboratory, the removed charges are tested to confirm end of life capability to function upon demand. These pyrotechnic charges are inserted in a small pressure chamber unit having a pre-measured volume, which is instrumented with rapid-response pressure transducers. Electrical signals typical of squib actuation signals are applied to the charges to fire them, and pressure response traces are recorded and then examined to establish potency against pre-established values.

Access for charging each accumulator with boron solution, draining the accumulator, and sampling from each accumulator is provided. Fill-and-drain and makeup operations are intended to be very infrequent operations (several year intervals). Periodic samples are taken to ensure acceptable solution characteristics. Charging the solution inventory is performed with the accumulator depressurized. Provision is made for a minimum of 8 sample withdrawals without a requirement for makeup. Sampling and makeup of the solution inventory can be performed with the accumulator at full pressure.

9.3.5.4 Instrumentation Requirements

The instrumentation and control system for the SLCS is designed to allow the injection of liquid poison into the reactor and to ensure that the liquid poison solution and its cover gas are maintained within the allowable range of initial conditions to achieve full solution injection upon demand.

Because of the passive nature of the system and the short operating time for the system, no provision is made for flow measurement. Injection status is provided by MCR indication of accumulator pressure and accumulator solution level for each train. These parameters are direct and independent indicators of injection quantity given normal operation of the system. Because of the high rate of injection by this system, verification of injection is almost immediately available (< 30 sec) by observation of accumulator level. The verification can be confirmed by observation of accumulator pressure, which is also a direct measure of injection under conditions of normal, unfaulted system operation.

Closure of the injection shut-off valve is automatically initiated by the accumulator level instrumentation using 2 out of 4 logic. Closure, or override, of the automatic closure initiation can also be initiated manually from the MCR. Operation of the accumulator vent system is manual from the MCR. Operation of the accumulator nitrogen charging, and makeup to accommodate small losses is manual. MCR alarms are provided for high, low, and low-low conditions of accumulator pressure and low and low-low conditions of accumulator solution level. At low-level conditions, the nitrogen and poison solution makeup systems are manually started. Accumulator temperature, solution level, and accumulator pressure instrumentation is provided locally inside the accumulator room.

The status of injection and shut-off valves vital to the operation of the system is provided in the MCR.

A further discussion of the SLCS instrumentation may be found in Section 7.4.

9.3.6 Instrument Air System

9.3.6.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The Instrument Air System (IAS) is a non-safety-related system and has no safety design basis.

Power Generation Design Bases

The function of the IAS is to provide dry, oil free, filtered compressed air to pneumatically operated valve operators, instrumentation, equipment and components.

The IAS is designed with sufficient capacity to operate during normal plant operation, transients, plant startup, and plant shutdown.

9.3.6.2 System Description

The IAS provides filtered, dry and oil-free compressed air for plant instrumentation, control systems and pneumatic valve/damper actuators located outside of the containment during normal operation. During refueling operations, the IAS supplies compressed air to the High Pressure Nitrogen Supply System (HPNSS) loads inside containment via the HPNSS piping. The IAS is shown in Figure 9.3-2.

Design of the system ensures that failure of the IAS does not compromise any safety-related system or component nor does it prevent a safe shutdown. Pneumatically operated devices are designed fail-safe and do not require continuous air supply under emergency or abnormal conditions.

The IAS consists of two identical 100% capacity trains in parallel, one normally operating and the other in standby. Components of the IAS are designed to meet ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, ASME Power Piping Code B31.1, or ASME Process Piping Code B31.3, as applicable.

During normal operation, one compressor is selected for continuous operation, while the other serves as standby and starts automatically if the continuously operating compressor cannot meet system demand. The operating compressor automatically loads or unloads in response to the IAS demand as determined by pressure changes in the air receivers.

The IAS is automatically switched to the standby AC power source during a LOPP and is backed up by the Service Air System (SAS) during failure of both IAS air compressors. The instrument air compressor units are powered from separate electrical buses.

Each of the compressors takes suction from the outside atmosphere through an air intake filter/silencer. Each compressor train is equipped with an after-cooler. Two air receivers service both air compressors. Air leaving the air receivers passes through one of two parallel instrument air filtering and drying trains, and a receiver/surge tank before being distributed to the instrument air piping system. Each train is equipped with redundant prefilters, a regenerative desiccant dryer, and redundant after-filter. Both air compressor trains are connected to a common header, which distributes to the Radwaste Building, Turbine Building and Reactor Building. The IAS can serve as a manual backup to the containment users through the HPNSS piping.

The cooling water for compressors is supplied from the Reactor Component Cooling Water System.

Performance Requirements for the IAS are provided in Table 9.3-6.

9.3.6.3 Safety Evaluation

The IAS is not a safety-related system, however, the IAS incorporates features that ensure its operation over the full range of normal plant operations. If IAS pressure falls below a desired limit, air from the Service Air System (SAS) is automatically added from a tie line. Air receivers and a receiver/surge tank are provided to maintain air supply pressure if all of the IAS and SAS compressors fail. Pneumatically operated devices are designed to fail-safe and do not require continuous air supply under emergency or abnormal conditions.

9.3.6.4 Inspection and Testing Requirements

IAS operability is demonstrated by use during normal plant operation. Compressors, after-coolers, air receivers, prefilters, air dryers, after-filters, and the control panel are shop inspected and tested. System operational tests for components normally closed to airflow are performed periodically to ensure system capability and integrity. Air filters are periodically inspected for cleanliness, and the desiccant in the air dryers is periodically sampled to verify its useful life. Periodic testing of air quality is performed to ensure compliance with ISA Standard 7.0.01. Pneumatic isolation valves are capable of operational integrity testing. A remote manual switch and open/closed position lights are provided in the Main Control Room (MCR) for verification of proper valve operation.

9.3.6.5 Instrumentation Application

Instrumentation for the IAS is primarily local, consisting of pressure, differential pressure and temperature and/or control. Pressure transmitters and pressure switches provide MCR pressure indications and alarms. The system is maintained at constant pressure, with local pressure reduction provided as required.

Pressure-reducing valves are used for services requiring less pressure than the respective receiver tank pressure.

9.3.7 Service Air System

9.3.7.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The Service Air System (SAS) is a nonsafety-related system and has no safety design basis, other than provision for safety-related containment penetrations and isolation valves, as described in Subsection 6.2.4.

Power Generation Design Bases

The SAS is designed with redundant active components.

The SAS has sufficient capacity to support plant operations during normal, transients, startup, and shutdown conditions.

9.3.7.2 System Description

The SAS provides filtered compressed air for general plant use and service air outlets located outside of the containment. Breathing air is also provided by the SAS. During Instrument Air System (IAS) failure, the SAS can supply compressed air to the IAS loads.

The SAS is shown in Figure 9.3-3.

The SAS is designed to provide compressed air of suitable quality for nonsafety-related functions.

The design ensures that failure of the SAS does not compromise the safety-related function of any safety-related system or component or prevent a safe shutdown.

The SAS provides compressed air for tank sparging, filter/demineralizer backwashing, air-operated tools and other services requiring air of lower quality than that provided by the IAS.

The SAS consists of two identical 50% capacity trains in parallel, one normally operating, and the other in standby. Components of the SAS are designed to meet ASME Boiler and Pressure Vessel Code, Sections III and VIII, Division 1, and ANSIASME Power Piping Code B31.1, and ASME Process Piping Code B31.3, as applicable.

During normal operation, one compressor train is selected for continuous operation, while the other serves as standby and starts automatically if the continuously operating compressor cannot meet system demand. The operating compressor automatically loads or unloads in response to the SAS demand as determined by pressure changes in the air receivers.

Each of the compressors takes suction from the outside atmosphere through an air intake filter/silencer. Each compressor train is equipped with an inter-cooler, after-cooler, moisture separator, and air receiver. Both air compressor trains are connected to a common header that distributes air to the breathing air purifiers, Radwaste Building, Turbine Building, and Reactor Building. The SAS also serves as a backup to the IAS.

The breathing air purifiers consist of two identical 100% trains in parallel, one normally operating, and the other in standby. The major components of the breathing air purifiers are designed to meet ASME Boiler and Pressure Vessel Code, Section VIII, Division I, ANSI/ASME Piping Code B31.3, and Occupational Safety and Health Administration (OSHA) breathing air requirements.

The SAS supplies service air to the breathing air purifiers. Each breathing air purifier is equipped with prefilter, twin desiccant towers, catalyst, and activated charcoal filter. One air receiver with a bypass line serves both purifiers. Both breathing air purifiers are connected to a common header that supplies the reactor, turbine, and Radwaste Buildings.

The cooling water for after-coolers and compressors is supplied from the Turbine Component Cooling Water System.

The service air compressor units are powered from separate electrical buses of the permanent nonsafety-related power distribution system.

The SAS includes system connections for connecting additional compressor capacity for high-usage outages, if required.

Performance requirements of the SAS are provided in Table 9.3-7.

9.3.7.3 Safety Evaluation

The SAS is not a safety-related system, however, the SAS incorporates features to ensure its operation over the full range of normal plant operations. Pneumatic-operated devices are designed to fail-safe and do not require continuous air supply under emergency or abnormal conditions.

9.3.7.4 Inspection and Testing Requirements

The SAS operability is demonstrated by use during normal plant operation. Compressors, inter-coolers, after-coolers, moisture separators, air receivers, breathing air purifiers, and the control panels are shop inspected and tested. System operational tests for components normally closed to airflow are performed periodically to ensure system capability and integrity. Filters are periodically inspected for cleanliness, and the desiccant in the breathing air purifiers is periodically sampled to ensure its performance. Periodic testing of breathing air quality is performed to ensure compliance with OSHA standards.

9.3.7.5 Instrumentation Application

Instrumentation for the SAS is primarily local, consisting of pressure, differential pressure and temperature indication and/or control. Pressure transmitters and pressure switches provide indications and alarms in the Main Control Room (MCR). The system is maintained at constant pressure, with local pressure reduction provided as required.

Pressure-reducing valves are used for services requiring less pressure than the respective receiver tank pressure.

9.3.8 High Pressure Nitrogen Supply System

9.3.8.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The High Pressure Nitrogen Supply System (HPNSS) does not perform any safety-related function. Therefore, the HPNSS has no safety design basis other than provision for safety-related containment penetrations and isolation valves, as described in Subsection 6.2.4.

Power Generation Design Bases

The HPNSS is designed to the following design bases:

Distributes clean, dry, oil-free nitrogen gas to containment nitrogen users from the Containment Inerting System (CIS). Nitrogen loads include the Automatic Depressurization Subsystem (ADS) Safety Relief Valve (SRV) accumulators, the Isolation Condenser (IC) steam and condensate line isolation valve accumulators, the Main Steamline Isolation Valve (MSIV) accumulators, and other pneumatically operated valves.

The HPNSS provides a means for switchover from CIS to nitrogen bottle backup during low CIS supply pressure.

The HPNSS provides a means for manual switchover from the HPNSS supply to the IAS supply to the HPNSS loads to provide an operating gas for HPNSS loads during refueling outages.

9.3.8.2 System Description

9.3.8.3 Summary Description

The HPNSS consists of the distribution piping between the CIS and the containment nitrogen users. The HPNSS also provides bottled high-pressure nitrogen gas that is clean, dry, and oil-free to the NBS ADS SRV accumulators, IC line isolation valves' accumulators, MSIVs, and other nitrogen loads if the CIS fails to maintain the required nitrogen supply pressure.

All containment nitrogen loads are normally supplied by the CIS. The CIS nitrogen supply line branches into two HPNSS distribution lines. One branch line supplies the low-pressure nitrogen loads (i.e., MSIVs, instruments, and pneumatic-operated valves) while the second branch supplies the high-pressure nitrogen loads (i.e., NBS ADS SRV accumulators and the IC piping isolation valve accumulators).

9.3.8.4 Detailed System Description

The HPNSS is shown in Figure 9.3-4.

The HPNSS provides the distribution piping from the CIS to the nitrogen loads in the containment. To meet the requirements of the accumulators, a pressure reducing station initially reduces the CIS nitrogen gas pressure. One of the two branch lines distributes high-pressure nitrogen to the accumulators. The remaining branch line incorporates a pressure reducing station to lower the CIS nitrogen supply to the required pressure.

The HPNSS incorporates containment isolation valves where the HPNSS supply lines penetrate the containment. A motor-operated isolation valve is located outboard of the containment penetration while a check valve, which also functions as an isolation valve, is provided inboard. The check valve prevents backflow while the isolation valve closes. The containment isolation can be initiated manually from the MCR by closing the outboard isolation valve.

The HPNSS backup consists of two bottle-rack trains in parallel. Each bottle-rack train consists of 8 or more bottles, each bottle with a pigtail and station valve, which are piped to a manifold. Each bottle rack manifold interfaces with the nitrogen supply distribution header through an isolation valve. The supply header incorporates a pressure reducing station to depressurize the bottled nitrogen gas to the required supply distribution pressure. The nitrogen bottle racks each have about 8-hour supply for the containment nitrogen loads upon loss of normal CIS supply.

The piping and valves of the HPNSS are designed to meet ANSI Piping Code B31.1. Its safety class is nonsafety-related.

HPNSS requirements are tabulated in Table 9.3-8.

System Operation

The HPNSS distributes CIS nitrogen supply to the loads in the containment during normal operation. An upstream pressure control valve on each branch modulates the CIS nitrogen supply to provide the required nitrogen supply pressure to the nitrogen loads.

If the CIS fails to maintain the required nitrogen supply pressure, the HPNSS provides uninterrupted nitrogen gas supply from the nitrogen storage bottles. When the nitrogen gas

pressure in the main header drops below the set pressure, the manifold isolation valve automatically opens to provide nitrogen gas from the storage bottles to all nitrogen loads.

One bottle rack train and one pressure-reducing station are utilized to maintain design nitrogen supply as required. The nitrogen bottle station valves and manifold isolation valve on one train are kept open, while the standby train bottle station valves and manifold isolation valves are kept closed. Switchover from one bottle rack train to the other is a manual operation.

The HPNSS bottled nitrogen normally remains on standby, through an isolation valve located upstream of the pressure reducing station. During low nitrogen supply pressure in the main supply header, the isolation valve automatically opens to allow nitrogen gas supply from the HPNSS nitrogen bottles to all system loads. The normal CIS supply line is isolated following a set time delay.

Restoration of the HPNSS to the CIS is by manual operation of the isolation valves from the MCR.

9.3.8.5 Safety Evaluation

The HPNSS is not safety-related, however, the system incorporates features that ensure reliable operation over the full range of normal plant operation and with earthquake intensities up to an SSE. Pneumatic-operated devices are designed for a fail-safe mode and do not require continuous air supply under emergency or abnormal conditions.

9.3.8.6 Inspection and Testing Requirements

The HPNSS is designed such that it can be tested at any time.

Periodic testing of nitrogen quality is performed to ensure compliance with ANSI/ISA 7.0.01. Nitrogen isolation valve integrity testing is performed by manual actuation by MCR operators using associated valve position indicating lights.

9.3.8.7 Instrumentation Requirements

The flow of nitrogen gas from the HPNSS bottled nitrogen is automatically initiated when a pressure sensor in the main supply line indicates low nitrogen supply pressure. The pressure switch also alarms in the MCR upon either low or high pressure. The CIS supply isolation valve closes following a time delay.

9.3.9 Hydrogen Water Chemistry System

9.3.9.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The Hydrogen Water Chemistry System (HWCS) is non-safety-related. However, it is required to be safe and reliable, consistent with the requirement of using hydrogen gas. The hydrogen piping in the Turbine Building is designed to Seismic Category II requirements.

Power Generation Design Basis

The ESBWR reactor coolant is demineralized water, typically containing 100 to 200 parts per billion (ppb) dissolved oxygen from the radiolytic decomposition of water. To mitigate the

potential for Intergranular Stress Corrosion Cracking (IGSCC) of sensitized austenitic stainless steels, the dissolved oxygen in the reactor water is reduced to less than 20 ppb by the addition of hydrogen to the feedwater. The amount of hydrogen required is in the range of 1.0 to 1.5 ppm. The exact amount required depends on many factors including in-core recirculation rates. The amount required is determined by testing performed during the initial operation of the plant.

The concentration of hydrogen and oxygen in the main steam line and eventually in the main condenser is altered in this process. This leaves an excess of hydrogen in the main condenser that would not have equivalent oxygen to combine with in the offgas system. To maintain the offgas system near its normal operating characteristics, a flow rate of oxygen equal to approximately one-half the injected hydrogen flow rate is injected in the offgas system upstream of the recombiner.

The HWCS utilizes the guidelines in EPRI report "BWR Hydrogen Water Chemistry Guidelines" (Reference 9.3-1).

9.3.9.2 System Description

The HWCS, illustrated in Figure 9.3-5, is composed of hydrogen and oxygen supply systems, systems to inject hydrogen in the feedwater and oxygen in the offgas and several monitoring systems to track the effectiveness of the HWCS. These systems monitor the oxygen levels in the offgas system, the feedwater system, the lower plenum region and the RWCU/SDC inlet; hydrogen and pH levels in the feedwater system, the lower plenum region and the RWCU/SDC inlet; and crack growth of pre-cracked samples in water from the lower plenum region.

The hydrogen and oxygen supply systems are is site dependent and shall be defined by the COL applicant. Hydrogen can be supplied either as a high-pressure gas or as a cryogenic liquid. Hydrogen and oxygen can also be generated on-site by the dissociation of water by electrolysis. The HWCS hydrogen supply system may be integrated with the generator hydrogen supply system (as described in Subsection 10.2.2.2) by the COL applicant.

The oxygen supply system is site dependent. A single oxygen supply system can meet the requirements of the HWCS and the condensate oxygen injection system described in Subsection 9.3.10.

9.3.9.3 Safety Evaluation

The HWCS is not safety-related, however, the HWCS is used, along with other measures, to reduce the likelihood of corrosion failures that would adversely affect plant availability.

9.3.9.4 Inspection and Testing Requirements

The operation of the HWCS will be demonstrated during initial plant operation. During a refueling or maintenance outage, hydrogen injection is not required. System maintenance or testing can be performed during these periods.

9.3.9.5 Instrumentation and Controls

Automatic control features in the HWCS minimize the need for operator attention and improve performance. These are as follows:

- Automatic variation of hydrogen and oxygen flow rates with reactor power level
- Automatic oxygen injection rate change delay, augmented as a function of reactor power level
- Automatic shutdown on various trip signals
- Isolation on system power loss, with operator initiated restart
- Reprogrammable alarms and controller electronics; and
- Hydrogen and oxygen flow monitor correction function to compensate for nonlinearities.

The oxygen and hydrogen injection systems are designed to trip under the following circumstances:

- Reactor scram;
- Low or high residual oxygen in the off-gas
- High area hydrogen concentration
- Low oxygen injection system supply pressure; and
- High hydrogen flow

The instrumentation provided includes the following:

- Flow monitors for measurement of hydrogen and oxygen flow rates
- Hydrogen area monitor sensors to detect any hydrogen leakage to the atmosphere
- Pressure gages for measurement of hydrogen and oxygen supply pressures and instrument air pressure
- An oxygen analyzer for measuring the percent oxygen leaving the offgas recombiner (with low oxygen level alarm)
- Sensors for measuring dissolved oxygen content
- Sensors for measuring pH and dissolved hydrogen; and
- A system for verifying the effectiveness of HWC by measuring electrochemical potential and crack growth rate.

9.3.10 Oxygen Injection System

9.3.10.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The Oxygen Injection System (OIS) does not perform any safety-related function. Therefore, the OIS has no safety design basis.

Power Generation Design Bases

The Oxygen Injection System is designed to add sufficient oxygen to the condensate system to suppress corrosion and corrosion product release in the Condensate and Feedwater System.

Experience has shown that the preferred feedwater oxygen concentration is 30 to 200 ppb. During startup and shutdown operation, the feedwater oxygen concentration is usually greater than the 30 to 200 ppb range. However, during power operation, deaeration in the main condenser can reduce the condensate oxygen concentration below 30 ppb, requiring that oxygen be added. The main function of the Oxygen Injection System is to maintain the oxygen concentration in the condensate and feedwater between 30 and 200 ppb with a target of less than 100 ppb during reactor operation.

9.3.10.2 System Description

The oxygen supply system is site dependent and shall be defined by the COL applicant. The oxygen supply system would typically consist of high-pressure gas cylinders or a liquid tank. The condensate oxygen injection module and the feedwater injection module are provided with pressure regulators and associated piping, valves, and controls to depressurize the gaseous oxygen and route it to the condensate and feedwater injection modules. There are check valves and isolation valves between the oxygen injection modules and the condensate lines downstream of the condensate demineralizers and the feedwater downstream of the direct contact feedwater heater.

The flow regulating valves in this system are operated from the MCR. Analyzers in the Process Sampling System (Subsection 9.3.2) monitor the oxygen concentration in the condensate/feedwater system. An operator can make changes in the oxygen injection rate in response to changes in the condensate/feedwater concentration. An automatic control system is not required because instantaneous changes in oxygen injection rate are not required.

9.3.10.3 Safety Evaluation

The injection system itself is not safety-related. The oxygen storage facility is located in an area where the amount of combustible material is limited through design (permanent combustible material) and administrative controls (temporary combustibles). Normal safe practices for handling high-pressure gases are followed.

9.3.10.4 Testing and Inspection Requirements

The oxygen injection system is demonstrated operable by its use during normal operation. The system valves can be tested to ensure operability from the MCR.

9.3.10.5 Instrumentation

The oxygen supply system has monitors that indicate to the operators when re-supply is required. Two flow elements (one for each injection point) indicate the oxygen gas flow rate at all times. The gas flow regulating valves have position indication in the MCR.

9.3.11 Zinc Injection System

9.3.11.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The Zinc Injection System (ZIS) does not perform any safety-related function. Therefore, the ZIS has no safety design basis.

Power Generation Design Bases:

Provisions are made to permit installation of a system for adding a zinc solution to the feedwater. Piping connections for a bypass loop around the feedwater pumps and space for the zinc addition equipment are provided. If experience shows it necessary, a zinc injection system can be added later in plant life. The amount of zinc in the reactor water will be less than 10 ppb during normal operation.

9.3.11.2 System Description

The COL applicant needs to determine if this system is required based on site water quality requirements.

9.3.11.3 Safety Evaluation

The Zinc Injection System is not safety-related, and does not affect the safety function of any other safety related system.

9.3.11.4 Test and Inspections

The Zinc Injection System, if necessary, can be installed at the connection points provided. Zinc injection is not performed when the plant is in cold shutdown.

9.3.11.5 Instrumentation

Instrumentation can be provided to automatically stop the injection of zinc solution if feedwater flow stops. The zinc injection rate can be manually adjusted based on the zinc concentration in the reactor water.

9.3.12 Auxiliary Boiler System

9.3.12.1 Design Basis

Safety (10 CFR 50.2) Design Bases

The Auxiliary Boiler System (ABS) is a nonsafety-related system and has no safety design basis.

Power Generation Design Bases

The ABS supplies steam required by the unit for plant use during startup and shutdown and at any other time when the main steam or gland steam evaporator steam (refer to Subsection 10.4.3) are unavailable.

9.3.12.2 System Description

9.3.12.3 General Description

During plant startup and shutdown and also at normal operation (if required), the ABS provides the necessary non-radioactive steam at the required pressure to the following equipment:

- Steam Jet Air Ejectors to maintain the motive power required to perform a continuous evacuation of the non-condensable gasses from the Main Condenser and to the Off-gas System

- Turbine Gland Sealing System to allow the Main Condenser to reach vacuum
- Main Condenser to deaerate the condensate in the hotwell during the startup of the plant
- Hot water generator of the Hot Water System
- Preoperational testing of off-gas system equipment
- Evaporation of liquid nitrogen for inerting of the Containment

The COL applicant shall determine the required capacity of the ABS.

9.3.12.4 Component Description

The ABS components are located in the Auxiliary Boiler Building. The following components are part of the ABS.

- Two 100% packaged auxiliary boilers (Electrode Type)
- One 100% Deaerator with integral storage tank
- Two 100% Auxiliary Boiler Feedwater Pumps
- Two 100% Auxiliary Boiler recirculation pumps
- One 100% Auxiliary Boiler Drain Tank
- Two 100% Continuous Blowdown Flash Tank
- Two 100% Steam Separators
- Immersion heaters
- Instrumentation and controls

The Auxiliary Boilers are electrode-type boilers, which utilize electricity to boil demineralized water to produce steam during plant startup, shutdown and off-line operation when main steam or gland steam evaporator steam is unavailable.

The Makeup Water System provides makeup feedwater to the ABS. A pressure control valve maintains the steam supply pressure while a level control valve regulates Auxiliary Boiler feedwater flow to the boiler. The steam generated by the Auxiliary Boilers passes through a Steam Separator and is then distributed via two supply lines to the auxiliary steam header and to the gland steam supply line in the Turbine Gland Seal System. Each supply line contains an air-operated block valve and check valve for isolation.

The condensate from the Continuous Blowdown Flash Tank is directed to the Auxiliary Boiler Drain Tank. The non-radioactive area of the Equipment and Floor Drain System collects drains from the ABS.

The Auxiliary Boiler feedwater recirculation pumps and immersion heaters maintain a high circulating feedwater temperature when the ABS remains on hot standby.

The ABS has sample connections to monitor pH, dissolved oxygen and conductivity.

9.3.12.5 Safety Evaluation

The ABS does not perform or ensure any safety-related function and therefore requires no nuclear safety evaluation. High-energy pipe rupture analysis is not required for the ABS because none of the lines pass through areas where safety-related equipment is located.

9.3.12.6 Testing and Inspection Requirements

Testing of the ABS is performed prior to initial plant operation. Components of the system are monitored during operation to verify satisfactory performance.

9.3.12.7 Instrumentation

A boiler control system is provided with the Auxiliary Boiler package for automatic control of the Auxiliary Boiler. Features of the control system include automatic shutdown of the Auxiliary Boiler and the Auxiliary Boiler feedwater pumps on an abnormal condition.

The ABS is provided with the necessary controls and indicators for local or remote monitoring and control of the operation of the system.

9.3.13 COL Information

9.3.13.1 Process Sampling System

The COL applicant shall determine if additional sample points are required based on site conditions and actual equipment.

9.3.13.2 Equipment & Floor Drain System

The COL applicant shall determine the final size of the drywell sump.

9.3.13.3 Oxygen Injection and Hydrogen Water Chemistry Systems

The COL applicant shall provide an oxygen supply consisting of high-pressure gas cylinders or a liquid tank sufficient to meet the requirements of the hydrogen water chemistry system and the oxygen injection system as specified in Subsections 9.3.9 and 9.3.10.

9.3.13.4 Zinc Injection System

The COL applicant shall determine if a Zinc Injection System is required based on the site specific water quality requirements.

9.3.13.5 Auxiliary Boiler System

The COL applicant shall determine the required capacity of the Auxiliary Boiler based on site conditions as well as the design of the building heating system (steam or hot water based).

9.3.14 References

9.3-1 Electric Power Research Institute, "BWR Hydrogen Water Chemistry Guidelines," EPRI Report NP-4947-SR, 1987.

Table 9.3-1

Process Sampling System Sampling Measurements

Sampled System	Typical Process Measurements **
Reactor Water Cleanup/Shutdown Cooling System	Conductivity, Dissolved Oxygen, pH, Chloride, Silica, Corrosion Product Metals, Gross Activity, Corrosion Product Activity, Fission Product Activity, Sulfate, I-131, Total Anions, Organic Impurities
Control Rod Drive System	Conductivity, Dissolved Oxygen
Fuel and Auxiliary Pools Cooling System	Conductivity, pH, Chloride, Silica, Corrosion Product Metals, Gross Activity, Corrosion Product Activity, Fission Product Activity, I-131, Turbidity, Sulfate, Total Anions, Organic Impurities
Main Steam System*	Gaseous Fission Products (Xe, Kr)
Condensate and Feedwater System	Conductivity, Dissolved Oxygen, Corrosion Product Metals, Iron, Copper, Chloride, Isotopics, Sulfate
Moisture Separator Reheater System	Iron, Copper
Heater Drain and Vent System	Iron, Copper
Generator Cooling System	Sodium, Chloride, Silica, Iron, Copper
Condensate Purification System	Chloride, Conductivity, Dissolved Oxygen, Isotopics, Corrosion Product Metals, Iron, Copper, Sulfate
Main Condenser and Auxiliaries	Conductivity or Sodium
Auxiliary Boiler System	pH, Cation Conductivity, Silica, Sodium, Ammonia, Morpholine
Liquid Radwaste System Effluent Sample Tank	Gross Radioactivity and identification and Concentration of Principal Radionuclide and Alpha Emitters, State and Federal Environmental Discharge Requirement such as pH, Suspended Solids, Oil and Grease, Iron, Copper, Sodium Nitrate

* The main steam sampling is listed as part of the Turbine Building Sample Station, but due to the high pressure, temperature, and radiation involved with a main steam sample this sample may be routed to a separate sample panel.

** Actual sample points will be determined by the COL applicant based on site conditions and specific equipment (refer to Section 9.3.13)

Table 9.3-2

Major Equipment for EFDS

Clean Drain Subsystem		
Reactor Building clean area floor drains (including non-essential electrical areas)		
Tanks or sumps	Quantity:	1
	Usable Capacity:	Volume - ≥ 3.25 m^3 (≥ 859 gal)
Pumps	Quantity:	2 - 100% capacity
	Capacity:	Flow – 30.66 m^3/hr (135 gpm) per pump
		Head - 61 m (200 ft) at discharge
	Type:	Sump pump, ≤ 22.37 kW (≤ 30 hp)
Control Building clean area floor drains		
Tanks or sumps	Quantity:	1
	Usable Capacity:	Volume – ≥ 3.25 m^3 (≥ 859 gal)
Pumps	Quantity:	2 - 100% capacity
	Capacity:	Flow – 30.66 m^3/hr (135 gpm) per pump
		Head – 61 m (200 ft) at discharge
	Type:	Sump pump, ≤ 22.37 kW (≤ 30 hp)
Turbine Building clean area floor drains		
Tanks or sumps	Quantity:	3
	Usable Capacity:	Volume – ≥ 3.25 m^3 (≥ 859 gal) each
Pumps	Quantity:	6 - 100% capacity (2 per sump)
	Capacity:	Flow – 30.66 m^3/hr (135 gpm) per pump
		Head – 61 m (200 ft) at discharge
	Type:	Sump pump, ≤ 22.37 kW (≤ 30 hp)

Table 9.3-2
Major Equipment for EFDS (continued)

Low Conductivity Waste (LCW) Drain Subsystem		
Drywell equipment drains		
Tanks or sumps	Quantity:	1
	Usable Capacity:	Volume - ≥ 3.25 m^3 (≥ 859 gal)
Pumps	Quantity:	2 - 100% capacity
	Capacity:	Flow - 30.66 m^3/hr (135 gpm) per pump
		Head – 61 m (200 ft) at discharge
	Type:	Sump pump, ≤ 22.37 kW (≤ 30 hp)
Reactor Building equipment drains		
Tanks or sumps	Quantity:	2
	Usable Capacity:	Volume - ≥ 3.25 m^3 (≥ 859 gal) each
Pumps	Quantity:	4 - 100% capacity (2 per sump)
	Capacity:	Flow - 30.66 m^3/hr (135 gpm) per pump
		Head - 61 m (200 ft) at discharge
	Type:	Sump pump, ≤ 22.37 kW (≤ 30 hp)
Fuel Building equipment drains		
Tanks or sumps	Quantity:	1
	Usable Capacity:	Volume - ≥ 3.25 m^3 (≥ 859 gal)
Pumps	Quantity:	2 - 100% capacity (2 per sump)
	Capacity:	Flow – 30.66 m^3/hr (135 gpm) per pump
		Head - 61 m (200 ft) at discharge
	Type:	Sump pump, ≤ 22.37 kW (≤ 30 hp)

Table 9.3-2
Major Equipment for EFDS (continued)

Turbine Building equipment drains		
Tanks or sumps	Quantity:	3
	Usable Capacity:	Volume - ≥ 3.25 m^3 (≥ 859 gal) each
Pumps	Quantity:	6 - 100% capacity (2 per sump)
	Capacity:	Flow – 30.66 m^3/hr (135 gpm) per pump
		Head – 61 m (200 ft) at discharge
	Type:	Sump pump, ≤ 22.37 kW (≤ 30 hp)
Radwaste Building equipment drains		
Tanks or sumps	Quantity:	1
	Usable Capacity:	Volume - ≥ 3.25 m^3 (≥ 859 gal)
Pumps	Quantity:	2 - 100% capacity
	Capacity:	Flow – 30.66 m^3/hr (135 gpm) per pump
		Head – 18 m (60 ft) at discharge
	Type:	Sump pump, ≤ 22.37 kW (≤ 30 hp)
High Conductivity Waste (HCW) Drain Subsystem		
Drywell floor drains		
Tanks or sumps	Quantity:	1
	Usable Capacity:	Volume - ≥ 3.25 m^3 (≥ 859 gal)
Pumps	Quantity:	2 - 100% capacity
	Capacity:	Flow – 30.66 m^3/hr (135 gpm) per pump
		Head – 61 m (200 ft) at discharge
	Type:	Sump pump, ≤ 22.37 kW (≤ 30 hp)

Table 9.3-2
Major Equipment for EFDS (continued)

Reactor Building floor drains		
Tanks or sumps	Quantity:	2
	Usable Capacity:	Volume - ≥ 3.25 m^3 (≥ 859 gal) each
Pumps	Quantity:	4 - 100% capacity (2 per sump)
	Capacity:	Flow – 30.66 m^3/hr (135 gpm) per pump
		Head - 61 m (200 ft) at discharge
	Type:	Sump pump, ≤ 22.37 kW (≤ 30 hp)
Fuel Building floor drains		
Tanks or sumps	Quantity:	1
	Usable Capacity:	Volume - ≥ 3.25 m^3 (≥ 859 gal) each
Pumps	Quantity:	2 - 100% capacity (2 per sump)
	Capacity:	Flow – 30.66 m^3/hr (135 gpm) per pump
		Head - 61 m (200 ft) at discharge
	Type:	Sump pump, ≤ 22.37 kW (≤ 30 hp)
Turbine Building floor drains		
Tanks or sumps	Quantity:	3
	Usable Capacity:	Volume - ≥ 3.25 m^3 (≥ 859 gal) each
Pumps	Quantity:	6 - 100% capacity (2 per sump)
	Capacity:	Flow – 30.66 m^3/hr (135 gpm) per pump
		Head – 61 m (200 ft) at discharge
	Type:	Sump pump, ≤ 22.37 kW (≤ 30 hp)

Table 9.3-2
Major Equipment for EFDS (continued)

Radwaste Building floor drains		
Tanks or sumps	Quantity:	1
	Usable Capacity:	Volume - ≥ 3.25 m^3 (≥ 859 gal)
Pumps	Quantity:	2 - 100% capacity
	Capacity:	Flow – 30.66 m^3/hr (135 gpm) per pump
		Head – 18 m (60 ft) at discharge
	Type:	Sump pump, ≤ 22.37 kW (≤ 30 hp)
Detergent Drain Subsystem		
Turbine Building detergent drains		
Tanks or sumps	Quantity:	1
	Usable Capacity:	Volume - ≥ 3.25 m^3 (≥ 859 gal)
Pumps	Quantity:	2 - 100% capacity
	Capacity:	Flow - 30.66 m^3/hr (135 gpm) per pump
		Head - 61 m (200 ft) at discharge
	Type:	Sump pump, ≤ 22.37 kW (≤ 30 hp)
Radwaste Building detergent drains		
Tanks or sumps	Quantity:	1
	Usable Capacity:	Volume - ≥ 3.25 m^3 (≥ 859 gal)
Pumps	Quantity:	2 - 100% capacity
	Capacity:	Flow – 30.66 m^3/hr (135 gpm) per pump
		Head – 18 m (60 ft) at discharge
	Type:	Sump pump, ≤ 22.37 kW (≤ 30 hp)

Table 9.3-2
Major Equipment for EFDS (continued)

Chemical Waste Drain Subsystem		
Turbine Building Chemical waste drains		
Tanks or sumps	Quantity:	1
	Usable Capacity:	Volume - ≥ 3.25 m^3 (≥ 859 gal)
Pumps	Quantity:	2 - 100% capacity
	Capacity:	Flow - 30.66 m^3/hr (135 gpm) per pump
		Head - 61 m (200 ft) at discharge
	Type:	Sump pump, ≤ 22.37 kW (≤ 30 hp)
Radwaste Building Chemical drains		
Tanks or sumps	Quantity:	1
	Usable Capacity:	Volume - ≥ 3.25 m^3 (≥ 859 gal)
Pumps	Quantity:	2 - 100% capacity
	Capacity:	Flow – 30.66 m^3/hr (135 gpm) per pump
		Head – 18 m (60 ft) at discharge
	Type:	Sump pump, ≤ 22.37 kW (≤ 30 hp)
Reactor Component Cooling Water Waste Drain Subsystem		
Reactor Component Cooling Water System waste drains		
Tanks or sumps	Quantity:	1
	Usable Capacity:	Volume - ≥ 13 m^3 (≥ 3434 gal)
Pumps	Quantity:	2 - 100% capacity
	Capacity:	Flow - 30.66 m^3/hr (135 gpm) per pump
		Head – 61 m (200 ft) at discharge
	Type:	Sump pump, ≤ 22.37 kW (≤ 30 hp)

Table 9.3-3

Safety-Related Portions of the SLCS

- An accumulator tank for each SLCS train at ambient temperature containing a volume of a 12.5 weight % solution of sodium pentaborate with the boron content enriched to 94% of the B_{10} isotope, sufficient to ensure injection of at least 7.8 m^3 (2061 gal) of solution.
- A piping system for nitrogen charging and sparging of the solution with valves, controls, and logic necessary to maintain 14.8 m^3 (523 ft^3) of nitrogen cover gas at a minimum absolute pressure of 14.82 MPa (2150 psia) in the accumulator for each SLCS train.
- A pressure relief line and valve to prevent nitrogen pressure from exceeding the design pressure for each accumulator.
- A vent system to permit depressurization of each accumulator for access or after completion of solution injection.
- An injection line with valves, controls, and logic to ensure manual or automatic injection, and post injection closure of the line for each SLCS train. The injection line is a 3-in. stainless steel line designed for 17.24 MPa (2500 psia) internal pressure with corresponding ratings for the valves.
- Redundant level instrumentation for each accumulator to ensure adequate solution inventory and to initiate closure of the injection line on completion of solution injection.
- A poison solution line used for initial charging and any necessary periodic makeup to each accumulator.

Table 9.3-4

Safety-Related Support Systems for the SLCS

- Power from the Class 1E 250 VDC and 120 VAC power systems
- Initiation signals for automatic initiation
- A sparger system consisting of a two reactor vessel penetrations to serve two trains, two internal injection lines, two distribution manifolds, and in each quadrant four injection nozzles located in the external core bypass volume to ensure uniform solution injection, each nozzle has two jet-openings angled outwardly from each other.
- Instrumentation and alarms to ensure conformance to equipment environmental qualification constraints

Table 9.3-5

SLCS ATWS Mitigation Function Parameters

Parameter	Value
Initial reactor absolute pressure	8.61 MPa (1250 psia)
Approximate initial injection flow rate	18.4 l/s (292 gpm)
Approximate average injection velocity for the first 5.4 m^3 of the injection	30.5 m/s (100 ft/s)
Approximate average velocity for the second 5.4 m^3 of the injection	18.4 m/s (60 ft/s)
Total solution injection (per each train) at the initial reactor absolute pressure	5.4 m^3 (1427 gal)
Equivalent natural boron concentration for the total solution injection volume, based on a hot shutdown liquid inventory *	≥ 1600 ppm
With the water level at the main steam line, the total injection solution inventory (per each train), and equivalent natural boron concentration at cold shutdown conditions	≥ 7.8 m^3 (2061 gal) > 1100 ppm **

* Liquid inventory in RPV calculated based on reactor coolant level extending up to main steam line nozzle.

** This concentration ensures maintaining shutdown reactivity even after initiation and operation of the reactor shutdown cooling system.

Table 9.3-6

Instrument Air System Requirements

Capacity	
Flow rate:	22.7 m^3/min (800 scfm), minimum
Pressure	
Air compressor intake, absolute:	0.1 MPa (14.7 psi)
Air compressor discharge, gage:	0.86 MPa (125 psi)
System operating, gage:	0.62 to 0.86 MPa (90 to 125 psi)
Maximum system operating, gage:	0.86 MPa (125 psi)
Temperature	
Air compressor intake:	-23 to 38°C (-10 to 100°F)
After-cooler outlet:	46°C (115°F) maximum
Pressure Dewpoint	
Air dryer outlet:	-40°C (-40°F) maximum
Filtration	
Particle size:	3 microns maximum

Table 9.3-7

Service Air System Requirements

Capacity	
Normal flow rate:	28 m^3/min (1000 scfm)
Maximum flow rate:	56 m^3/min (2000 scfm)
Pressure	
Air compressor intake, absolute:	0.1 MPa (14.7 psi)
Air compressor discharge, gage:	0.7 MPa (100 psi)
System operating, gage:	0.65 to 0.72 MPa (94 to 105 psi)
Maximum system operating, gage:	0.86 MPa (125 psi)
Temperature	
Air compressor intake:	-23 to 38°C (-10 to 100°F)
After-cooler outlet:	38°C (100°F) maximum
Filtration	
Particle size:	10 micron maximum
Breathing air particle size:	0.5 micron maximum

Table 9.3-8

High Pressure Nitrogen Supply Requirements

Nitrogen Demand	
MSIVs and containment instrumentation (intermittent):	9627 l/min (340 scfm)
SRV and IC Isolation Valve accumulator recharging (intermittent):	12743 l/min (450 scfm)
SRV and IC Isolation Valve leakage:	0.472 l/min (1/60 scfm) each
Bottles (intermittent):	10307 l/min (364 scfm)
Normal nitrogen supply from CIS: (Intermittent):	12743 l/min (450 scfm) maximum
Pressure	
MSIV and other containment instruments supply:	8.79 kg/cm^{2}g (125 psig)
SRV and IC Isolation Valve accumulators supply (maximum):	14.06 kg/cm^{2}g (200 psig) maximum
SRV and IC Isolation Valve accumulators:	11.53 kg/cm^{2}g (164 psig) minimum
Bottle initial fill:	254.16 kg/cm^2 abs (3615 psia)

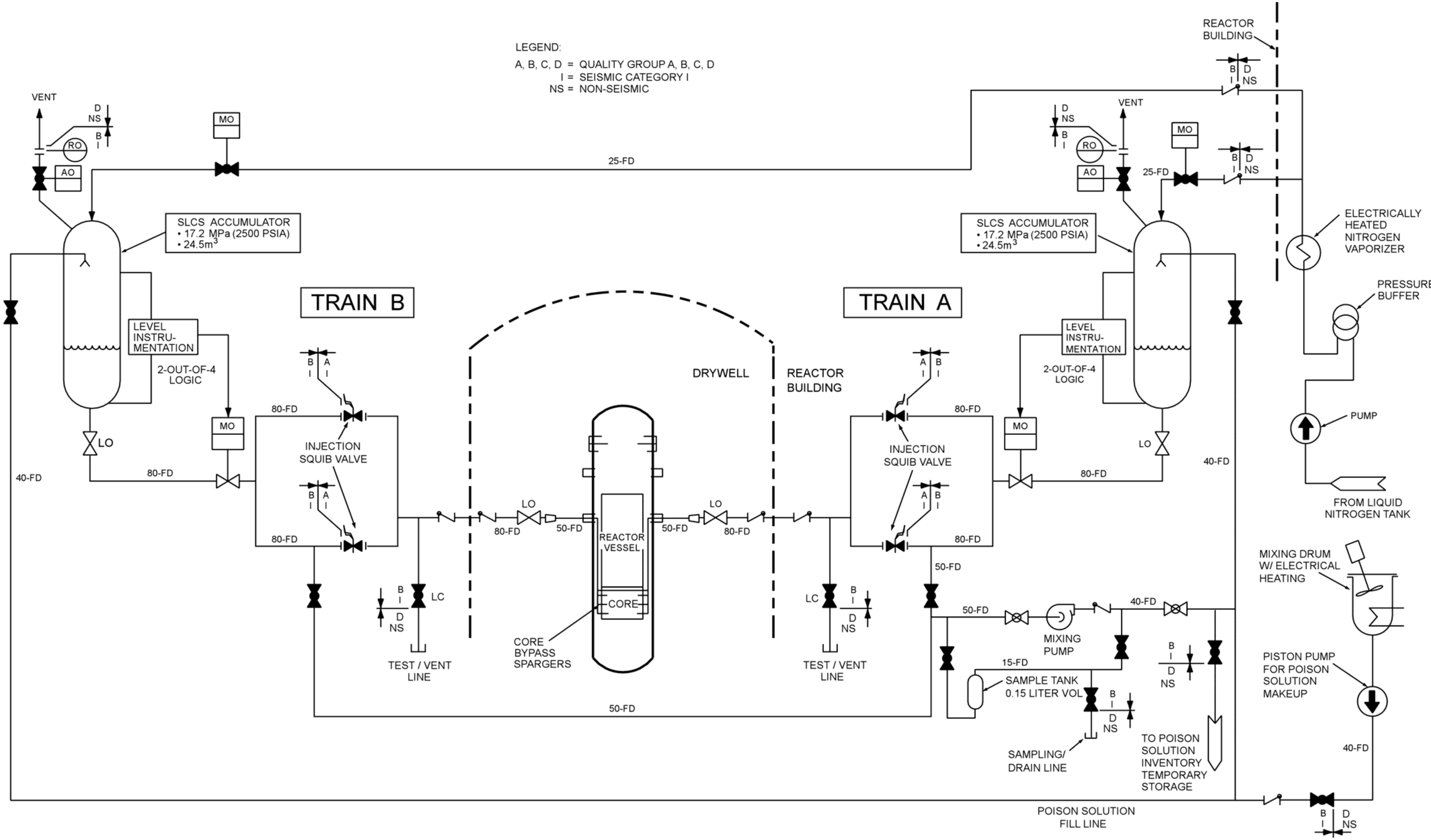


Figure 9.3-1. Standby Liquid Control System Simplified Diagram

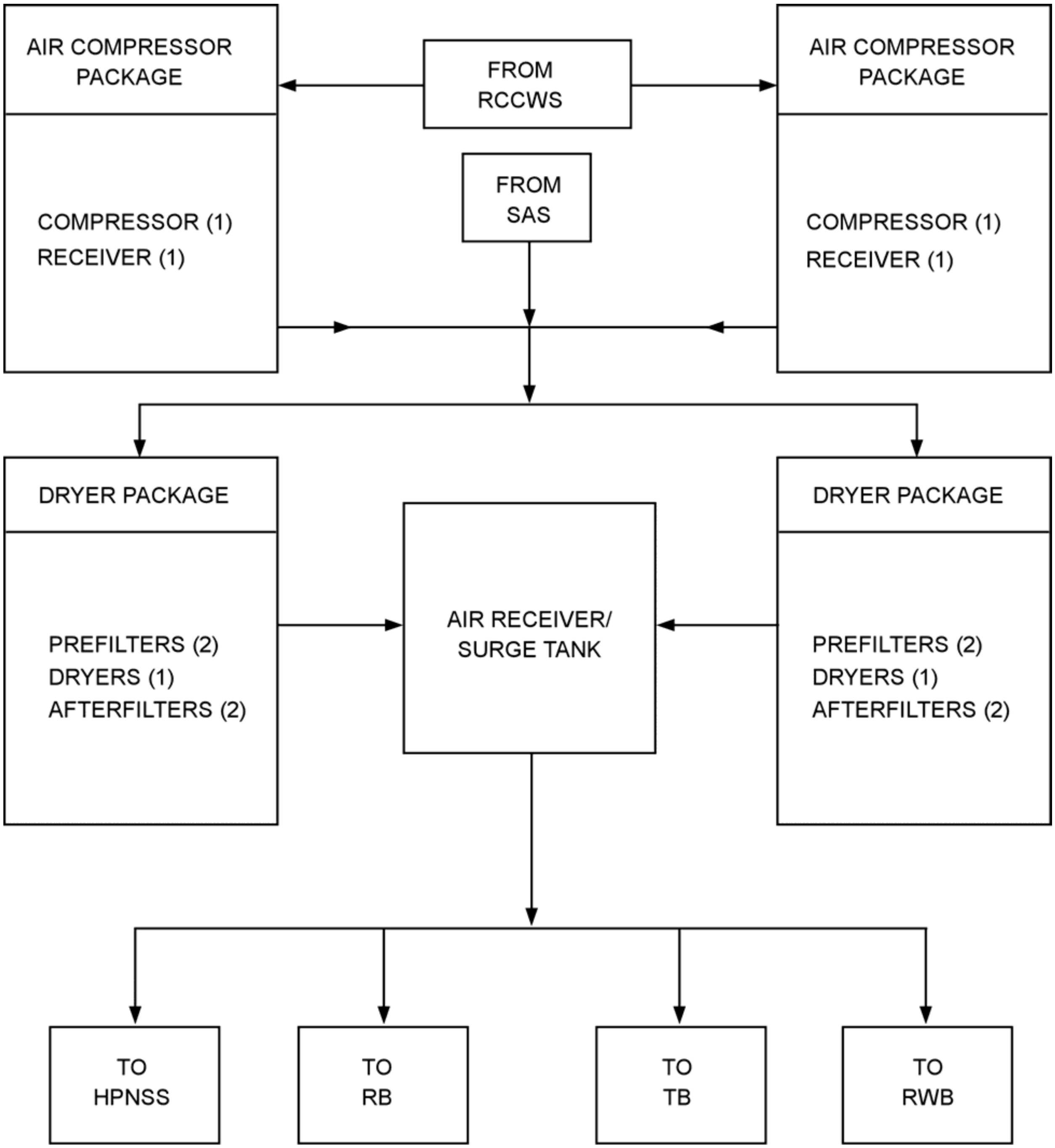


Figure 9.3-2. Instrument Air System Simplified Diagram

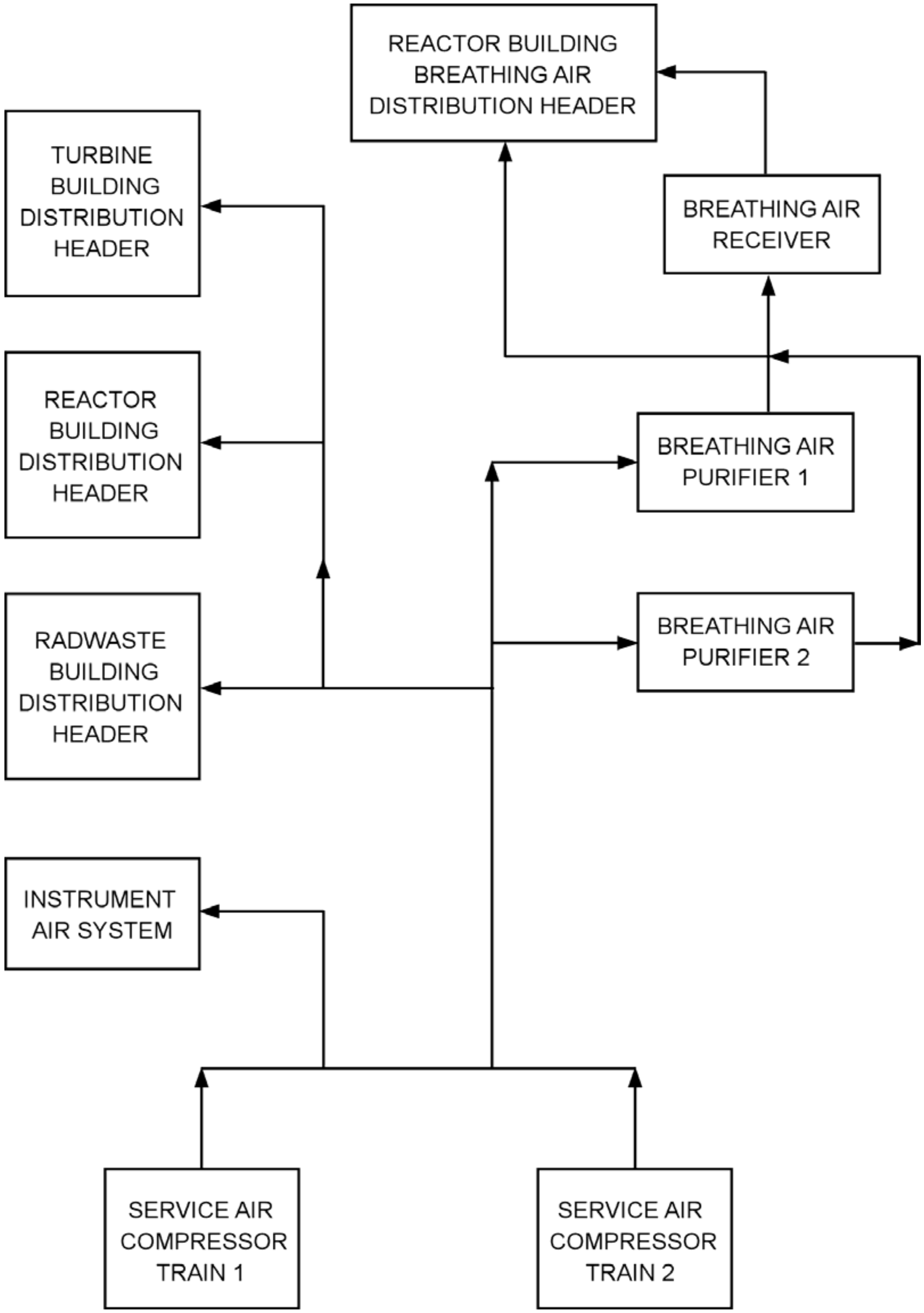


Figure 9.3-3. Service Air System Simplified Diagram

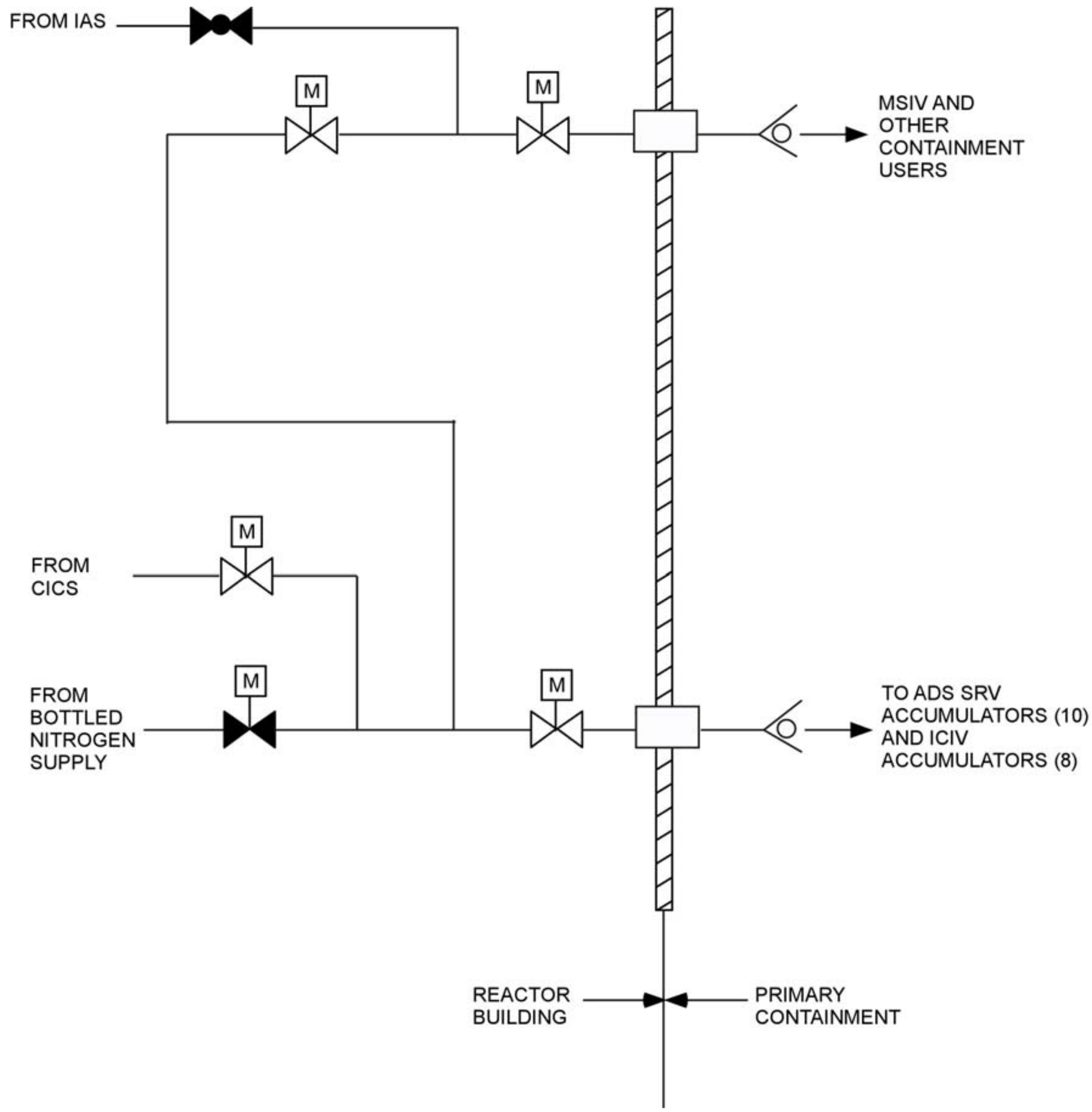


Figure 9.3-4. HPNSS Simplified Diagram

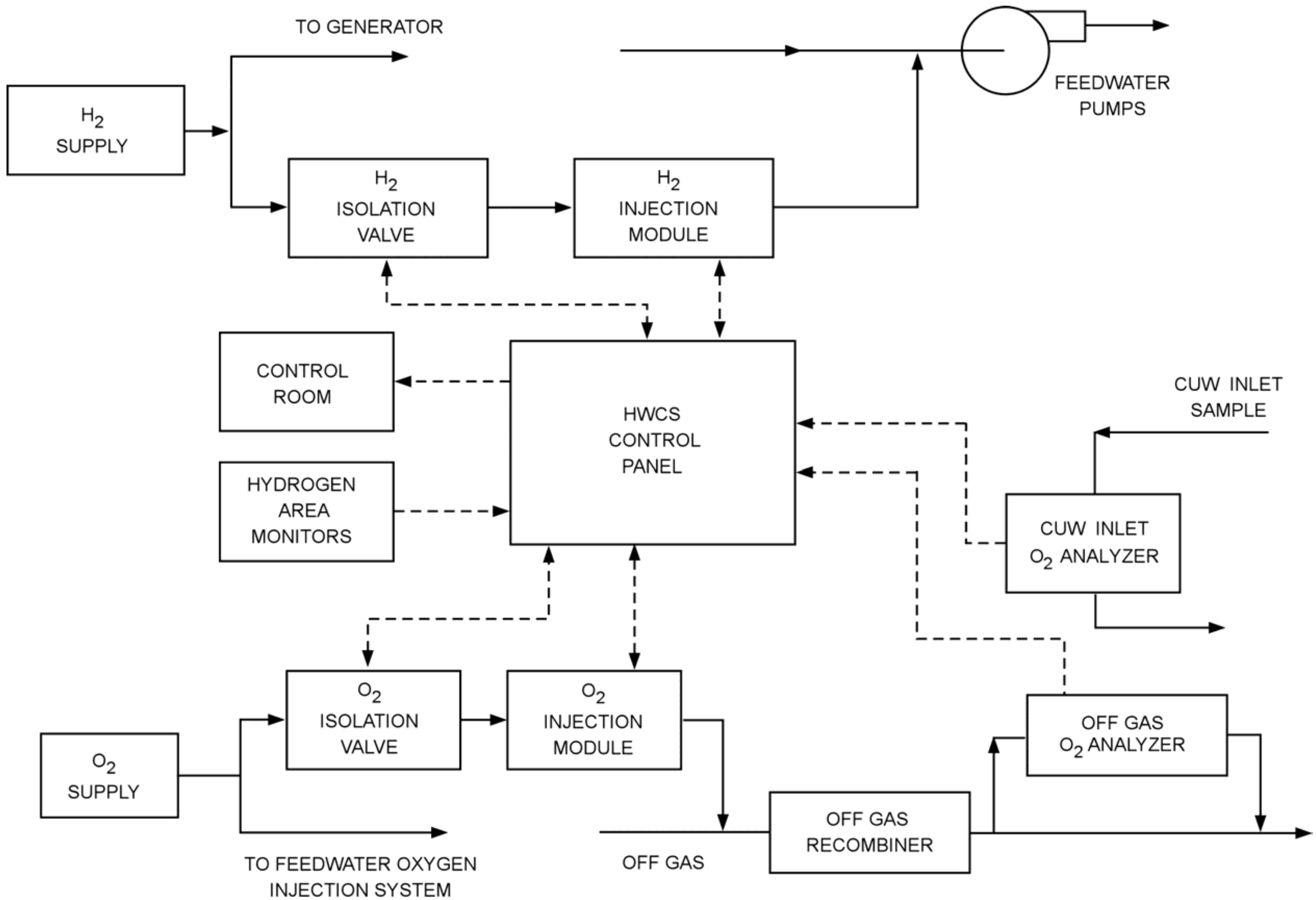


Figure 9.3-5. Hydrogen Water Chemistry System Simplified Diagram

9.4 AIR CONDITIONING, HEATING, COOLING, AND VENTILATION

9.4.1 Control Room Area Ventilation System

The Control Building Heating, Ventilation and Air Conditioning System (CBHVS) serves all areas of the Control Building. The CBHVS maintains space design temperatures, quality of air and pressurization. It provides a controlled environment for personnel safety and comfort, and for the proper operation and integrity of equipment located in the control building.

The CBHVS consists of three sub-systems:

- The Control Room Habitability Area HVAC Sub-system (CRHAHVS) serves the Main Control Room (MCR) and associated support areas. These areas comprise the Control Room Habitability Areas (CRHA).
- The Emergency Breathing Air System (EBAS) supplies pressurized air to the CRHA during radiological events in the event of a Station Blackout (SBO).
- The Control Building General Area HVAC (CBGAHVS) serves the area outside the CRHA.

9.4.1.1 Design Bases

Safety (10 CFR 50.2) Design Bases

Habitability requirements for the CRHA are discussed and described in Section 6.4.

Most CBHVS components are nonsafety-related. The exceptions are the CRHA envelope, isolation dampers and EBAS. These safety-related isolation dampers fail closed upon a loss of control signal, power, or instrument air. EBAS is automatically actuated upon isolation of the CRHA envelope.

Most CBHVS components are designated as Seismic Category II. Exceptions include the safety-related CRHA envelope, isolation dampers, EBAS and associated controls, which are Seismic Category I.

The following CRHA components are safety-related and Seismic Category I:

- Boundary envelope including structures, doors, and components.
- Connections to EBAS and EBAS components.
- Ductwork from the CRHA boundary envelope up to the CRHA isolation dampers and the CRHA isolation dampers.

The CBHVS outside air intake structures are nonsafety-related and do not require tornado dampers and tornado missile shields.

The CRHA envelope is comprised of Seismic Category I structures and components. This meets GDC Criteria 2 requirements regarding protection from postulated seismic events.

Whenever electric power is available, a release of toxic gas causes the CRHAHVS air inlet and exhaust dampers to close. The MCR air is recirculated with no outside air makeup. This meets

GDC 4 as it relates to accommodating the effects of and being compatible with postulated accidents and the effects of the release of toxic gases.

The ESBWR CBHVS supports a single unit, including one CRHA envelope. This meets the intent of GDC 5 because:

- Each ESBWR unit at a multi-unit site has a separate control room
- The ability to perform safety functions in the event of an accident in one unit
- An orderly shutdown and cool down of remaining unit(s) would not be impaired[raw825]

The CBHVS System provides a safety-related means to passively maintain habitable conditions in the CRHA following a design basis accident (radiological event concurrent with SBO).

An Emergency Filter Unit (EFU) including HEPA and charcoal filters serves the CRHA envelope when electric power is available.

Radiation detected in the CRHA outside air inlet causes the following actions:

- The normally closed EFU outside air inlet to open
- The normal outside air inlet and exhaust dampers to close
- The EFU to automatically start

The CRHA is isolated during SBO conditions and the safety-related EBAS provides pressurization and breathing quality air. This meets GDC 19, as it relates to maintaining a habitable control room under accident conditions by providing adequate radiation protection.

The CBHVS System provides the capability to maintain the integrity of the CRHA with redundant safety-related isolation dampers in all ductwork penetrating the CRHA envelope. The active safety-related components (CRHA isolation dampers and EBAS), that ensure habitability in the CRHA envelope, are redundant. Therefore a single active failure cannot result in a loss of the system performance capability.

During normal modes of operation and emergency modes with electrical power available, the CRHA is maintained within the temperature and relative humidity ranges noted in Table 9.4-1 by the nonsafety-related CRHAHVS. During emergency operation, with an SBO, a nonsafety-related MCR recirculation air handling unit (AHU), powered from the Uninterruptible AC Power Supply System, automatically starts and maintains the MCR temperature within 8.3°C of the normal operating temperature for two hours. This allows the continued operation of certain high heat producing nonsafety-related MCR DCIS electric loads. These nonsafety-related MCR DCIS electrical loads automatically de-energize should the redundant MCR recirculation AHU not be available. The MCR temperature rise is limited by the CRHA envelope design to 8.3°C for 72 hours in an emergency mode of operation with a SBO event by passive cooling features.

Power Generation Design Bases

The CBHVS System:

- Provides a controlled environment for personnel comfort and safety. Sufficient outside air is provided to meet ventilation requirements for acceptable indoor air quality per

ASHRAE 62-2001 (Table 2). See Table 9.4-1 for area design temperature and humidity design parameters.

- Provides a controlled environment for the proper operation and integrity of equipment in the Control Building during normal, startup and shutdown operations.
- Provides redundant active components to increase reliability, availability and maintainability of the ventilation system.
- Provides shutoff dampers on the inlet and outlet of fans and air handling units (AHU) to allow for maintenance.
- Provides shutoff valves at the inlet and outlet of cooling and heating coils to allow for maintenance.
- Provides access doors for AHU fans, filter sections and duct mounted dampers to allow for maintenance.
- Provides the capability for manual control of system fans to facilitate maintenance and testing.
- Minimizes exposure to personnel during inspection and maintenance by locating equipment and instrumentation as far as practical from potential sources of high radiation.
- Maintains higher than atmospheric (positive) pressure to minimize the infiltration of outside air. Construction materials and processes ensure the Control Building structure maintains low leakage or leak tight conditions above and below grade. The CRHA envelope penetrations are sealed and access doors are designed with self-closing devices that close and latch the doors following use. There are double door airlocks in the CRHA envelope for access and egress during emergencies when the CRHA is isolated and EBAS is operating.
- Reduces the potential spread of airborne contamination by maintaining airflow from areas of lower potential for contamination to areas of greater potential for contamination. The CRHA is maintained at a higher pressure than surrounding areas.
- Provides a safety-related means to passively maintain habitable conditions in the CRHA following a design basis accident (radiological event concurrent with SBO).
- Provides the capability to maintain the integrity of the CRHA with redundant safety-related isolation dampers in all ductwork penetrating the CRHA envelope.
- Detects and limits the introduction of airborne hazardous materials (radioactivity, smoke, chlorine gas, or other site-specific toxic gas) into the CRHA. Details regarding site-specific toxic gases will be described by the site-specific toxic gas study.
- Provides the capability to exhaust smoke, heat and gaseous combustion products from inside the Control Building to the outside atmosphere in the event of a fire. Construction materials and processes ensure that materials of construction are non-combustible and heat and flame resistant wherever possible. Materials that produce toxic or noxious vapors when subjected to a fire are avoided.

- Maintains its structural integrity after a Safe Shutdown Earthquake (SSE). Safety-related components must remain operational after a SSE.
- Is designed such that failure of the system does not compromise or otherwise damage safety-related equipment.
- Is provided with bullet-resistant exterior HVAC openings that penetrate the MCR vital envelope in accordance with 10 CFR 73.

9.4.1.2 System Description

Summary Description

The CBHVS sub-systems CRHAHVS and CBGAHVS are recirculating ventilation systems to provide filtered, heated and humidified, or cooled air to serve all areas of the Control Building. The EBAS provides breathing air and pressurization to the CRHA during a radiological event concurrent with an SBO. The CBHVS maintains space design temperatures and air quality. Outside air is normally supplied to augment the return air to maintain the building under a slight positive pressure. Return/exhaust fans normally direct most of the system airflow back to the system return flow with a portion of the flow exhausted to the atmosphere. CBHVS provides a controlled environment for personnel safety and comfort, and for the proper operation and integrity of equipment located in the Control Building.

CBHVS equipment, including fans, AHUs and the EFU are located within the Control Building Seismic Category II structural areas. The EBAS and the CRHA envelope are located within the Control Building Seismic Category I structural areas.

Detailed System Description

Figures 9.4-1, 9.4-2, 9.4-3 and 9.4-4 show the simplified system diagrams for the CRHAHVS, the EBAS and the CBGAHVS Set A and B, respectively. Table 9.4-2 lists the major equipment that comprises the CBHVS system.

The CRHA envelope includes the following areas:

- Main Control Room
- Shift Supervisor Office
- Shift Supervisor Conference Room
- Operator’s Area
- Shift Technical Advisor Office
- Main Control Room Storage Room
- Electrical Panel Board Room
- Restroom A
- Restroom B

These areas constitute the operation control area, which can be isolated and remain habitable for 72 hours, if required, by the existence of a LOCA or high radiation condition. Also, potential

sources of danger such as steam lines, pressurized piping, pressure vessels, CO_2 fire fighting containers, etc. are located outside of the CRHA.

The CRHAHVS consists of two trains. Each train consists of:

- One 100% capacity supply AHU
- One 100% capacity return/exhaust fan
- One 100% capacity emergency filtration unit (EFU)
- One 100% EFU fan
- Redundant set of CRHA isolation dampers (safety-related)
- Supplemental electric duct heaters

In addition, two 100% capacity MCR recirculation AHUs and two 100% air-cooled condensing units are provided.

The CRHAHVS is configured as a recirculation system that incorporates a common supply and return duct system for distributing conditioned air to the CRHA. The outside air intake and exhaust are adjusted as required to maintain a slightly positive pressure in the CRHA.

The intake design and location are in accordance with Regulatory Guide 1.194. Intake design, location and control also include considerations that minimize the introduction of radiological material, toxic gases, hazardous chemicals, smoke, dust and other foreign material. Ductwork, housings, access openings, etc. are constructed in such a manner as to minimize inleakage of potentially contaminated air into the CRHAHVS air stream.

During normal operation, air travels through the AHU stages and particulates are removed from the air by low and high efficiency filters. Heat is transferred between the air and the heating and cooling coils. Moisture is added to the heated air stream, if required, to maintain minimum humidity levels in the CRHA by the automatically controlled humidifier. Moisture is removed from the cooled air stream. The supply AHU distributes conditioned air through ductwork to the CRHA.

Each EFU consists of an electric heating coil, medium efficiency filters (40-45%), high efficiency particulate air (HEPA) filters and charcoal adsorption filters. The EFUs operate only during a radiological emergency when electrical power is available.

Exhaust air from the restroom is ducted to the exhaust fan and exhausted to the outside atmosphere.

The MCR recirculation AHUs provide cooling to the MCR during the first two hours of an SBO. This nonsafety-related system automatically starts and removes heat generated from nonsafety-related heat rejection loads that are only energized during the first two hours of the SBO. If the recirculation AHUs are not available during the SBO, the nonsafety-related loads are automatically de-energized. The air-cooled condensing outdoor units (CDU) reject the MCR recirculation unit heat. The Uninterruptible AC Power Supply System provides power for the MCR recirculation AHUs and CDUs.

The EBAS consists of multiple independent redundant compressed breathing air tank trains.

Each train consists of:

- Compressed breathing air tanks
- A two stage pressure regulator
- Isolation valves
- A sample port
- CRHA distribution piping
- An overpressure relief valve, filling port and manual vent

The EBAS provides sufficient breathing quality air to maintain positive pressure in the CRHA during a SBO concurrent with a radiological event. The EBAS system is automatically initiated.

The CBGAHVS consists of:

- Two sets of two 100% capacity supply AHUs
- Two sets of two 100% capacity return/exhaust fans
- Supplemental electric duct heaters

The CBGAHVS serves non-divisional equipment rooms, corridors and other miscellaneous rooms in the Control Building general areas. Set A serves Division I and IV areas. Set B serves Division II and III areas. Each set is configured as a recirculation system that incorporates a common supply and return duct system for the distribution of conditioned air. During normal operation air travels through the AHU stages. Particulates are removed from the air by low and high efficiency filters. Heat is transferred between the air and the heating and cooling coils. The outside air intake and exhaust are adjusted to maintain a slightly positive pressure in the Control Building general areas.

System Operation

The CBHVS operates during all modes of normal power plant operation, including startup and shutdown. The CBHVS is not required to operate during an SBO except for the EBAS. During an SBO concurrent with a radiological event the EBAS operates for up to 72 hours. Also, the MCR AHUs/CDUs operate for the first two hours of an SBO; otherwise certain nonsafety-related loads are automatically de-energized. The CRHA isolation dampers fail closed on a loss of AC power or instrument air. Rooms containing safety-related equipment have passive cooling features to limit the temperature rise to the maximum temperature limits listed in Table 9.4-1 for the first 72 hours of an SBO.

Normal Operating Mode:

- Each sub-system of the CBHVS is fully operable with one train of its redundant equipment inoperable
- The CRHAHVS and CBGAHVS operate with one supply AHU and one exhaust/return fan in operation to maintain design conditions in the respective areas served. The outside air intakes and exhausts are adjusted to maintain a slightly positive pressure in the CRHA and CBGA
- The CRHAHVS maintains normal design conditions in the CRHA. One supply AHU and its corresponding return/exhaust fan is manually selected to start and cause its return

air and outside dampers to open to the required positions. The MCR recirculation AHUs/CDUs, the EFUs, and EFU fans do not operate during normal operation

- The CBGAHVS maintains normal design conditions in the general areas of the Control Building. One supply AHU and its corresponding return/exhaust fan is manually selected to start and cause its return air and outside dampers to open to the required positions
- Electric duct heaters and unit heaters provide heat when required to maintain minimum space temperature. Thermostats control the unit heaters to maintain the space temperatures. Heating coils are provided in the supply AHUs when required to preheat the outside air
- Cooling coils are provided in the supply AHUs and provide cooling to the CRHA and Control Building general areas as required to maintain design conditions

Standby Operating Mode, in the event of low airflow in a supply or exhaust duct:

- The operating AHU and return/exhaust fan trips and the associated isolation dampers close.
- The standby AHU and return/exhaust fans start and associated dampers automatically open.

Fire/Smoke Operating Modes

The following is a brief description of the Fire/Smoke Operating Modes. For a more complete description of the interface between the HVAC systems and the Fire Protection System, refer to Section 9.5.1.2.9.

- Upon detection of smoke in the CRHAHVS or the CBGAHVS outside air intake, the normal outside air inlet dampers and the exhaust dampers close. Return air is recirculated through the AHU. In the CRHAHVS, only the restroom exhaust air dampers close. With the exhaust flow path closed, the CRHAHVS restroom exhaust fan is stopped manually.
- Upon detection of smoke in the CRHAHVS or the CBGAHVS supply or return air duct the sub-system shuts down and the isolation dampers close.
- MCR operators manually initiate the smoke purge mode of operation of the CRHAHVS or the CBGAHVS. Fully opening the normal outside air inlet dampers and exhaust air dampers and closing the recirculation dampers accomplish smoke purge. This provides 100% outside airflow. Any closed dampers in the fire area that are required to be open for purging smoke are reopened as part of the smoke purge mode. Area smoke detectors are provided in the CRHA and general areas of the Control Building.

Radiological Event Operation:

- When AC power is available, an outside air high radiation signal automatically starts the EFU fan and opens the normally closed outside air inlet dampers to the EFU. The signal also closes the normal outside inlet dampers to the AHU and closes the exhaust air dampers. All outside air is drawn through an EFU. Return air is routed to both the EFU and the AHU.

- When offsite and onsite AC power is lost (SBO), detection of an outside air high radiation condition initiates an automatic shutdown signal in the CRHAHVS control system. The signal shuts down the supply AHU, the associated return/exhaust fan and sends a closure signal to the redundant CRHA isolation dampers. Due to the SBO event EBAS is automatically started to supply breathing air to the CRHA. The MCR recirculation AHUs/CDUs also start. The loss of AC Power causes the supply AHU, return/exhaust fan and restroom exhaust fan operation to stop. Note that the loss of AC power would cause the CRHA isolation dampers to revert to their fail-safe position (closed).

Toxic Gas Mode Operation:

- Upon detection of a toxic gas present at the outside air intake to the CRHAHVS the outside air and exhaust dampers automatically close. The restroom exhaust dampers automatically close. Full return airflow is recirculated through the supply AHU. With the restroom exhaust flow path closed, the CRHAHVS restroom exhaust fan is manually stopped.
- Toxic gas sensors are provided as required by site-specific conditions.

9.4.1.3 Safety Evaluation

The CBHVS is nonsafety-related except for the CRHA envelope and EBAS, which are safety-related. The CRHA envelope includes structures, doors, components, ductwork between the CRHA envelope and the isolation dampers and the isolation dampers. The redundant isolation dampers fail closed upon a loss of control signal, power, or instrument air.

9.4.1.4 Testing and Inspection Requirements

Routine testing of components of the CBHVS is conducted in accordance with routine power plant requirements for demonstrating system and component operability and integrity.

Periodic surveillance testing of safety-related CRHA isolation dampers and the EBAS components are performed per IEEE-338. Safety-related CRHA isolation dampers and the EBAS are operational during plant normal and abnormal operating modes. The EBAS pressure-retaining components (tanks, piping and valves) are designed to meet the in-service inspection (ISI) requirements of ASME Section XI.

The CRHAHVS filtration components are periodically tested in accordance with ANSI/ASME N509, Nuclear Power Plant Air Cleaning Units and Components, and ANSI/ASME N510, Testing of Nuclear Air Cleaning Systems. HEPA filters are tested periodically with dioctyl phthalate (DOP), and the charcoal filters are periodically tested for bypasses.

9.4.1.5 Instrumentation Requirements

The CBHVS system component operating status and system parameters are monitored, indicated and controlled in the MCR and locally when required.

CRHA Isolation Damper position indicators (open/closed) are provided and are located in the MCR.

Flow instrumentation is provided for fans and AHUs to indicate status and to trip malfunctioning units on low flow and to start standby units.

Differential pressure transmitters are used to indicate filter pressure drop and alarm high filter pressure drop.

CRHAHVS differential pressure transmitters are provided to monitor CRHA pressure with respect to atmosphere and adjacent areas. Multiple transmitters are used with low select logic to compensate for wind effects.

CRHA airlock door position instrumentation is provided and an audible alarm sounds if airlock doors are open during a SBO.

Room temperature sensors are provided to:

- Monitor Room Temperature
- Provide control signals to heating and cooling coils
- Provide alarms on high or low space temperatures

Duct temperature sensors are provided to indicate outside air, coil entering, and coil leaving and supply temperatures as required by system logic control.

Instrument sensing elements are located and mounted such that the accuracy of the measured parameter is representative and optimized.

Smoke detectors are provided as required by NFPA 90A to detect smoke in the system ductwork and Control Building areas.

Site-specific toxic gas detectors are provided in air intake plenums as required. An audible alarm sounds in the MCR if a toxic gas is detected.

The Essential DCIS (E-DCIS) provides a control and instrumentation data communication network to support the CBHVS safety-related building isolation dampers.

9.4.2 Fuel Building HVAC System (FBHVS)

The Fuel Building Heating Ventilation and Air Conditioning System (FBHVS) serves the following areas of the Fuel Building:

- General areas,
- Spent Fuel Pool,
- Equipment areas.

9.4.2.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The FBHVS is nonsafety-related except for the isolation dampers and ducting penetrating the Fuel Building boundary. The Fuel Building boundary is automatically isolated in the event of fuel handling accident or other radiological accidents. With the above exception, the FBHVS performs no safety-related functions.

Power Generation Design Bases

The Fuel Building HVAC System:

- Provides a controlled environment for personnel comfort, and proper operation and integrity of equipment located in the building. See Table 9.4-3 for area temperatures.
- Maintains a negative pressure in the building to minimize exfiltration of potentially contaminated air. See Table 9.4-3 for system design pressures.
- Maintains airflow from areas of lower potential for contamination to areas of greater potential for contamination.
- Is provided with redundant active components to increase the reliability, availability, and maintainability of the system.
- Is capable of exhausting smoke, heat and gaseous combustion products in the event of a fire.
- Shuts down during radiological accidents and isolates the Fuel Building boundary to prevent uncontrolled releases to the outside atmosphere.
- Provides capability to divert exhaust air to the Reactor Building HVAC Purge Exhaust Filter Unit.
- Provides pool sweep ventilation air over the Spent Fuel Pool surface.
- Is designed such that failure of the system does not compromise or otherwise damage safety-related equipment.
- Is provided with shutoff dampers on the inlet and outlet of fans and AHUs to allow for maintenance.
- Is provided with shutoff valves at the inlet and outlet of cooling and heating coils to allow for maintenance.
- Is provided with access doors for AHUs, fans, filter sections, and duct-mounted dampers to allow for maintenance.
- Is provided with capability for manual control of system fans to facilitate testing and maintenance.
- Maintains its structural integrity after a Safe Shutdown Earthquake.

Relative to the FBHVS, this subsection addresses applicable requirements of General Design Criteria (GDC) 2, 5, 60 and 61. These GDCs are discussed in Standard Review Plan (SRP) 9.4.2 Rev.2, July 1981.

The ESBWR:

- Meets GDC 2, as it relates to meeting the guidance of Regulatory Guide (RG) 1.29. Applicable sections of RG 1.29 are Position C.1 for safety-related portions and Position C.2 for nonsafety-related portions.
- Meets GDC 5, as it relates to shared systems and components important to safety for the Fuel Building isolation dampers.

- Meets GDC 60, as to the systems capability to suitably control release of gaseous radioactive effluents to the environment. The system may direct its exhaust air to the Reactor Building HVAC Purge Exhaust Filter Unit during periods of high radioactivity. The Reactor Building HVAC Purge Exhaust Filter Unit is designed, tested and maintained in accordance with Regulatory Guide 1.140.
- Meets GDC 61, as it relates to the capability to provide containment, confinement, and filtering to limit releases of airborne radioactivity. The system may direct its exhaust air to the Reactor Building HVAC Purge Exhaust Filter Unit during periods of high radioactivity. The Reactor Building HVAC Purge Exhaust Filter Unit is designed, tested and maintained in accordance with Regulatory Guide 1.140.

9.4.2.2 System Description

Summary Description

The FBHV System maintains space design temperatures, quality of air, and pressurization in the Fuel Building. The system consists of two sub-systems: FBGAHV and FBFPHV. The FBGAHV serves the general areas of the Fuel Building. The FBFPHV serves the Spent Fuel Pool and equipment areas of the Fuel Building. Recirculation air handling units provide supplementary cooling for selected rooms in the Fuel Building.

Detailed System Description

Figure 9.4-5 shows the simplified system diagram for the FBGAHV sub-system. Table 9.4-4 shows the major equipment for FBGAHV sub-system.

The FBGAHV is a once-through ventilation system with redundant air handling units (AHUs), exhaust fans and Fuel Building boundary isolation dampers. Each AHU includes low and medium efficiency filters, heating and cooling coils, and an AHU supply fan. Outside air is filtered and heated or cooled prior to being distributed by the AHU in service. A common supply duct system is incorporated to distribute conditioned air to the general areas of the Fuel Building. The exhaust fan discharges the air to the outside atmosphere through the monitored vent stack where the exhaust air is monitored for radioactivity. The exhaust air may be manually diverted to the Reactor Building HVAC Purge Exhaust Filter Unit. Electric unit heaters provide supplementary heating. A recirculation AHU provides supplementary cooling for the fine motion control rod drive (FMCRD) room.. The hot water and chilled water systems provide heating and cooling water for the FBGAHV AHUs. The instrument air system provides instrument air for the pneumatic actuators.

The FBGAHV AHUs are located in the Fuel Building HVAC Equipment Area.. The FBGAHV exhaust fans are located in the Reactor Building. The FMCRD recirculation AHU is located in the Fuel Building.

Figure 9.4-6 shows the system diagram for the FBFPHV sub-system. Table 9.4-5 shows the major equipment for the FBFPHV sub-system.

The FBFPHV is a once-through ventilation system with redundant AHUs and exhaust fans. Each AHU includes low and medium efficiency filters, heating and cooling coils, and an AHU supply fan. Outside air is filtered, heated or cooled, and distributed across the Spent Fuel Pool surface and to the equipment areas. Air is exhausted from the Spent Fuel Pool, through

redundant Fuel Building boundary isolation dampers, to the outside atmosphere through the vent stack. During high radiation conditions, the exhaust air may be manually diverted to the Reactor Building HVAC Purge Exhaust Filter unit. The exhaust fans are also used for smoke removal. Electric unit heaters provide supplementary heating. Cooling for the FBFPHV AHUs is provided by the chilled water system. Instrument air is provided for the pneumatic actuators.

The FBFPHV AHUs are located in the Fuel Building HVAC Equipment Area.. The FBFPHV exhaust fans are located in the Reactor Building.

During high radiation conditions, the Fuel Building boundary isolation dampers close automatically and the supply AHU and exhaust fan shut down automatically in both sub-systems.

System Operation

The FBHV operates during all normal, startup and shutdown modes of plant operation.

During normal operation, both the FBGAHV and FBFPHV sub-systems are fully operable. Each sub-system operates with one supply AHU and one exhaust fan in service. The redundant AHU and fans are maintained on standby. In the event of low airflow in an exhaust duct, the standby exhaust fan starts. Simultaneously, due to a loss of negative pressure in the area, the AHU supply fan serving the area stops. The AHU supply fan restarts upon reestablishment of the required negative pressure. In the event of a fan failure, the failed fan automatically shuts down and the standby fan automatically starts.

On detection of high radiation, the Process Radiation Monitoring System provides a signal that trips the FBGAHV and FBFPHV sub-systems. Each sub-system's supply AHU and exhaust fan shuts down and their associated dampers close. Exhaust air from either sub-system may be manually diverted to the Reactor Building HVAC purge exhaust filter unit. It is then exhausted to the plant vent stack by the Reactor Building HVAC purge exhaust filter unit exhaust fan. Normal ventilation for the area is resumed once the area is decontaminated or the source of radioactivity is removed.

If smoke is detected in a supply air duct, the affected sub-system is shut down. In the event of a fire, fire dampers close to isolate the fire area. Following a recovery from a fire, a sub-system exhaust fan removes smoke from the area by exhausting to the outside.

The FMCRD room AHU fan is started and stopped locally. A room thermostat modulates the chilled water valve in response to the room temperature.

An individual local thermostat controls each electric unit heater.

9.4.2.3 Safety Evaluation

The FBHV System is not required to operate during a Station Blackout (SBO).

The Fuel Building boundary isolation dampers automatically close in the event of a fuel handling accident or other radiological accident. The safety-related isolation dampers fail closed upon a loss of control signal, power, or instrument air.

The FBHVS components are designed as Seismic Category II, except for the safety-related isolation dampers and associated controls. The isolation dampers and associated controls are designed as Seismic Category I.

The FBHV does not have any safety-related functions, except for boundary isolation dampers closing in the event of radiological accidents. Redundant dampers and controls are provided so the refueling area is isolated upon demand even if a damper or control fails.

9.4.2.4 Testing and Inspection Requirements

The FBHV System is designed to permit periodic inspection and testing of major components, such as fans, motors, dampers, coils, filters, ducts, piping, and valves to verify their integrity and capability. Equipment layout provides easy access for inspection and maintenance.

Routine testing of the FBHV System is conducted in accordance with normal power plant requirements. This testing demonstrates system and component operability and integrity.

Surveillance testing of safety-related isolation dampers is carried out in accordance with IEEE-338.

9.4.2.5 Instrumentation Requirements

The FBHV System is operated from the Main Control Room. The Fuel Building ventilation systems are manually controlled, except for certain automatic operations described below.

- Fuel Building boundary isolation dampers close on receipt of a high radiation signal or on a loss of AC power.
- For supply and exhaust fans, the lead fan is selected manually. The standby fan automatically starts upon indication of low flow in the associated discharge duct.
- Fan operation is allowed only when the corresponding fan shutoff dampers (one upstream and one downstream) are open.
- Supply fans auto start after the exhaust fans have started and a negative pressure has been established in the ventilated spaces.
- Differential pressures between the ventilated spaces and the outside are transmitted to a pressure controller. The pressure controller adjusts the exhaust fan's variable inlet vanes and exhaust airflow to maintain a negative pressure.

The FBHVS system component operating status and system parameters are monitored and indicated in the MCR and locally where required.

Indications and alarms include the following:

- Indicators for system operating parameters, including flow rates, temperatures, damper position, filter pressure drop and building pressure with respect to atmospheric;
- Alarms for high or low conditions, including airflow rates, temperatures, filter pressure drop, building differential pressure and smoke detection.

9.4.3 Radwaste Building Heating, Ventilation and Air Conditioning System

The Radwaste Building HVAC (RWBHVAC) system consists of the following subsystems:

- Radwaste Building Control Room (RWBCR) HVAC subsystem
- Radwaste Building General Area (RWBGA) HVAC subsystem

For the nonsafety-related portions of the RWBHVAC, this subsection addresses or refers to other DCD locations that address the applicable requirements of General Design Criteria (GDC) 2, 5 and 60 discussed in Standard Review Plan (SRP) 9.4.3 Rev. 2, July 1981. The ESBWR:

- Meets GDC 2, as it relates to meeting the guidance of Regulatory Guide 1.29, Position C.2 for nonsafety-related portions.
- Because there are no shared systems and/or components important to safety in the Radwaste Building, GDC 5 does not apply.
- Meets GDC 60, as to the systems capability to suitably control release of gaseous radioactive effluents to the environment. The system can direct its exhaust air to the RWBGA exhaust filtration units. The RWBGA exhaust filtration unit is designed, tested and maintained in accordance with Regulatory Guide 1.140.

9.4.3.1 Design Bases

The RWBHVAC system provides a controlled environment for personnel comfort and for proper operation and integrity of equipment.

RWBCR HVAC subsystem

- The RWBCR HVAC subsystem maintains the Radwaste Building control room area temperature.
- The RWBCR HVAC subsystem maintains the control room areas at a slightly positive pressure relative to adjacent areas to minimize infiltration of air.
- Redundant components are provided to increase system reliability, availability and maintainability.

RWBGA HVAC subsystem

- The RWBGA HVAC subsystem maintains the conditions in the Radwaste Building general area as provided in Table 9.4-6.
- The RWBGA HVAC subsystem maintains the Radwaste Building general area at a slight negative pressure relative to adjacent areas and outside atmosphere to prevent the exfiltration of air to adjacent areas. Adequate exhaust from the trailer bays is provided to maintain inflow of air from the outside when the truck doors are open.
- The RWBGA HVAC subsystem is comprised of supply and exhaust subsystems to maintain direction of air flow from personnel occupancy areas towards areas of increasing potential contamination. Exhaust hoods are provided at locations where, under normal operation, contaminants could escape to the surrounding areas.
- The RWBGA HVAC subsystem provides the capability to exhaust air from the mobile radwaste processing systems.
- All exhaust air from the Radwaste Building general area is discharged to the plant vent stack.
- Redundant components are provided as necessary to increase system reliability, availability and maintainability.

- Filtered outdoor air is provided at a minimum air exchange rate of two volume changes per hour.
- The RWBGA HVAC subsystem limits the release of airborne radioactive particulates to the atmosphere by HEPA filtering of the exhaust air from the building prior to discharge to the atmosphere.
- The exhaust air is monitored for radiation prior to discharge to atmosphere.

9.4.3.2 System Description

Summary Description

The RWBCR HVAC subsystem is a recirculating air conditioning system to provide filtered, heated or cooled, and humidified air to the RWBCR area to maintain the required design ambient conditions and pressurization. The RWBCR consists of two 100% capacity air-handling units and a common outside air intake louver. Each air-handling unit contains prefilters, high efficiency filters, a humidifier, a chilled water cooling coil, a hot water heating coil, and a supply fan section. Conditioned air is supplied to the control room area through ducts, dampers and registers.

The RWBCR HVAC subsystem is capable of once-through operation for smoke removal using a separate 100% capacity exhaust fan.

The RWBGA HVAC subsystem is a once-through air conditioning system to provide filtered and heated or cooled, and humidified air to the RWBGA. The RWBGA HVAC supply consists of two 100% capacity air-handling units connected to a common supply distribution ductwork and a common outside air intake louver. Isolation dampers are provided at the inlet and outlet of each unit. Each air-handling unit contains prefilters, high efficiency filters, a chilled water cooling coil, a hot water heating coil, a humidifier, a centrifugal fan, and an automatic damper.

The RWBGA HVAC subsystem exhaust consists of three 50% capacity filtration trains, each with a medium efficiency prefilter and a HEPA filter, a 50% capacity exhaust fan, and a check valve/backdraft damper. Exhaust capacity is greater than the supply capacity in order to maintain the required RWBGA negative pressure. Each filtration train is connected to a common exhaust collection duct and a common exhaust duct discharging to the plant vent stack.

The RWBGA HVAC exhaust subsystem is capable of once-through operation for smoke removal. The HEPA filters are bypassed in this mode.

Detailed System Description

The RWBHVAC system simplified system diagram is provided in Figure 9.4-7. The system includes the major equipment listed in Table 9.4-7.

The RWBHVAC system equipment is located in the Radwaste Building HVAC Fan and Filter room.

All RWBHVAC system equipment is classified as nonsafety-related, seismic Category NS, and is powered from a non-safety bus distribution system.

The Hot Water System and the Chilled Water System provide the heating and cooling for the air-handling units. Makeup water is provided to the humidifiers and instrument air is provided to the pneumatic controls.

Hot water from the Hot Water System is piped to and from heating coils in the air-handling units. Flow control valves adjust the hot water flow through the heating coils by using signals from temperature sensors in the Radwaste Building.

System Operations

The RWBCR HVAC subsystem operates by mixing return air and outside air. The air mixture is filtered, cooled or heated, humidified and distributed to the RWBCR area. One 100% capacity air handling supply unit normally operates.

Following a fire, the system can be placed in the purge mode by manually starting the smoke removal fan and operating the supply system in the once-through mode.

The RWBGA HVAC subsystem operates in the once-through mode. One 100% air handling supply unit and two 50% exhaust filtration trains operate during normal plant operation. The second air handling supply unit and the third 50% exhaust filtration train are in standby. The supply fans are interlocked with the exhaust fans. Starting the RWBGA HVAC subsystem starts the lead filtration train exhaust fan. Once negative pressure in RWBGA is established, the outside air intake damper opens and the lead air-handling unit supply fan starts. Outside air is filtered (heated or cooled) humidified, and distributed to the RWBGA.

Failure of one operating exhaust fan that results in the loss of negative pressure in the radwaste general area automatically starts the redundant standby exhaust fan (and filtration train). The supply fan continues to operate. The negative pressure in the building can be lost momentarily without damage to the building structure. If the standby exhaust fan does not start, the supply fan and the operating exhaust fan are stopped.

Following a fire, the RWBGA Exhaust Subsystem is placed in the smoke removal mode by closing the HEPA filtration inlet and outlet dampers, opening the bypass duct dampers, and operating the exhaust fan(s).

9.4.3.3 Safety Evaluation

The RWBHVAC system has no safety-related function.

Operational failure of any single unit of the RWBHVAC system does not prevent safety-related equipment from performing any safety-related function.

9.4.3.4 Testing and Inspection Requirements

The RWBHVAC system is designed to permit periodic inspection and testing of major components, such as fans, motors, dampers, coils, filters, ducts, piping and valves to verify their integrity and capability. Equipment layout provides easy access for inspection and maintenance.

RWBHVAC components are tested periodically to verify system availability. Filtration units, including HEPA filters, are periodically tested in accordance with Regulatory Guide 1.140, Nuclear Air and Gas Treatment.

9.4.3.5 Instrumentation Requirements

Instrumentation and controls for the RWBHVAC system are located at a local panel in the Radwaste Building. Selected HVAC alarm signals are transmitted to the general trouble alarm located in the Radwaste Building control room. These indications and controls include the following:

- Start-Stop-Auto control switches for system and operating equipment
- System operating parameters, (including flow rate, temperature, humidity and differential pressure);
- Damper position indication and controls;
- Failure alarms for major components; and
- High radiation in the exhaust air duct.

The RWBHVAC system is manually controlled, except for certain automatic operations described below.

For the RWBGA exhaust fans, the lead fans are started manually and the standby fan automatically starts upon indication of low flow in either lead fan discharge duct.

Interlocks only allow fan operation when the corresponding fan isolation dampers (one upstream and one downstream) are open. For the RWBGA HVAC subsystem, the interlock only allows the lead supply fan to run when negative pressure is established in the associated spaces. Differential pressures between these areas and the outside are transmitted to a pressure controller (located on the HVAC board in the Radwaste Building control room) that adjusts the exhaust fan inlet vanes and exhaust airflow to maintain negative air pressure in the ventilated spaces.

A temperature controller modulates the temperature control valves in the water supply lines to the cooling and heating coils from signals from temperature transmitters in the Radwaste Building control room and general areas. A relative humidity controller adjusts the RWBCR HVAC subsystem humidifier to maintain the humidity within the desired range in the Radwaste Building control room.

A low differential pressure across the operating fan sounds an alarm in the Radwaste Building control room, de-energizes the failed fan, and starts the corresponding standby fan. The fan discharge damper closes when the fan is de-energized.

A general interlock between exhaust fans and supply fans stops all the RWBGA Subsystem fans when the Radwaste Building general area air pressure becomes higher (or lower) than specified to avoid damage to the building structure.

9.4.4 Turbine Building HVAC System

The Turbine Building HVAC system (TBHV) includes the Turbine Building supply air fans and associated filter trains, and the Turbine Building exhaust fans and associated filter trains. The various fan-coil units for local area heating and cooling within the Turbine Building are included in the TBHV system.

9.4.4.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The TBHV system does not perform or ensure any safety-related function, and thus, has no safety design basis.

Power Generation Design Bases

The TBHV system:

- Provides temperature control and air movement control for personnel comfort;
- Optimizes equipment performance by the removal of heat dissipated from plant equipment;
- Provides a sufficient quantity of filtered fresh air for personnel;
- Provides for air movement from areas of lesser potential airborne radioactivity to areas of greater potential airborne radioactivity prior to final exhaust;
- Minimizes the possibility of exhaust air recirculation into the air intake; and
- Minimizes the escape of potential airborne radioactivity to the outside atmosphere during normal operation by exhausting air, through filters from the areas in which a significant potential for contamination exists;
- Provides capability to exhaust the smoke, heat and gaseous combustion products in event of a fire.
- Regarding the ESBWR non-safety related TBHV system, this subsection addresses or refers to other DCD locations that address the applicable requirements of the General Design Criteria (GDC) 2, 5 and 60, discussed in Standard Review Plan (SRP) 9.4.4, Rev. 2, July 1981. The ESBWR:
- Meets GDC 2, as it relates to meeting the guidance of Regulatory Guide 1.29, Position C.2 for non-safety related portions
- Is not applicable to GDC 5, because there are no shared systems and components important to safety in the Turbine Building
- Meets GDC 60, as to the system capability to suitably control release of gaseous radioactive effluents to the environment. The system can direct its exhaust air to the TBHV system filtration units. The TBHV system filtration units are designed, tested and maintained in accordance with Regulatory Guide 1.140.

9.4.4.2 System Description

9.4.4.3 Summary Description

Figure 9.4-8 shows the TBHV system Simplified System Diagram.

The TBHV system supplies air from the outside to the Turbine Building non-contaminated areas and removes it from potentially contaminated rooms.

The main stairwells are pressurized to prevent infiltration of smoke from other Turbine Building areas in the event of a fire.

The TBHV system is designed to minimize exfiltration by maintaining a slightly negative pressure in the Turbine Building by exhausting more air than is supplied to the Turbine Building.

Exhaust air from potentially high airborne contamination Turbine Building areas or component vents is collected, filtered, and discharged to the atmosphere through the Turbine Building Compartment Exhaust (TBCE) system.

Exhaust air from other (low potential airborne contamination) Turbine Building areas and component vents, except lube oil areas, is exhausted to the atmosphere through the Turbine Building Exhaust (TBE) system.

Exhaust air from the lube oil area is exhausted to the atmosphere without filtration.

Turbine Building exhaust air is directed to the plant vent stack where it is monitored for radiation prior to being discharged to the atmosphere.

The TBHV system is designed to provide for local air recirculation and cooling in high heat load areas using local unit coolers. A minimum of 50% standby cooling capacity is provided in areas where a loss of cooling could cause degraded equipment performance.

Turbine Building ventilation systems and subsystems required to for normal plant operation are provided with redundant fans with automatic start logic.

The TBHV system equipment is located in the Turbine Building.

9.4.4.4 Detailed System Description

Turbine Building Air Supply (TBAS) subsystem

The TBAS subsystem consists of outside air intake louvers, dampers, high efficiency filters, hot water heating coils, chilled water cooling coils, and three 50% capacity constant volume supply fans.

Two of the three fans are normally operating to supply filtered, temperature-controlled air to all levels of the Turbine Building. The third fan is a standby unit that starts automatically upon failure of either operating fan. On the outlet common duct there is one pneumatically operated damper to maintain the desired negative pressure in the Turbine Building. Each supply fan is provided with a pneumatically operated isolation damper.

The TBAS uses 100% outside air during normal plant operation. .

The TBAS subsystem fans are started manually from the MCR. The supply fans are interlocked with the TBHV system exhaust fans and TBHV system compartment exhaust fans to ensure that the exhaust fans are running before a supply fan is started.

Temperature controllers located at the heating and cooling coils air outlet modulate the TBAS subsystem air handling heating and cooling coil operation.

Turbine Building Exhaust (TBE) Subsystem

The TBE fans exhaust air from the building clean and low potential contamination areas. The exhaust air is filtered through high efficiency particulate absorbers (HEPA) filters and exhausted through the monitored vent stack .

The TBE subsystem is provided with three 50% capacity fans downstream of the filter train. Two fans are normally in operation and one is in automatic standby.

A filter bypass is provided to allow purging smoke from Turbine Building in the event of a fire. All three TBE fans can be operated simultaneously to provide maximum smoke removal, if necessary.

Each TBE fan is provided with pneumatically operated inlet vanes and isolation dampers. A flow controller automatically adjusts the blade pitch of the operating fans to maintain a constant airflow rate. . Failure of one operating exhaust fan automatically starts the standby fan. The TBHV system exhaust fans are interlocked with the TBAS fans.

Turbine Building Compartment Exhaust (TBCE) Subsystem

The TBCE subsystem consists of two 100% capacity exhaust fans, one high (H8) efficiency filter unit and associated controls. One fan is normally in operation with the other one in automatic standby. The subsystem includes a 100% capacity filter bypass duct for purging smoke in the event of a fire.

The air exhausted from the Turbine Building high potential airborne contamination compartments and equipment vents is filtered through a high efficiency filter before it is released to the atmosphere through the plant vent stack, except during smoke removal.

The TBCE subsystem has radiation detectors in the exhaust duct to monitor the air for radioactivity prior to its being discharged to the plant vent stack.

The two exhaust fans are provided with inlet vanes and isolation dampers. An airflow controller automatically adjusts the inlet vanes of the operating fan to maintain a constant system exhaust flowrate. In the automatic mode, loss of flow from the operating fan starts the standby fan.

Turbine Building Lube Oil Area Exhaust (TBLOE) Subsystem

The TBLOE subsystem includes two 100% capacity fans, isolation dampers and exhaust ductwork. The TBLOE fans discharge the exhaust air directly to the atmosphere through the plant vent stack, passing first through the air filtration unit of TBE subsystem. One fan is designed to continuously exhaust at a constant volumetric flow rate from the Turbine Lube Oil Tank Room. A bypass duct is provided around the lube oil exhaust fans for purging high temperature combustion products and limiting room pressurization in the event of a fire in one of the rooms.

Turbine Building Decontamination Room Exhaust (TBDRE) Subsystem

The TBDRE subsystem consists of one air filtration unit, which includes one 100 % capacity exhaust fan, a high efficiency particulate adsorber (HEPA) filter, an isolation damper and associated controls.

The air exhausted from the TBDRE, once filtered, passes through the air filtration unit of TBE subsystem and is finally released to the atmosphere through the plant vent stack, except during smoke removal.

The subsystem includes a 100% capacity filter bypass duct for purging smoke in the event of a fire.

TBHV System Unit Coolers and Unit Heaters

Localized unit coolers and unit heaters are provided as required in various locations within the Turbine Building. The unit coolers are supplied with chilled water from the balance of plant subsystem of the Chilled Water System (CWS) and the unit heaters are supplied with heated water from the hot water system.

Temperature controls for the unit coolers and unit heaters are located in the unit inlet air path or are installed locally.

The cooling coils of the Reactor Components Cooling Water System (RCCWS), Nuclear Island subsystem of the CWS and Instrument Air System rooms are fed from the corresponding Nuclear Island subsystem of the CWS train.

9.4.4.5 System Operation

The Turbine Building HVAC system is designed to operate during all modes of normal power plant operation, including start-up and shutdown.

Normal operation

The TBHV system fans are started start manually and operate automatically thereafter. Standby fans start automatically if one of the running fans trip due to low flow or equipment trip.

Smoke Purge Mode

Upon detection of smoke in the Turbine Building, the TBAS subsystem outside air supply fans and the TBE subsystem exhaust fans stop automatically.

Upon detection of smoke in the TBCE or the TBLOE or the TBDRE subsystems MCR operators bypass the subsystem filters manually.

MCR operators normally initiate the smoke purge mode of operation of the Turbine Building. Smoke purge is accomplished by starting two supply fans in the TBAS subsystem and two exhaust fans in the TBE subsystem. This provides 100% outside air. All the three fans in the TBAS subsystem and in the TBE subsystem can be started to provide maximum smoke removal.

Loss of Preferred Outside Power (LOPP)

Upon a LOPP, at least one of the fans of the TBE subsystem remains in operation because they are powered from the non-safety- related diesel generators.

The fan coil units of the RCCWS, Nuclear Island subsystem of the CWS and Instrument Air System rooms also remain in operation.

9.4.4.6 Safety Evaluation

The TBHV system does not perform or ensure safety-related function.

Where a system is provided with a redundant fan, failure of an operating fan automatically starts the standby fan to maintain continuity of ventilation.

The exhaust air from the TBHV system is monitored for radioactivity prior to discharge to the plant vent. Alarms annunciate in the MCR upon detection of high radiation. Section 11.5 describes the radiological monitoring system.

The TBHV system components are designed as Seismic Category NS.

9.4.4.7 Tests and Inspections

All major components are tested and inspected as separate components prior to installation and as integrated systems after installation to ensure design performance. Ductwork system airflows are measured and adjusted to meet design requirements and all instruments are calibrated to the design setpoints. The systems are preoperational tested in accordance with the requirements of Chapter 14.

Periodic inspections and measurements including air flows, water flows, air and water temperatures, filter pressure drops, controls positions, are taken to verify the systems operating conditions and to ensure the integrity of the systems for normal plant operation.

The TBHV system filtration components are periodically tested in accordance with ANSI/ASME NS09, Nuclear Power Plant Air Cleaning Units and Components, and ANSI/ASME N510, Testing of Nuclear Air Cleaning System. HEPA filters are tested periodically with dioctyl phthalate (DOP) and the charcoal filters are periodically tested for bypasses.

9.4.4.8 Instrumentation Requirements

All control actuations, indicators, and alarms for normal plant operation are located in the MCR. Controls and instrumentation for the TBHV system include:

- Heating and cooling temperature indicators, controls and alarms for the entering air;
- Low and high temperature switches and alarms for heated and cooled air supply;
- Differential pressure indicators, differential pressure switches and alarm for the air filters;
- Supply airflow indicator and controls, alarms and trips for supply fans; and
- Airflow failure switch, alarm and trip for each exhaust fan

9.4.5 Engineered Safety Feature Ventilation System

The engineered safety features described in Chapter 6 do not require a separate ventilation system. This section is not applicable to the ESBWR design.

9.4.6 Reactor Building HVAC System

- The Reactor Building Heating, Ventilation and Air Conditioning Systems (RBHVS) serves the following areas of the Reactor Building:
- The potentially contaminated areas.
- The refueling area.
- The non-radiologically controlled areas.
- The RBHVS does not serve the primary containment except during inerting operations.

9.4.6.1 Design Bases

Safety (10 CFR 50.2) Design Bases

With the following exception, the RBHV System is nonsafety-related. The isolation dampers and ducting penetrating the Reactor Building boundary and associated controls that provide the isolation signal are safety-related. The RBHV System performs no safety-related function except for automatic isolation of the Reactor Building boundary during accidents.

Power Generation Design Bases

The RBHV System:

- Provides a controlled environment for personnel comfort and safety, and for proper operation and integrity of equipment. See Table 9.4-8 for area temperatures maintained.
- Maintains potentially contaminated areas at a negative pressure to minimize exfiltration of potentially contaminated air.
- Maintains clean areas of the building, except for the battery rooms, at a positive pressure to minimize infiltration of outside air.
- Maintains airflow from areas of lower potential for contamination to areas of greater potential for contamination.
- Is provided with redundant active components to increase the reliability, availability, and maintainability of the systems.
- Is capable of exhausting smoke, heat and gaseous combustion products in the event of a fire.
- Shuts down during radiological events and isolates the Reactor Building boundary to prevent uncontrolled releases to the outside atmosphere.
- Provides the capability to manually divert exhaust air for processing through the Reactor Building HVAC purge exhaust filter units.
- Provides pool sweep ventilation air over the refueling area pool surface.
- Maintains its structural integrity after a safe shutdown earthquake.
- Is designed such that failure of the system does not compromise or otherwise damage safety-related equipment.

- Is provided with shutoff dampers on the inlet and outlet of fans and air handling units (AHUs) to allow for maintenance.
- Is provided with shutoff valves at the inlet and outlet of cooling and heating coils to allow for maintenance.
- Is provided with access doors for AHUs, fans, filter sections, and duct mounted dampers to allow for maintenance.
- Is provided with capability for manual control of system fans to facilitate testing and maintenance.
- Maintains the hydrogen concentration levels in the battery rooms below 1% by volume.
- Replaces the primary containment inerted atmosphere with conditioned air during a refueling operation.
- Provides filtered exhaust capability for the Fuel Building through the Reactor Building HVAC purge exhaust filter unit.

9.4.6.2 System Description

Summary Description

The RBHVS maintains space design temperature, quality of air, and pressurization in the Reactor Building. The system consists of three sub-systems. The Reactor Building Contaminated Area HVAC Sub-system (CONAVS) serves the potentially contaminated areas of the Reactor Building. The Refueling and Pool Area HVAC Sub-system (REPAVS) serves the refueling area of the Reactor Building. The Reactor Building Clean Area HVAC Sub-system (CLAVS) serves the clean (non-radiological controlled) areas of the Reactor Building.

Detailed System Description

Figure 9.4-10 shows a simplified system diagram for the CONAVS sub-system. Table 9.4-11 shows the major equipment for the CONAVS sub-system.

The CONAVS is a once-through ventilation system and consists of redundant AHUs; exhaust fans and building isolation dampers. It includes a primary containment purge exhaust fan, recirculation AHUs and unit heaters. Each AHU includes low and medium efficiency filters, heating and cooling coils and a supply fan. Outside air is filtered and heated or cooled prior to distribution by the AHU in service. The chilled water system provides cooling water for the CONAVS AHUs. The Instrument Air System provides instrument air for the pneumatic actuators. A common supply air duct distributes conditioned air to the potentially contaminated areas of the Reactor Building. Air is exhausted from the potentially contaminated areas of the Reactor Building by the operating exhaust fan and discharged to the plant vent stack. During primary containment de-inerting operations the supply airflow rate of the AHU supply fan is increased. At the same time the airflow rate of the exhaust fan is increased an equal amount. In the event of a fire, fire dampers close to isolate the fire area. In the event smoke is detected in the supply air duct, the affected sub-system is shut down. The exhaust fans are then used for smoke removal with the exhaust air being monitored for radiological contamination. If contaminated, temporary portable filters may be used to exhaust the contaminated air. The building isolation dampers close and the supply and exhaust fans stop due to high radiation in the

exhaust ducts. CONAVS also includes redundant Reactor Building HVAC purge exhaust filter units and exhaust fans. During radiological events, exhaust air from contaminated areas may be manually diverted through the Reactor Building HVAC purge exhaust filter units. The supply AHUs and normal exhaust fans are shut down during filtered purge exhaust. Recirculation AHUs provide supplementary cooling for selected rooms. Electric unit heaters provide supplementary heating.

The CONAVS AHUs are located in the Fuel Building HVAC Equipment Area. The CONAVS exhaust fans are located in the Reactor Building. The Reactor Building HVAC purge exhaust filter unit and exhaust fans are located in the Reactor Building. The steam tunnel recirculating AHUs are located in the Turbine Building.

The refueling machine control room recirculating AHU is located in the Reactor Building. Electric unit heaters are located in or near the areas they serve.

Figure 9.4-11 shows a simplified system diagram for the REPAVS sub-system. Table 9.4-10 shows the major equipment for the REPAVS sub-system.

The REPAVS is a once-through ventilation system and. consists of redundant AHUs, exhaust fans and building isolation dampers. Each AHU includes low and medium efficiency filters, heating and cooling coils and a supply fan. Outside air is filtered and heated or cooled prior to distribution by the AHU in service. The conditioned air is distributed to the refueling area and across the pool surface. Exhaust air is ducted to the exhaust fans and exhausted to the outside atmosphere through the plant vent stack. During a radiological event, exhaust air from the refueling area may be manually diverted through the Reactor Building HVAC purge exhaust filter units. The chilled water system provides cooling water for the REPAVS AHUs. The instrument air system provides instrument air for the pneumatic actuators. In the event of a fire, fire dampers close to isolate the fire area. In the event smoke is detected in the supply air duct, the affected sub-system is shut down. The exhaust fans are then used for smoke removal with the exhaust air being monitored for radiological contamination. If contaminated, temporary portable filters are used to exhaust the contaminated air. The building isolation dampers close and the supply and exhaust fans stop due to high radiation in the exhaust ducts.

The REPAVS AHUs are located in the Fuel Building HVAC Equipment Area. The REPAVS exhaust fans are located in the Reactor Building. Electric unit heaters are located in or near the areas they serve.

Figure 9.4-9 shows a simplified system diagram for the CLAVS sub-system. Table 9.4-9 shows the major equipment for the CLAVS sub-system.

The CLAVS is a recirculating ventilation system with redundant AHUs, return/exhaust fans and smoke exhaust fans. Each AHU includes low and medium efficiency filters, heating and cooling coils and a supply fan. A mixture of outside and return air is filtered and heated/cooled prior to distribution by the AHU in service. A common supply and return/exhaust air duct system distributes conditioned air to and from the Reactor Building clean areas. Return air not directed back to the AHU is exhausted directly outdoors. An economizer cycle is used, when outside air conditions are suitable, to reduce mechanical cooling operating hours. The economizer cycle provides all outside air, or a mixture of outside air and return air, to Reactor Building clean areas. The temperature of the air provided is at or below the supply air design temperature. In the event of a fire, fire dampers close to isolate the fire area. In the event smoke is detected in the supply

air duct, the affected sub-system is shut down. The CLAVS smoke exhaust fans are then used for smoke removal. The chilled water system provides cooling water for the CLAVS AHUs. The instrument air system provides instrument air for the pneumatic actuators. Electric unit heaters provide supplementary heating. The CLAVS AHU supplies air to the battery rooms. The air is then exhausted from the battery rooms by the battery room exhaust fans which discharge directly to the plant vent stack.

The CLAVS AHUs and return/exhaust fans are located in the Fuel Building HVAC Equipment Area. The CLAVS smoke exhaust fans are located in the Reactor Building. The electric unit heaters are located in or near the areas they serve.

System Operation

The RBHVS operates during normal power plant operation, plant startup, and plant shutdown. It is not required to operate during a Station Blackout.

During normal operation, the CONAVS sub-system operates with one AHU and one exhaust fan in service. The exhaust fan starts first to establish negative pressure in the areas served. Then the AHU supply fan starts. Failure of an operating exhaust fan automatically energizes the standby exhaust fan. Simultaneously, the CONAVS AHU supply fan is de-energized due to a loss in room negative pressure. The AHU supply fan is re-energized upon reestablishment of room negative pressure.

Before and during personnel entry into the primary containment area, the CONAVS is used to de-inert the primary containment. The CONAVS AHU supply fan provides purge supply air to primary containment while the primary containment purge exhaust fan exhausts air from primary containment. On detection of high radiation in the exhaust air by PRMS, supply and exhaust dampers to primary containment are automatically closed. During inerting operation, the CONAVS exhausts air from primary containment while the Containment Inerting System supplies nitrogen to the primary containment.

During normal operation, the REPAVS sub-system operates with one AHU and one exhaust fan in service. The exhaust fan starts first to establish negative pressure in the areas served. Then the AHU supply fan starts. Failure of an operating exhaust fan automatically energizes the standby exhaust fan. Simultaneously, the REPAVS AHU supply fan is de-energized due to a loss in room negative pressure. The AHU supply fan is re-energized upon reestablishment of room negative pressure.

During normal operation, the CLAVS sub-system operates with one AHU and one return/exhaust fan in service. When outside air conditions are suitable, the CLAVS incorporates an economizer cycle to reduce operating hours for mechanical cooling equipment. Failure of an operating AHU supply fan automatically energizes the standby AHU supply fan and de-energizes the failed fan. Simultaneously, the return/exhaust fan is de-energized due to a loss in room pressurization. The return/exhaust fan is re-energized upon reestablishment of room positive pressure.

Following a fire recovery, exhaust fans or smoke exhaust fans are used to remove smoke from the area by exhausting to the outdoors.

An individual local thermostat controls each RBHVS electric unit heater.

9.4.6.3 Safety Evaluation

The RBHVS is nonsafety-related, except for the building isolation dampers. The safety-related isolation dampers fail closed upon a loss of control signal, power, or instrument air.

The RBHVS components are designed as Seismic Category II, except for the safety-related building isolation dampers and associated controls. The building isolation dampers and associated controls are designed as Seismic Category I.

The RBHVS does not perform any safety-related functions, except for boundary isolation dampers closing in the event of radiological events. Redundant dampers and controls are provided so the refueling area can be isolated even if one of the dampers or controls fail.

Rooms containing safety-related equipment have passive cooling features designed to limit the room temperature to the equipment's environmental qualification temperature.

9.4.6.4 Testing and Inspection Requirements

Routine testing of the RBHVS is conducted in accordance with normal power plant requirements for demonstrating system and component operability. Periodic surveillance testing of safety-related building isolation dampers is carried out per IEEE-338.

The Reactor Building HVAC purge exhaust filter components are periodically tested in accordance with ASME N509, Nuclear Power Plant Air Cleaning Units and Components and ASME N510, Testing of Nuclear Air Treatment Systems. HEPA filters are tested for penetration of a challenge aerosol (dioctyl phthalate) periodically.

9.4.6.5 Instrumentation Requirements

The RBHVS is operated from the MCR. A local run/stop control switch is provided for each fan for maintenance and testing purposes. The Reactor Building ventilation systems are manually controlled, except for certain automatic operations described below.

- Reactor Building boundary isolation dampers close on receipt a high radiation signal or on a loss of AC power
- For systems with redundant fans, the lead fan is selected manually. The standby fan automatically starts upon indication of low flow in the associated discharge duct.
- Fan operation is allowed only when the corresponding fan shutoff dampers (one upstream and one downstream) are open
- The CLAVS return/exhaust fan auto starts after the supply fan starts and the ventilated spaces are at a positive pressure
- Differential pressures between the ventilated spaces and the outside are transmitted to a pressure controller. The controller adjusts the CLAVS AHU supply fan's variable inlet vanes and airflow to maintain the ventilated at a positive pressure
- A temperature controller modulates the CLAVS outside, return and exhaust air dampers when outside air temperatures are below design supply air temperatures. Damper modulation provides a mixture of outside and return air at or below design supply air temperatures to the ventilated spaces

- The CONAVS supply fan auto starts after the exhaust fan starts and a negative pressure has been established in the ventilated spaces
- Differential pressures between the ventilated spaces and the outside are transmitted to a pressure controller. The pressure controller adjusts the CONAVS exhaust fan's variable inlet vanes and exhaust airflow to maintain a negative pressure
- When a recirculating AHU is started, the fan runs continuously. A room thermostat automatically modulates the chilled water supplied to the cooling coil to maintain the room temperature
- Local thermostats automatically start the unit heaters are located in rooms served by CLAVS and CONAVS
- The RBHVS system component operating status and system parameters are monitored and indicated in the MCR and locally where required.

Indications and alarms include the following:

- Indicators for system operating parameters, including flow rates, damper position, filter pressure drop, building pressure with respect to atmospheric and temperatures;
- Alarms for high or low conditions, including airflow rates, temperatures, filter pressure drop, building differential pressure and smoke detection.

9.4.7 Electrical Building HVAC System

The Electrical Building HVAC System (EBHVACS) System consists of the following subsystems:

- Electric and Electronic Rooms (EER) HVAC subsystem
- Technical Support Center (TSC) HVAC subsystem
- Diesel Generators (DG) HVAC subsystem

9.4.7.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The EBHVACS does not perform or ensure any safety-related function, and thus, has no safety design basis.

Power Generation Design Bases

The EER HVAC subsystem:

- Provides conditioned air to maintain acceptable temperatures for equipment and personnel comfort and habitability
- Provides a sufficient quantity of filtered fresh air for personnel
- Prevents the buildup of hydrogen in the non-safety related battery rooms to less than 2 percent hydrogen by volume

The TSC HVAC subsystem:

- Provides a controlled environment for personal comfort and safety and for the proper operation and integrity of equipment in the TSC
- Maintains the TSC at a slightly positive pressure with respect to the adjacent rooms and outside environment to minimize the infiltration of air. The TSC HVAC subsystem automatically switches to the recirculation mode if toxic gases or smoke are detected in the outside intake air. In this case, there may be no differential pressure between the TSC and the surrounding areas
- Provides filtration of airborne hazardous materials (radioactivity, smoke, chlorine gas or other site-specific toxic gas) into the TSC
- Removes vitiated air from the kitchen and restrooms
- Redundant components are included to increase the reliability, availability and maintainability of the ventilation system
- The on-site diesel generators provide electrical power to the TSC HVAC subsystem in case of Loss of Preferred Power (LOPP)

The DG HVAC subsystem:

- Provides ventilation air to maintain acceptable temperatures within the generator rooms for equipment operation and reliability during periods of diesel generator operation
- Provides adequate heating and ventilation for suitable environmental conditions for maintenance personnel working in the diesel generator room when the generators are not in operation
- Provides suitable environmental conditions for equipment operation in each diesel generator electrical and electronic equipment area under the various modes of diesel generator operation
- Prevents the accumulation of combustible vapors and dissipate their concentration in the fuel oil day tank room

9.4.7.2 System Description

Summary Description

Figure 9.4-12 shows the EBHVACS Simplified System Diagram.

The EER HVAC subsystem provides a controlled environment for the Electric Equipment Building switchgear, cable spreading, electronic and non-safety related battery rooms.

The EER HVAC subsystem consists of two independent HVAC trains. One train services the rooms where the train A electric and electronic equipment is located and the other EER HVAC subsystem train services the rooms where the train B electric and electronic equipment is located. Each EER HVAC subsystem train is a recirculation ventilation system to provide heated or cooled air to the EER. The recirculating system includes an air handing unit with filter, heating and cooling coils and two redundant fans. Building air is normally extracted from the battery rooms by two redundant fans.

The TSC HVAC subsystem is a recirculating ventilation system to provide filtered (heated or cooled) and humidified air to the TSC. Two supply fans and filtration units with high efficiency particulate air (HEPA) filters and charcoal filters remove airborne hazardous materials and supply fresh air to the TSC to augment the return air to maintain the TSC under slight positive pressure. The recirculating system includes redundant air conditioning units (with air mixing plenum, filters, heating and cooling coils, and humidifier) and recirculating fans to provide conditioned air through ducts, dampers, and registers to the TSC. The exhaust system includes redundant fans to direct the air from the kitchen and toilet areas into the atmosphere.

The normal heating and ventilation system of the DG HVAC subsystem serves the diesel generator area. Each diesel generator train is provided with independent ventilation and heating equipment for the building areas serving that diesel generator train. Each normal heating and ventilation subsystem for a diesel generator train consists of one 100 percent capacity engine room air handling unit which ventilates the diesel generator room and the diesel fuel oil day tank room.

The supplementary ventilation system of the DG HVAC subsystem consists of roof-mounted exhaust fans and motor-operated air intake dampers mounted on the exterior walls of each diesel generator area. The DG HVAC subsystem electronic equipment area cooling system consists of an air handing unit with a filter, a cooling coil and the associated fan. Independent air handing units serve each of the diesel generator areas.

All the EBHVACS equipment is located in the Electrical Building.

9.4.7.2.2 System Operation

Normal Operating Mode

EER HVAC Subsystem

One of the two air supply fans of each train is normally operating to supply filtered, temperature-controlled air to the Electrical Building. The second fan is a standby unit that starts automatically upon failure of the operating fan. One of the two air exhaust fans of each train is normally operating to extract air from battery rooms. The second fan is a standby unit that starts automatically upon failure of the operating fan. Each fan is provided with backdraft isolation dampers. The EER HVAC subsystem uses 100% outside air when the outside air temperature is moderate to maintain the minimum operating cost. The EER HVAC subsystem modulates the return and outside air dampers to maximize the control of the inside air temperature using the outside air to minimize the energy used for either cooling by the chilled water system or heating by the plant heating system. In extreme outside air temperature conditions (either high or low), the outside air intake dampers are at their minimum position.

A minimum exhaust air is continuously extracted from battery rooms in order to keep hydrogen concentration below 2% by volume.

Temperature controllers located at the heating and cooling coils air outlet modulate the EER HVAC subsystem air handling heating and cooling coil operation.

TSC HVAC Subsystem

During normal operation, outside air, filtered, heated/cooled and moisturized/demoisturized in the air-handling unit is propelled by fans and supplied to the TSC. General rooms and areas

exhaust air is recirculated to the air-handling unit. Ventilation air is exhausted from the kitchen and restrooms by roof fans.

The TSC HVAC subsystem automatically transfers from its normal operation mode to its radiological mode upon detection of radioactivity at the outside air intakes.

DG HVAC Subsystem

During normal operation, the diesel generators are on stand-by and electronic equipment is energized. Outside air, filtered and heated (if required) in the all-fresh-air handling unit, is propelled by a fan and supplied to general areas, electronic equipment areas and the diesel oil day tank. Exhaust air from general areas is discharged outdoors by means of automatically operated control dampers.

The electronic equipment air-handling unit recirculates and cools the air of the electronic equipment areas to control the temperature.

The supplementary ventilation system starts automatically whenever the generator is started. The roof fans stop automatically on low temperature.

Smoke Removal Operating Mode

Supply the ventilation Air Handing Units and Exhaust fans stop automatically if smoke is detected. Once the fire has been extinguished, smoke removal operation is initiated manually by starting the smoke fans from the MCR.

9.4.7.3 Safety Evaluation

The EBHVACS does not perform or ensure any safety-related function.

The EBHVACS components are designed as Seismic Category NS.

Where a system is provided with a redundant device, failure of an operating device automatically starts the standby device to maintain continuity of ventilation.

The intake air is monitored for radioactivity and filtered (if required) prior to being introduced in the Technical Support Center.

9.4.7.4 Testing and Inspection Requirements

Major components are tested and inspected as separate components prior to installation and as integrated systems after installation to ensure design performance. Ductwork system airflows are measured and adjusted to meet design requirements

and all instruments are calibrated to the design setpoints. The systems are preoperational tested in accordance with the requirements of Chapter 14.

Periodic inspections and measurements including air flows, water flows, air and water temperatures, filter pressure drops, controls positions, are taken to verify the systems operating conditions and to ensure the integrity of the systems for normal plant operation.

The EBHVACS filtration components are periodically tested in accordance with ANSI/ASME N509, Nuclear Power Plant Air Cleaning Units and Components, and ANSI/ASME N510, Testing of Nuclear Air Cleaning Systems. HEPA filters are tested periodically, and the charcoal filters are periodically tested for bypass.

9.4.7.5 Instrumentation Requirements

All control actuations, indicators, and alarms for normal plant operation are located in the MCR. Controls and instrumentation for the EBHVACS include:

- Heating and cooling temperature indicators, controls and alarms for the entering mixed air and recirculated air
- Low and high temperature sensors and alarms for heated and cooled air supply;
- Differential pressure transmitters to monitor filters pressure drop, and alarm high filter pressure drop
- Airflow indicators, controls, alarms and trips for each supply fan and
- Airflow failure sensor and alarm for each exhaust fan
- Differential pressure transmitters to monitor and control positive pressure of the TSC with respect to the surrounding areas.

9.1.8 Drywell Cooling System[EA1137]

9.4.6.6 Design Basis

Safety (10 CFR 50.2) Design Bases

The Drywell Cooling System has no safety-related function, and thus, has no safety design basis.

Power Generation Design Bases

The Drywell Cooling System (DCS) is classified as a nonsafety-related and Seismic Category II system. The DCS performs the following functions during stable and transient operating conditions through the entire operating range, from startup to full load condition to refueling:

- Maintain temperature in the upper and the lower drywell spaces within specified limits during normal operation
- Accelerate drywell cooldown during the period from hot reactor shutdown to cold shutdown
- Aid in complete purging of nitrogen from the drywell during shutdown
- Maintain a habitable environment for plant personnel during plant shutdowns for refueling and maintenance and
- Limit drywell temperature during LOPP

Table 9.4-12 contains the DCS design parameters.

9.4.6.7 System Description

Summary Description

The DCS maintains the thermal environment within the drywell to specified conditions during normal reactor operation, hot standby and refueling using Fan Cooling Units (FCUs). The cooling medium of the FCUs is Chilled Water System (CWS) water.. There are separate FCUs for the upper and the lower drywell regions.

Figure 9.4-13 shows a simplified DCS diagram. Subsection 9.2.7 describes the CWS.

Detailed System Description

The DCS is a closed loop recirculating air/nitrogen cooling system with no outside air/nitrogen introduced into the system except during refueling. The system uses direct-drive type FCUs to deliver cooled air/nitrogen to various areas of the upper and the lower drywell. Ducts distribute the cooled, recirculated air/nitrogen through diffusers and nozzles.

The drywell heat loads are transferred to the Nuclear Island subsystem of the (CWS) circulating through the cooling coils of the FCUs. The DCS consists of four FCUs, two located in the upper drywell and two in the lower drywell.

Each upper drywell FCU has a cooling capacity of 50% of the upper drywell design heat load during normal plant operating conditions. Both FCUs are normally operating. Each FCU comprises a cooling coil and two fans downstream of the coil. Nuclear Island subsystem of CWS train A supplies one FCU, and Nuclear Island subsystem of CWS train B supplies the other. One of the fans operates while the other is on standby status. The fan on standby automatically starts upon loss of the lead fan. Cooled air/nitrogen leaving the FCUs enters a common plenum and is distributed to the various zones in the upper drywell through distribution ducts. Return ducts are not provided. The FCUs draw air/nitrogen directly from the upper drywell. Each FCU is equipped with a condensate collection pan.

Each lower drywell FCU has a cooling capacity of 50% of the lower drywell design heat load. Each FCU comprises a cooling coil and two fans downstream of the coil. One of the fans operates while the other is on standby status. The fan on standby automatically starts upon loss of the lead fan. Nuclear Island subsystem of CWS train A supplies one FCU, while Nuclear Island of subsystem CWS train B supplies the other. Cooled air/nitrogen is supplied below the RPV and in the RPV support area through supply ducts. Return ducts are not provided. The FCUs draw air/nitrogen directly from the lower drywell.

Each FCU has a condensate collection pan. The condensate collected from the FCUs in the upper and the lower drywell is piped to a Leak Detection and Isolation System (LD&IS) flowmeter to measure the condensation rate contribution to unidentified leakage.

The piping for train A and train B of the Nuclear Island subsystem of CWS independently penetrate the containment. The cooling coils of one FCU in the upper drywell and one FCU in the lower drywell are piped in parallel to Nuclear Island subsystem of CWS train A and the remaining two are piped in parallel to Nuclear Island subsystem of CWS train B. The system is designed so both FCUs in the upper drywell and both FCUs in the lower drywell are always operating during normal plant operation assuming the loss of a single electrical group or failure of any single FCU motor or fan. Upon failure of one FCU, the two fans of the remaining FCU are in service. One FCU with two fans in operation maintains the drywell temperature below the maximum allowed.

Table 9.4-13 provides a description of the upper DCS and lower DCS FCUs. Table 9.4-14 provides a summary of the drywell heat loads.

The FCU fans and fan motors are designed to be operable during containment integrated leak testing (ILRT).

System Operation

During normal plant operating condition, two FCUs in the upper drywell and two FCUs in the lower drywell are continuously operating to maintain the ambient conditions described in Table 9.4-12.

During plant refueling conditions, one FCU in the upper drywell and one FCU in the lower drywell continuously operate with two fans in service to maintain a habitable environment in the drywell for maintenance activities.

Nonsafety-related on-site diesel generators power the FCUs during a LOPP as long as there is no loss-of-coolant-accident (LOCA) signal.

9.4.6.8 Safety Evaluation

The DCS does not perform any plant safety-related function. Failure of the system does not compromise any safety-related system or component nor does it prevent safe shutdown of the plant.

9.4.6.9 Testing and Inspection Requirements

The FCU coils are tested for pressure integrity in conjunction with the Nuclear Island subsystem of CWS after the installation is completed. Hydrostatic testing of piping systems is performed at least 1.5 times the design pressure, for a minimum of 30 minutes with no indicated leakage. Pneumatic testing may be substituted for hydrostatic testing in accordance with applicable codes.

The supply ducts have test connections for verifying calibration of operating controls.

9.4.6.10 Instrumentation Requirements

Each FCU motor can be controlled manually from the MCR. Indicating lights in the MCR display the status of each unit. Failure of an FCU and a subsequent temperature rise in the discharge stream activates an alarm in the MCR.

A flow switch is provided in each fan discharge duct at the downstream side of its gravity backdraft damper. The standby fan automatically starts upon failure of a fan. Failure of a fan activates a low flow alarm in the MCR.

Preset flow reducing devices are provided in the supply ducts so that, regardless of which FCUs are operating, the air/nitrogen distribution requirements are met. Gravity-type backdraft dampers prevent reverse flow through a unit that is not operating.

There are temperature instruments for measuring the temperatures of the supply and return air/nitrogen to each FCU.

9.4.7 Containment Inerting System

9.4.7.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The Containment Inerting System (CIS) does not perform any safety-related function. Therefore, the CIS has no safety design bases other than provision for safety-related containment penetrations and isolation valves, as described in Subsection 6.2.4.

Power Generation Design Bases

- The CIS is designed to establish an inert atmosphere (i.e., less than 4% oxygen by volume) throughout the containment in less than 4 hours and less than 2% oxygen by volume in the next 8 hours following an outage.
- The CIS is designed to maintain the containment oxygen concentration below the maximum permissible limit (3%) during normal, abnormal, and accident conditions to assure an inert atmosphere.
- The CIS is designed to maintain a slightly positive pressure in the primary containment during normal, abnormal, and accident conditions to prevent air (oxygen) in-leakage into the inerted spaces from the Reactor Building. The CIS nitrogen gas makeup supply line is designed for the normal daily operating capacity to maintain approximately 4.8 kPaG (0.7 psig) positive pressure within the containment. The system has the capability to replenish containment atmosphere leakage at a design value of 0.5% per day based on containment operating pressure.
- The inerting auxiliary steam vaporizer is sized to provide at least 2.5 times the containment (wetwell and drywell) free volume of nitrogen within the allotted 4 hours. The temperature of the injected nitrogen is within the range of 10°C (50°F) to 65°C (150°F).
- The CIS is designed to permit de-inerting the containment for safe operator access without breathing apparatus in less than 12 hours.
- The CIS is designed to perform continuous containment leakage rate monitoring and detect gross leakage of containment atmosphere during normal reactor operation.
- The CIS is also designed to release containment pressure before uncontrolled containment failure could occur. (See Subsection 6.2.5)

9.4.7.2 System Description

Summary Description

The CIS establishes and maintains an inert atmosphere within the primary containment during all plant operating modes except during plant shutdown for refueling or maintenance and during limited periods of time to permit access for inspection during reactor low power operation. The purpose of the system is to provide an inert containment atmosphere (≤ 3% oxygen) during normal operation to minimize hydrogen burn inside the containment

A simplified CIS system diagram is shown in Figure 9.4-14.

Detailed System Description

The CIS consists of a pressurized liquid storage tank, a steam-heated main vaporizer for large nitrogen flow, electric heater for vaporizing makeup flow, two injection lines, an exhaust line, a bleed line, a dedicated containment overpressure relief line and associated valves, controls and instrumentation. All CIS components are located inside the Reactor Building except the liquid nitrogen storage tank and the steam-heated main vaporizer that are located in the yard.

The first of the injection lines is used only for makeup. It includes an electric heater to vaporize the nitrogen and to regulate the nitrogen temperature to acceptable injection temperatures. Remotely operated valves, together with a pressure-reducing valve, enable the operator to accomplish low rates of nitrogen injection into the drywell and suppression pool airspace.

The second injection line is used for the inerting function where larger flow rates of nitrogen are required. This line provides the flow path for vaporized nitrogen at an appropriate temperature from the steam-heated main vaporizer to be injected into the containment through remotely operated valves and a pressure-reducing valve to injection points common with the makeup supply. The inerting and makeup lines converge to common injection points in the upper drywell and suppression pool airspace.

The CIS includes an exhaust line from the lower drywell on the opposite side of containment from the injection points. The discharge line connects to the Reactor Building HVAC system exhaust before being diverted to the plant stack.

A small bleed line bypassing the main exhaust line is also provided for manual pressure control of the containment during normal reactor operation.

Redundant primary containment isolation valves provided in the inerting, makeup, exhaust and bleed lines close automatically upon receipt of an isolation signal from the Leak Detection and Isolation System (LD&IS). Discussion of these signals is provided in Subsection 7.3.3.

Upstream of the pressure-reducing valve in the makeup line, a small branch line is provided and connected to the High Pressure Nitrogen Supply System (HPNSS). This line is used for the initial HPNSS charging and makeup to maintain the ADS SRV and Inboard MSIV accumulators charged with nitrogen during normal plant operation.

System Operation

During plant startup, large flow rates of nitrogen from the liquid nitrogen storage tank are vaporized by the steam-heated vaporizer and injected into the drywell and the wetwell. The exhaust line is kept open to displace containment resident atmosphere with nitrogen. Once the desired concentration of oxygen is reached, the exhaust line is closed. When the required inerted containment operating pressure is attained, the nitrogen supply shutoff valve and the inerting isolation valves are closed to terminate the inerting process. The system is capable of inerting the containment to ≤ 4% oxygen by volume within four hours. The CIS is capable of establishing a more completely inert atmosphere, equal to or less than 2% in containment with the next eight hours after reaching 4% conditions.

Containment pressure is maintained automatically after manually aligning the nitrogen makeup subsystem. Low flows of liquid nitrogen are vaporized and heated to the desired temperature and injected into the drywell and the wetwell to makeup for the nitrogen out-leakage. The primary

containment atmosphere is kept constant at a slightly positive pressure relative to the Reactor Building to preclude air (oxygen) in-leakage. In response to a change in containment pressure, the pressure control valve modulates (opens or closes) to provide nitrogen makeup and thereby maintaining the containment pressure. The flow integrator will monitor the nitrogen makeup to compensate for leakage during normal containment pressure control and to the HPNSS. Large makeup flow indicates gross or excessive leakage and is annunciated in the MCR. Manual venting through the exhaust bleed line controls increases in containment pressure greater than the normal operating range.

During plant shutdown, the containment atmosphere is de-inerted to allow safe personnel access inside the primary containment. Breathable air from the Reactor Building HVAC system is injected into the drywell and wetwell air space through the inerting injection line. The incoming air displaces containment gases (mostly nitrogen) into the exhaust line. The Reactor Building HVAC system exhaust fans, filters, and radiation detectors remove the vented gases and then they are diverted to the plant stack. The CIS is capable of reaching a volumetric oxygen concentration of ≥ 19% within 12 hours after de-inerting begins.

9.4.7.3 Safety Evaluation

The CIS has no safety-related function except the containment isolation function, which is discussed in Subsection 6.2.4. Failure of the CIS does not compromise any safety-related system or component, nor does it prevent a safe shutdown of the plant.

9.4.7.4 Testing and Inspection Requirements

CIS containment penetrations, including isolation valves, undergo routine in-service inspection and testing as required by ASME Code, Section XI.

Permanently installed instrumentation inside primary containment is maintained, tested, and calibrated during every refueling outage.

9.4.7.5 Instrumentation Requirements

CIS instrumentation requirements are discussed in Subsection 7.7.9.

9.4.8 COL Information

9.4.8.1 Containment Inerting System

The COL applicant shall provide a nitrogen storage tank with enough capacity to ensure that the containment will be inert to ≤ 4% dry basis-percent (DB%) oxygen by volume within four hours with provision for recharging from portable sources.

9.4.9 References

None

Table 9.4-1

Design Parameters for the CBHVS System

CRHAHVS and CBGAHVS	
Operating periods:	Normal plant operation, plant startup, and plant shutdown
Outside Air Design Conditions:	
For CRHAHVS and EBAS (0% Exceedance values)	Summer: 46.1°C (115°F) Dry Bulb 26.7°C (80°F) Wet Bulb Winter: 40.0°C (-40°F) Dry bulb
For CBGAHVS: (1% Exceedance values)	Summer: 37.8°C (100°F) Dry Bulb 26.1°C (79°F) Wet Bulb Winter: -23.3°C (-10°F) Dry bulb
Inside Design temperatures and humidity:	
CRHA (normal operation)	22.8°C (73°F) to 25.6°C (78°F) and 25% to 60% relative humidity (RH)
CRHA (SBO)	Maximum 8.3° C (15°F) rise above normal operating temperature for the first 72 hours into the event, RH not controlled
DCIS rooms/miscellaneous areas	22.8°C (73°F) to 25.6°C (78°F), RH not controlled
1E DCIS rooms (SBO)	50°C (122°F) maximum
HVAC equipment room:	10°C (50°F) to 40°C(104°F), RH not controlled
Pressurization:	> atmospheric pressure
CBGAHVS	22.8°C (73°F) to 25.6°C (78°F), RH not controlled
EBAS	
Operation period:	Emergency mode
Breathing air supply capacity:	9.5 l/s/person for 5 persons (47.5 l/s total) for 72 hours
Pressurization capability:	31 Pa positive differential

Table 9.4-2

Major Equipment for CBHVS

CRHAHVS		
Supply Air Handling Units	Quantity:	2 - 100% capacity each
	Capacity:	Flow – 5,250 l/s per unit
		Cooling – 100,029 watts (28.4 tons)
		Heating - 330,463 watts at 0% Exceedance 206,447 watts at 1% Exceedance
	Type	Sheet Metal housing containing high and low efficiency filters, chilled water cooling coil, heating coil, humidifier and centrifugal fan
Supply AHU fans	Quantity:	1 - 100% capacity each per AHU
	Capacity:	Flow – 5,250 l/s per unit
		Pressure - 1.64 kPa static pressure
	Type:	Centrifugal, with inlet vanes, 14.9 kW (20 hp)
Return/exhaust fans	Quantity:	2 - 100% capacity each
	Capacity:	Flow – 5,050 l/s per unit
		Pressure – 0.65 kPa static pressure
	Type:	Centrifugal, with inlet vanes, 5.6 kW (7.5 hp)
CRHAHVS EFU		
Emergency Filter Unit	Quantity:	2 - 100% capacity each
	Capacity:	Flow – 300 l/s per unit
		Pressure - 1.64 kPa static pressure
	Type	Sheet metal housing containing electric heater, medium efficiency filters, HEPA filters, charcoal filters
EFU fans	Quantity:	1 - 100% capacity each per EFU
	Capacity:	Flow – 300 l/s per unit
		Pressure – 1.64 kPa static pressure
	Type	Centrifugal, with inlet vanes, 1.1 kW (1.5 hp)

Table 9.4-3

Design Parameters for FBHVS

FBGAHV		
Operating periods:	Normal plant operation, plant startup, and plant shutdown	
Temperatures:		
Outdoor Design:	Summer:	37.8°C (100°F) Dry Bulb
		26.1°C (79°F) Wet Bulb
	Winter:	-23.3°C (-10°F) Dry bulb
Indoor Design:		
Occupied Areas	23° C to 26° C (73° F to 78° F)	
Occupied areas with moderate work and areas with electronic equipment:	18° C to 29° C (65° F to 85° F)	
Areas with frequent inspection/maint. (without sensitive electronic equipment):	10° C to 40° C (50° F to 104° F)	
HVAC equipment room:	10° C to 40° C (50° F to 104° F)	
Pressurization:	62 Pa (- 1/4 in. w.g.) minimum relative to surrounding areas	
FBFPHV		
Operating periods:	Same as FBGAHV	
Temperatures:	Same as FBGAHV	
Areas with infrequent inspections or maintenance activities (without sensitive equipment):	10° C to 40° C (50° F to 104° F)	
Spent Fuel Pool area wet bulb global temperature:	Below 27°C (80°F)	
Pressurization:	62 Pa (- 1/4 in. w.g.) minimum relative to surrounding areas	

Table 9.4-4

Major Equipment for FBGAHV

Supply air handling units	Quantity:	2 - 100% capacity (one running and one standby)
	Capacity:	Flow – 12,300 l/s (26,060 cfm) per unit
		Cooling - 756,514 watts (2,582,400 Btu/h)
		Heating - 579,741 watts (1,978,656 Btu/h)
AHU Supply fans	Quantity:	2 - 100% capacity (one running and one standby)
	Capacity:	Flow – 12,300 l/s (26,060 cfm) per unit
		Pressure - 1620 Pa (6.5 in. wg) static pressure
	Type:	Centrifugal, direct drive, 37 kW (50 hp)
Exhaust fans	Quantity:	2 - 100% capacity (one running and one standby)
	Capacity:	Flow – 13,550 l/s (28,710 cfm) per unit
		Pressure - 400 Pa (1.6 in. wg) static pressure
	Type:	Centrifugal, direct drive, 11.2 kW (15 hp)
Building Supply Isolation Damper	Quantity:	1 (Safety-Related, Seismic Category I)
	Capacity:	12,300 l/s (26,060 cfm)
	Type:	Parallel Blade
	ASME AG-1 Seat Leakage Class	10.44 liter/second per square meter (1 cubic foot per minute/square foot) at 250 Pascal differential pressure
	Actuator Type	Pneumatic, fail close
Building Exhaust Isolation Damper	Quantity:	1 (Safety-Related, Seismic Category I)
	Type:	Parallel Blade
	Capacity:	13,550 l/s (28,710 cfm)
	ASME AG-1 Seat Leakage Class	10.44 liter/second per square meter (1 cubic foot per minute/square foot) at 250 Pascal differential pressure
	Actuator Type	Pneumatic, fail close
FMCRD Recirculation AHU	Quantity:	1 - 100% capacity
	Capacity:	Flow – 600 l/s (1,272 cfm) per unit
		Filtration – low efficiency
AHU Supply fan	Quantity:	1 - 100% capacity
	Capacity:	Flow – 600 l/s (1,272 cfm) per unit
	Type:	Centrifugal, direct drive

Table 9.4-5

Major Equipment for FBFPHV

Supply air handling units	Quantity:	2 - 100% capacity (one running and one standby)
	Capacity:	Flow – 14,350 l/s (30,405 cfm) per unit
		Cooling - 882,333 watts (3,012,000 Btu/h)
		Heating - 676,161 watts (2,307,737 Btu/h)
AHU Supply fans	Quantity:	2 - 100% capacity (one running and one standby)
	Capacity:	Flow – 14,350 l/s (30,405 cfm) per unit
		Pressure - 1620 Pa (6.5 in. wg) static pressure
	Type:	Centrifugal, direct drive, 45 kW (60 hp)
Exhaust fans	Quantity:	2 - 100% capacity (one running and one standby)
	Capacity:	Flow – 15,790 l/s (33,457 cfm) per unit
		Pressure - 400 Pa (1.6 in. wg) static pressure
	Type:	Centrifugal, direct drive, 11.2 kW (15 hp)
Building Supply Isolation Damper	Quantity:	1 (Safety-Related, Seismic Category I)
	Capacity:	14,350 l/s (30,405 cfm)
	Type:	Parallel Blade
	ASME AG-1 Seat Leakage Class	10.44 liter/second per square meter (1 cubic foot per minute/square foot) at 250 Pascal differential pressure
	Actuator Type	Pneumatic, fail close
Building Exhaust Isolation Damper	Quantity:	1 (Safety-Related, Seismic Category I)
	Type:	Parallel Blade
	Capacity:	15,800 l/s (32,843cfm)
	ASME AG-1 Seat Leakage Class	10.44 liter/second per square meter (1 cubic foot per minute/square foot) at 250 Pascal differential pressure
	Actuator Type	Pneumatic, fail close

Table 9.4-6

RWBHVAC Design Conditions

Control Room and areas with electronic equipment:	23°C to 26°C (73°F to 78°F) and relative humidity between 35-50%
Corridors and general access areas:	10°C to 40°C (50°F to 104°F)
Equipment cells:	10°C to 50°C (50°F to 122°F)
Tank rooms:	10°C to 50°C (50°F to 122°F)
HVAC equipment room:	10°C to 40°C (50°F to 104°F)

Design room differential pressure

Control Room areas and electronic equipment room areas:	+31Pa
General areas:	-31Pa

Table 9.4-7

Major Equipment for the RWBHVAC System

Common fresh air intake plenum		
RWBCR	Quantity:	2 - 100% capacity
RWBGA	Quantity:	2 - 100% capacity
Air conditioning units		
RWBCR	Quantity:	2 - 100% capacity
RWBGA	Quantity:	2 - 100% capacity
Exhaust Fans		
RWBCR (smoke)	Quantity: Type:	1 - 100% capacity Centrifugal
RWBGA	Quantity: Type:	3 - 50% capacity Centrifugal
Filter units		
RWBGA Exhaust Filtration Units	Quantity: Type:	3 - 50% capacity Medium efficiency and HEPA

Table 9.4-8

Design Parameters for RBHVS

Description			**Requirements**
CONAVS and REPAVS			
Operation periods:			Normal plant operation, plant startup, and plant shutdown.
Temperatures:	Outdoor Design:	Summer: Winter:	37.8° Cdb (100° F), 26.1° Cwb (79° F) -23.3° Cdb (-10° F)
	Indoor Design:	Occupied areas:	23°C to 26°C (73°F to 78°F)
	Occupied areas with moderate work and areas with electronic equipment:		18°C to 29°C (65°F to 85°F)
	Areas with frequent inspections/maintenance (without sensitive electronic equipment):		10°C to 40°C (50°F to 104°F)
HVAC equipment room:			10°C to 40°C (50°F to 104°F)
Pressurization:			62 Pa (- ¼ in. wg.) minimum relative to surrounding areas
CLAVS			
Operation periods:			Normal plant operation, plant startup, and plant shutdown.
Temperatures:	Outdoor Design:	Summer: Winter:	37.8° Cdb (100° F), 26.1° Cwb (79° F) -23.3° Cdb (-10° F)
	Indoor Design:	Occupied areas:	23°C to 26°C (73°F to 78°F)
	Occupied areas with moderate work and areas with electronic equipment:		18°C to 29°C (65°F to 85°F)
	Areas with frequent inspections/maintenance activities (without sensitive electronic equipment):		10°C to 40°C (50°F to 104°F)
Pressurization (battery rooms):			62 Pa (- ¼ in. wg.) minimum relative to surrounding areas
Pressurization (other CLAVS rooms):			31 Pa (+ ⅛ in. wg.) minimum relative to surrounding areas

Table 9.4-9

Major Equipment for CLAVS

Supply air handling units	Quantity:	2 - 100% capacity (one running and one standby)
	Capacity:	Normal flow – 25,250 l/s (53,502 cfm) per unit
		Filtration - medium efficiency
		Cooling - 993,518 watts (3,186,097 Btu/h)
		Heating - 99,384 watts (339,198 Btu/h)
AHU Supply fans	Quantity:	2 - 100% capacity (one running and one standby)
	Capacity:	Normal flow - 25,250 l/s (53,502 cfm) per fan
		Pressure - 1640 Pa (6.6 in. wg) static pressure
	Type:	Centrifugal, variable inlet vanes, direct drive, 75kW (100 hp)
Return/exhaust fans	Quantity:	2 - 100% capacity (one running and one standby)
	Capacity:	Flow – 22,800 l/s (48,310 cfm) per fan
		Pressure - 650 Pa (2.6 in. wg) static pressure
	Type:	Centrifugal with inlet vanes, 30 kW (40 hp)
Smoke exhaust fans	Quantity:	2 - 100% capacity (both standby)
	Capacity:	Flow – 15,400 l/s (32,630 cfm) per fan
		Pressure - 620 Pa (2.5 in. wg) static pressure
	Type:	Centrifugal with inlet vanes, 18.6 kW (25 hp)
Battery Room exhaust fan	Quantity:	2 - 100% capacity (one running and one standby)
	Capacity:	Flow – 2,050 l/s (4,345cfm) per fan
		Pressure - 650 Pa (2.6 in. wg) static pressure
	Type:	Centrifugal with inlet vanes, 2.2 kW (3 hp)

Table 9.4-10
Major Equipment for REPAVS

Supply air handling units	Quantity:	2 - 100% capacity (one running and one standby)
	Capacity:	Flow – 29,150_ l/s (61,765 cfm) per unit
		Cooling – 1,605,845 watts (5,480,749 Btu/h)
		Heating – 1,193,955 watts (4,074,968 Btu/h)
AHU Supply fans	Quantity:	2 - 100% capacity (one running and one standby)
	Capacity:	Flow - 29,150_ l/s (61,765 cfm) per unit
		Pressure – 2,020 Pa (8.1 in. wg) static pressure
	Type:	Centrifugal with inlet vanes, 110 kW (150 hp)
Exhaust fans	Quantity:	2 - 100% capacity
	Capacity:	Flow – 32,050 l/s (67,910 cfm) per fan
		Pressure - 650 Pa (2.6 in. wg) static pressure
	Type:	Centrifugal with inlet vanes, 37 kW (50 hp),
Safety-related Building Isolation Damper	Quantity:	4 (2 redundant dampers for each supply and exhaust duct)
	Type:	Parallel Blade
	ASME AG-1 Seat Leakage Class	10.44 liter/second per square meter (1 cubic foot per minute/square foot) at 250 Pascal differential pressure
	Actuator Type	Pneumatic, fail close

Table 9.4-11

Major Equipment for CONAVS

Supply air handling units	Quantity:	2 - 100% capacity (one running and one standby)
	Capacity:	Max flow – 24,250 l/s (51,385 cfm) per unit
		Filtration - medium efficiency
		Cooling - 1,338,892 watts (4,569,638 Btu/h)
		Heating - 993,256 watts (3,389,983 Btu/h)
AHU Supply fans	Quantity:	2 - 100% capacity (one running and one standby)
	Capacity:	Max flow - 24,250 l/s (51,385 cfm) per fan
		Pressure - 2,020 Pa (8.1 in. wg) static pressure
	Type:	Centrifugal, variable inlet vanes, direct drive, 93 kW (125 hp)
Exhaust fans	Quantity:	2 - 100% capacity (one running and one standby)
	Capacity:	Max flow – 26,050 l/s (55,200 cfm) per fan
		Pressure - 650 Pa (2.6 in. wg) static pressure
	Type:	Centrifugal with inlet vanes, 30 kW (40 hp)
Primary containment purge exhaust fan	Quantity:	1 - 100% capacity (one running and one standby)
	Capacity:	Flow -6,100 l/s (12,925 cfm) per fan
		Pressure - 650 Pa (2.6 in. wg) static pressure
	Type:	Centrifugal, variable inlet vanes, 7.5 kW (10 hp)
Safety-related Building Isolation Damper	Quantity:	4 (2 redundant dampers for each supply and exhaust duct)
	Type:	Parallel Blade
	ASME AG-1 Seat Leakage Class	10.44 liter/second per square meter (1 cubic foot per minute/square foot) at 250 Pascal differential pressure
	Actuator Type	Pneumatic, fail close

Table 9.4-11
Major Equipment for CONAVS (continued)

Main Steam Tunnel Recirculation AHU	Quantity:	2- 100% capacity (used when cooling is necessary)
	Capacity:	Flow - 9,000 l/s (19,070 cfm) per unit
		Filtration – low efficiency
		Cooling - 312,000 watts (1,064,856 Btu/h)
AHU Supply Fan	Quantity:	1- 100% capacity
	Capacity:	Flow - 9,000 l/s (19,070 cfm) per unit
		Pressure - 1,170 Pa (4.7 in. wg) static pressure
	Type:	Centrifugal, direct drive,11.2 kW (15 hp)
Refueling Machine Control Room Recirculation AHU	Quantity:	1- 100% capacity (used when cooling is necessary)
	Capacity:	Flow - * l/s (* cfm) per unit
		Pressure - * Pa (* in. wg) static pressure
		Filtration – low efficiency
		Cooling - * watts (* Btu/h)
	Type:	Centrifugal, direct drive, * kW (* hp)
Purge exhaust filter unit	Quantity:	2 - 100% capacity (used when purging and when temporarily filtering exhaust from other areas)
	Capacity:	Flow – 4,800 l/s (10,170 cfm)
	Type:	High efficiency and HEPA
Purge exhaust filter unit exhaust fans	Quantity:	2 - 100% capacity (used when purging and when temporarily filtering exhaust from other areas)
	Capacity:	Flow - 4,800 l/s (10,170 cfm) per fan
		Pressure - 2,490 Pa (10 in. wg) static pressure
	Type:	Centrifugal with inlet vanes, 22.4 kW (30 hp)

* - To be provided by the COL applicant.

Table 9.4-12

Drywell Cooling System Design Parameters

Specifically, the DCS is designed to maintain the following conditions in the upper and lower drywell during normal and plant refueling modes of operation:	
Normal Plant Operation:	
Average dry bulb temperature	≤57°C (≤135°F)
Maximum temperature of ambient atmosphere in each drywell zone	66°C (150.8°F)
Plant Refueling:	
Average dry bulb temperature	25°C (77°F)

Table 9.4-13

Drywell Cooling System Fan Cooling Units

Upper Drywell FCUs	
Number of fans per FCU	2
Motor and Fan	Directly coupled
Number of coils per FCU	1 or more
Cooling coil type	Plate Fin (4 fins/cm max) (11 fins/inch max.)
Air inlet temperature	57°C (135°F)
Air outlet relative humidity	90 to 100%
Water inlet temperature	7°C (45°F)
Air flow rate (total)	114,410 m^3/h (67,400 cfm)
Water flow rate	[45 m^3/h (198.1gpm)]
Cooling capacity (each FCU)	1,211,740 kcal/h (4,8 x 10^6 Btu/h)
Fan type	Vaneaxial
Lower Drywell FCUs	
Number of fans per FCU	2
Motor and Fan	Directly coupled
Number of coils per FCU	1
Cooling coil type	Plate Fin (4 fins/cm max.) (11 fins/inch max.)
Air inlet temperature	57°C (135°F)
Air outlet relative humidity	90 to 100%
Water inlet temperature	7°C (45°F)
Air flow rate (total)	31.195 m^3/h (18.360 cfm)
Water flow rate	[16.2 m^3/h (71.3gpm)]
Cooling capacity (each FCU)	318,426 kcal/hr (1.26 x 10^6 Btu/h)
Fan type	Vaneaxial

Table 9.4-14

Drywell Cooling System Heat Loads

Upper Drywell		
	Normal kcal/h (Btu/h)	Refueling kcal/h (Btu/h)
Sensible Load	869,561 (3.45 x 10^6)	[252,016 (1 x 10^6)]
Latent Load	183,971 (0.73 x 10^6)	[10,080 (0.04 x 10^6)]
Total Load	1,053,532 (4.18 x 10^6)	[626,096 (1.04 x 10^6)]
Lower Drywell		
	Normal kcal/h (Btu/h)	Refueling kcal/h (Btu/h)
Sensible Load	183,971 (0.73 x 10^6)	[75,605 (0.3 x 10^6)]
Latent Load	93,246 (0.37 x 10^6)	[Negligible]
Total Load	277,217 (1.1 x 10^6)	[75,605 (0.3 x 10^6)]

Figure 9.4-1. CRHAHVS Simplified System Diagram

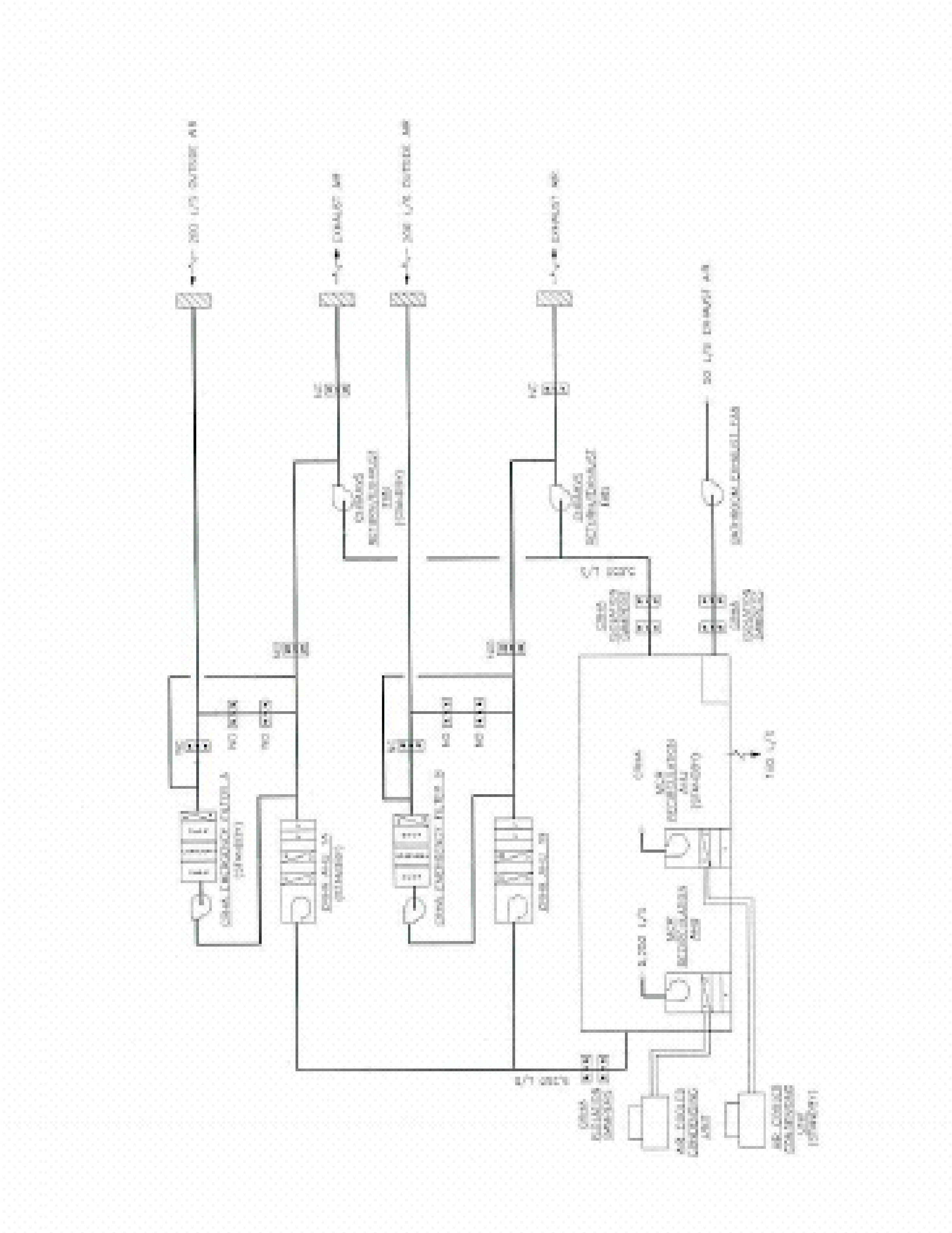


Figure 9.4-2. EBAS System Diagram

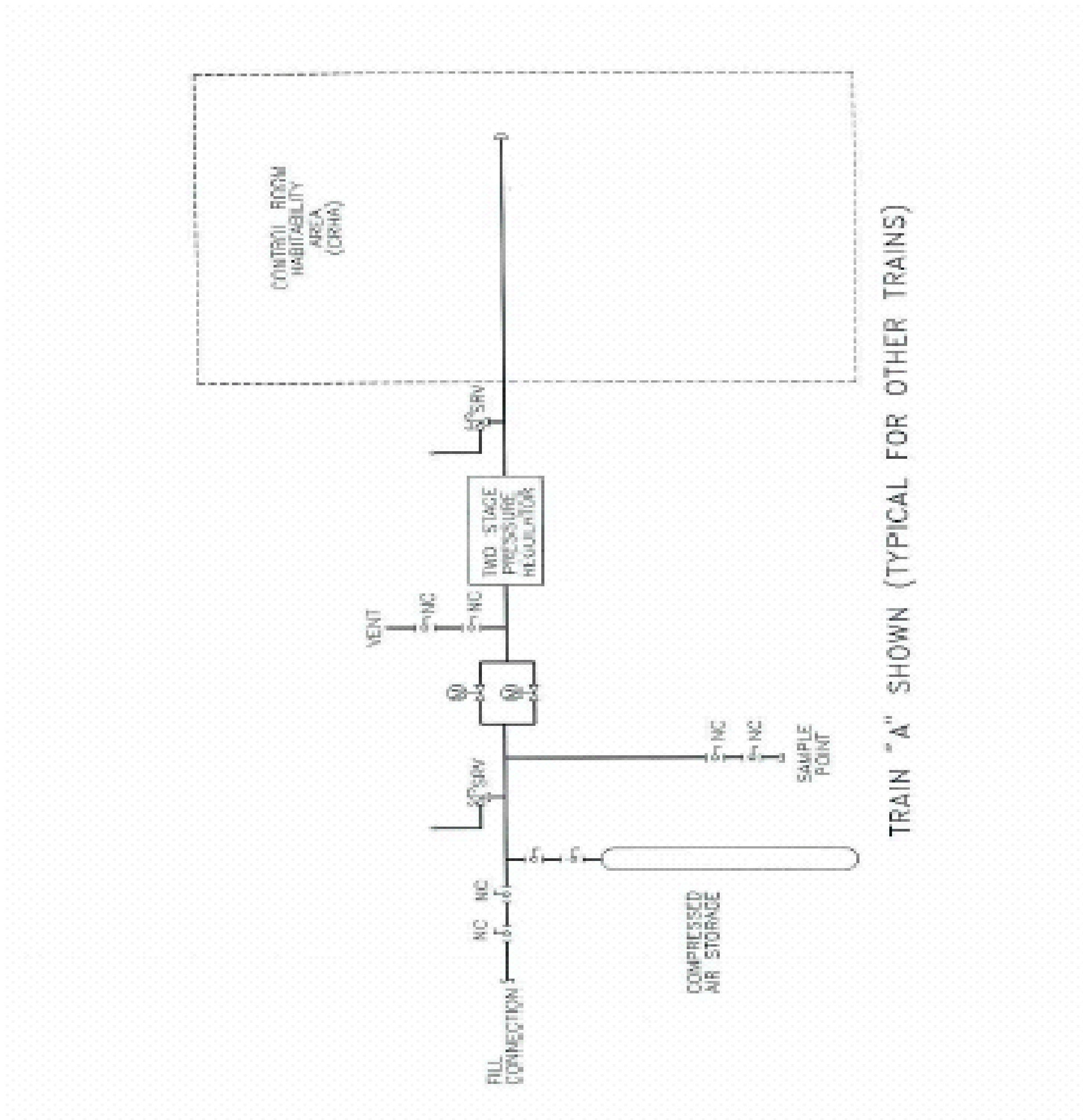


Figure 9.4-3. CBGAHVS SET A Simplified System Diagram

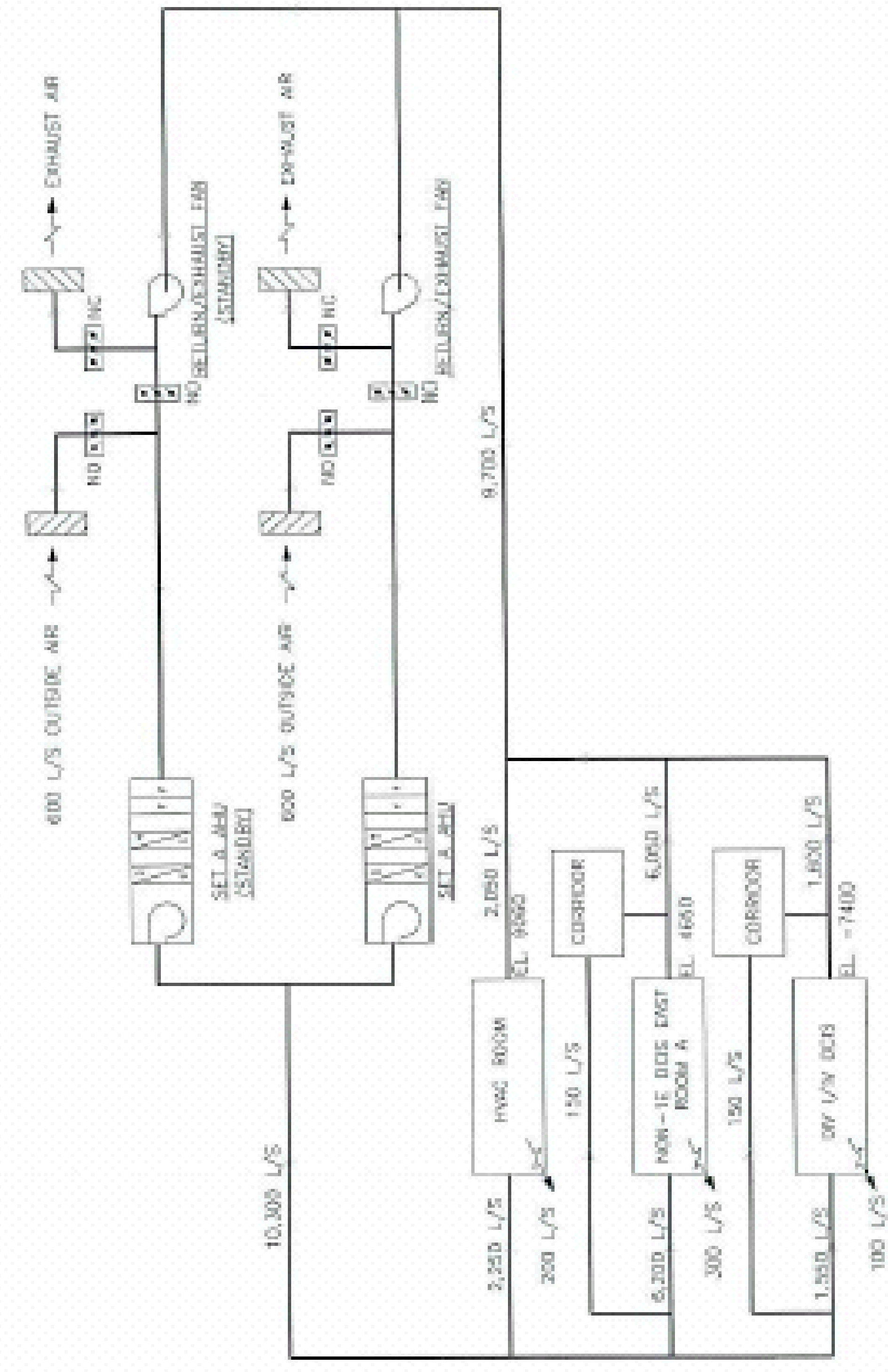


Figure 9.4-4. CBGAHVS SET B Simplified System Flow Diagram

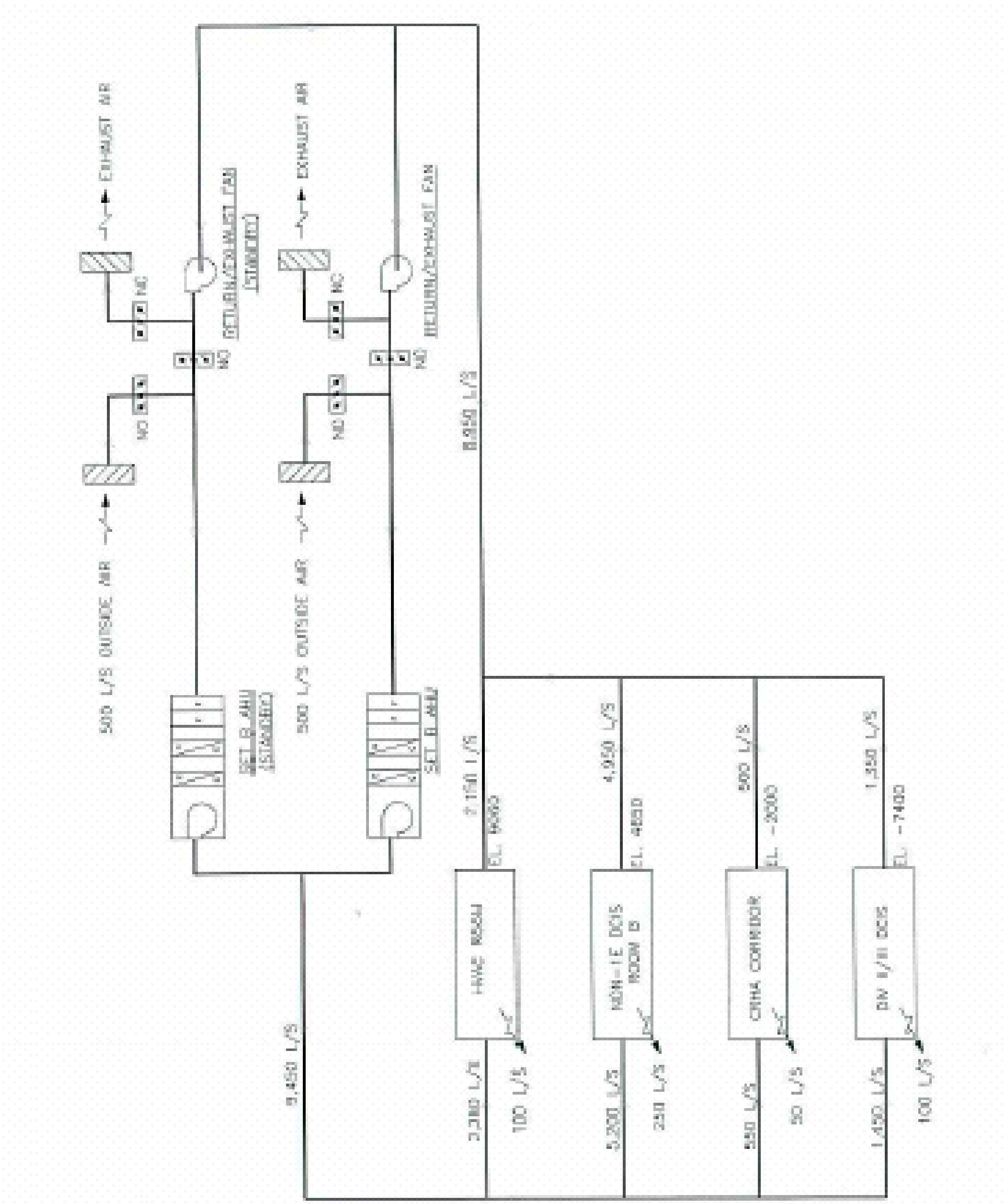


Figure 9.4-5. FBGAHV Simplified System Diagram

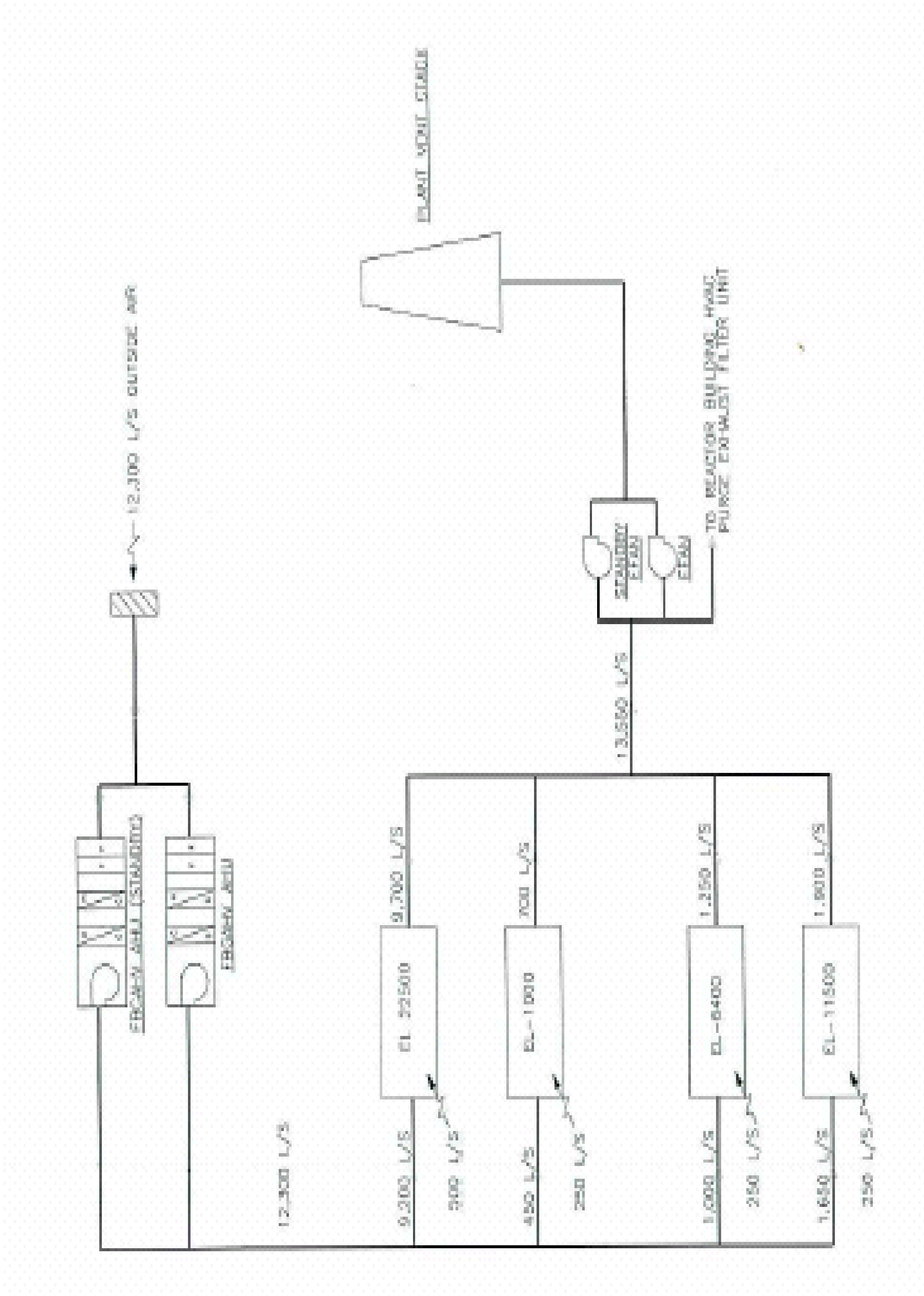


Figure 9.4-6. FBFPHV Simplified System Diagram

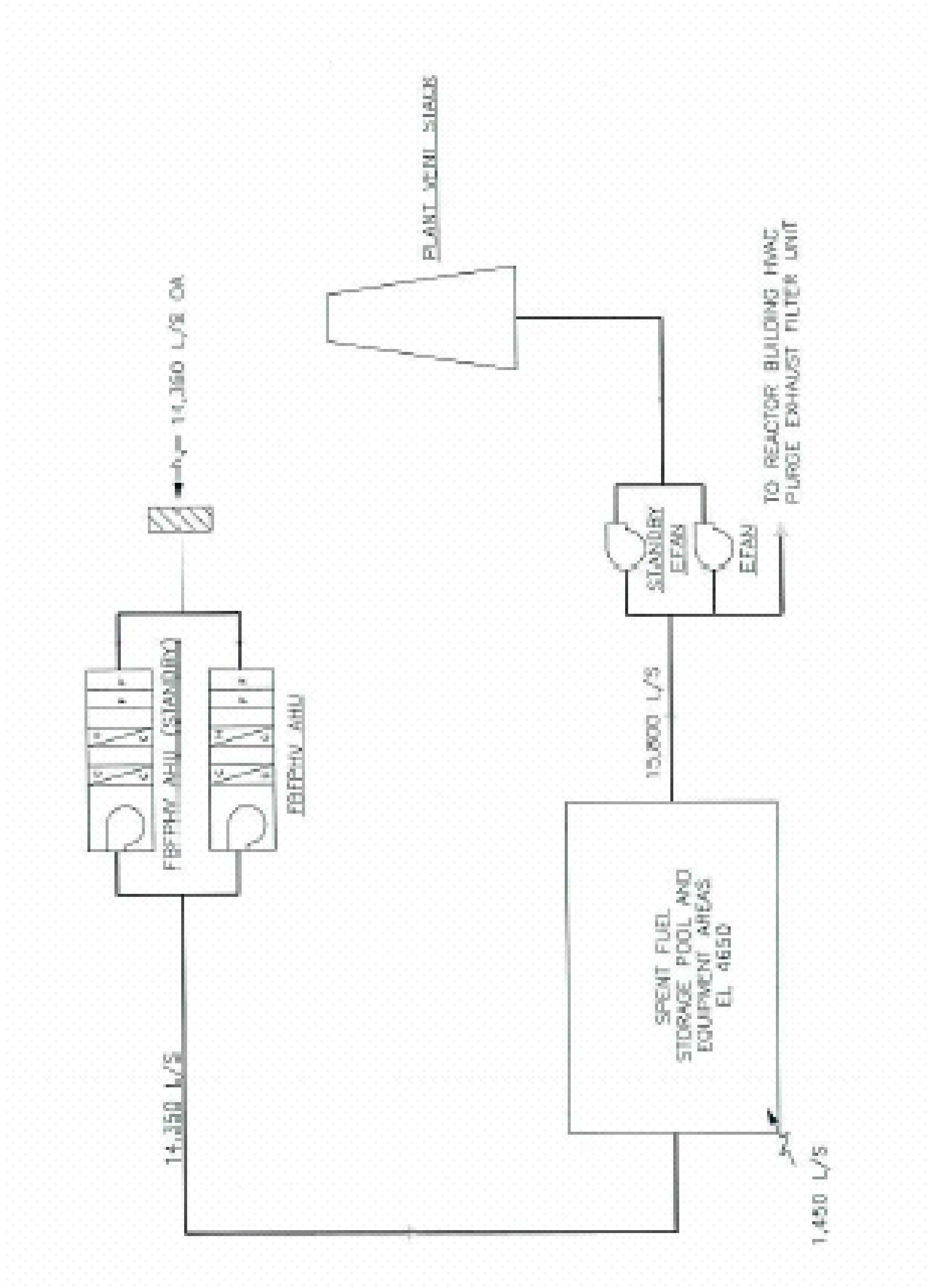
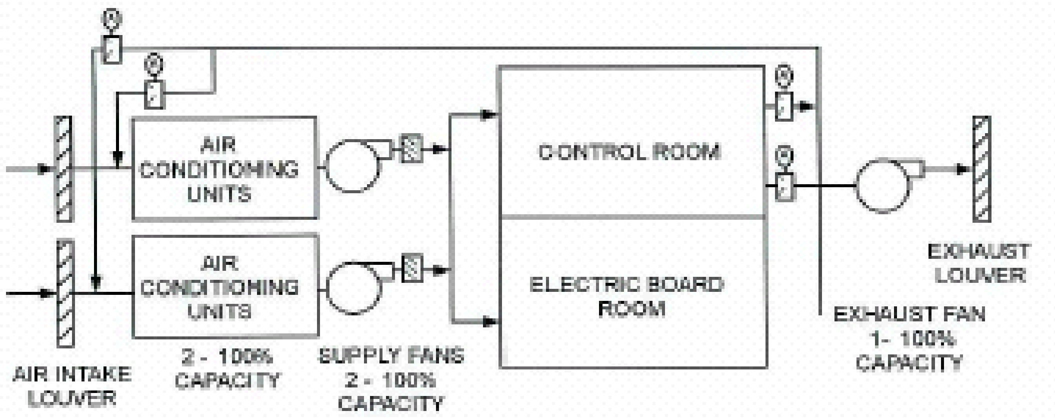
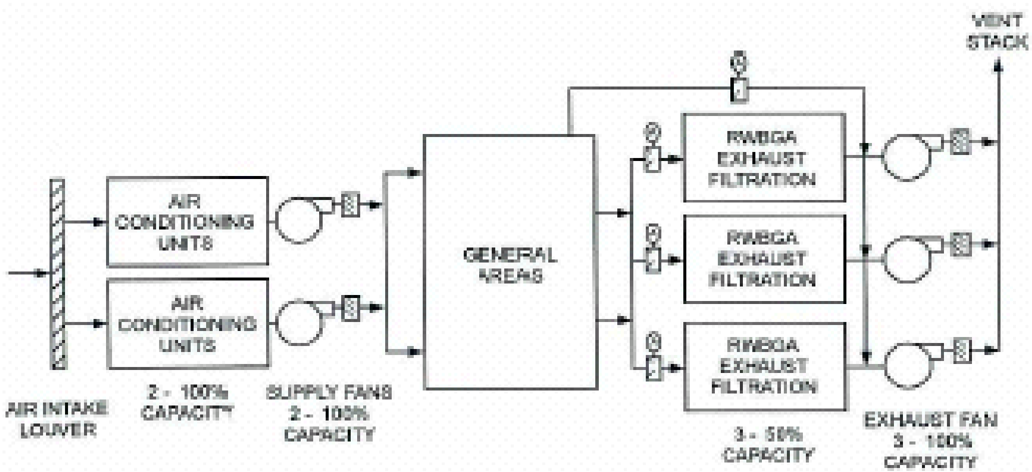


Figure 9.4-7. RWBHVAC Simplified System Diagrams



RWBCR Simplified System Diagram



RWBGA Simplified System Diagram

Figure 9.4-8 TBHVAC Simplified System Diagram - Sheet 1 of 3

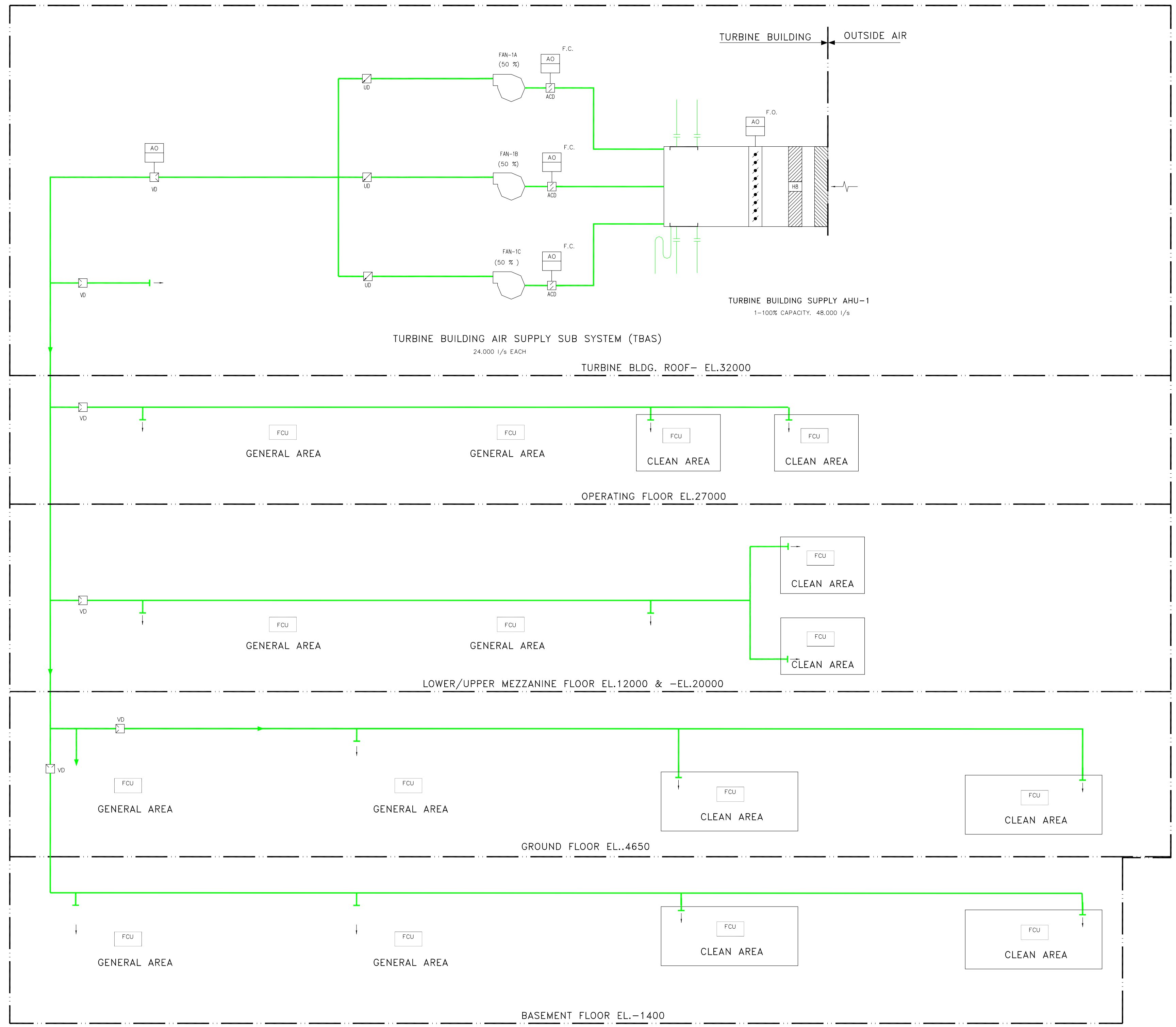


Figure 9.4-8 TBHVAC Simplified System Diagram - Sheet 2 of 3

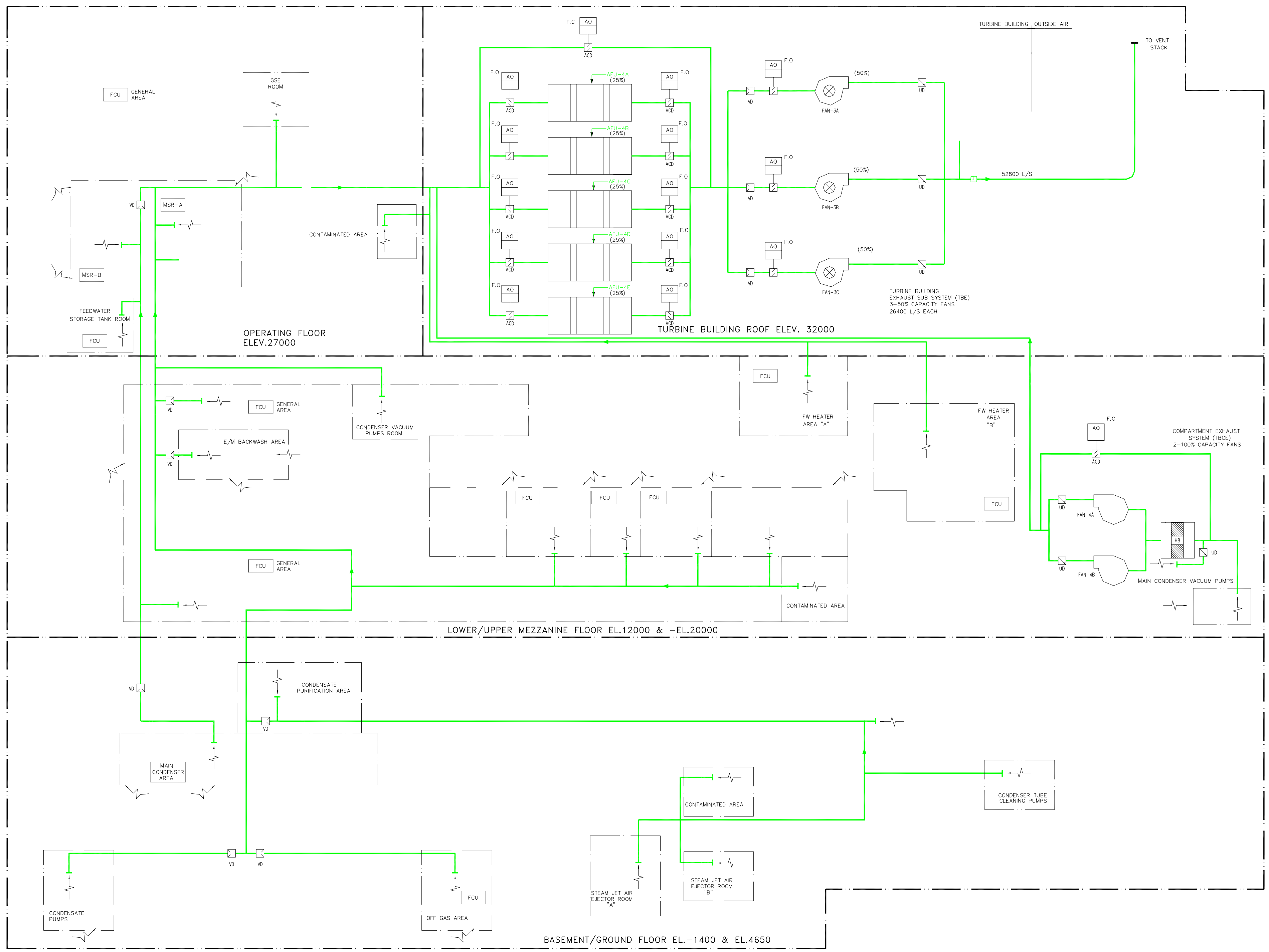


Figure 9.4-8 TBHVAC Simplified System Diagram - Sheet 3 of 3

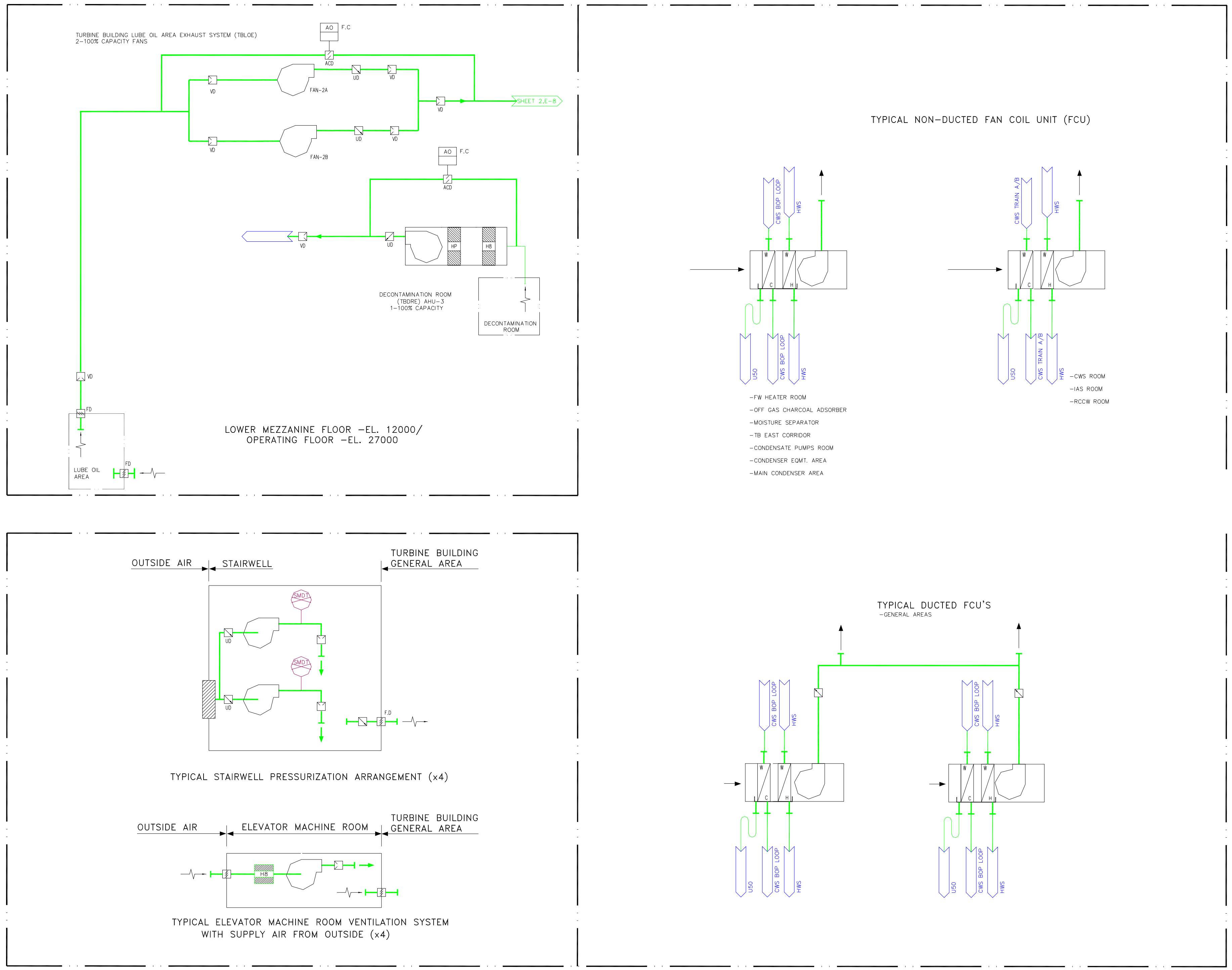


Figure 9.4-9. CLAVS Simplified System Diagram

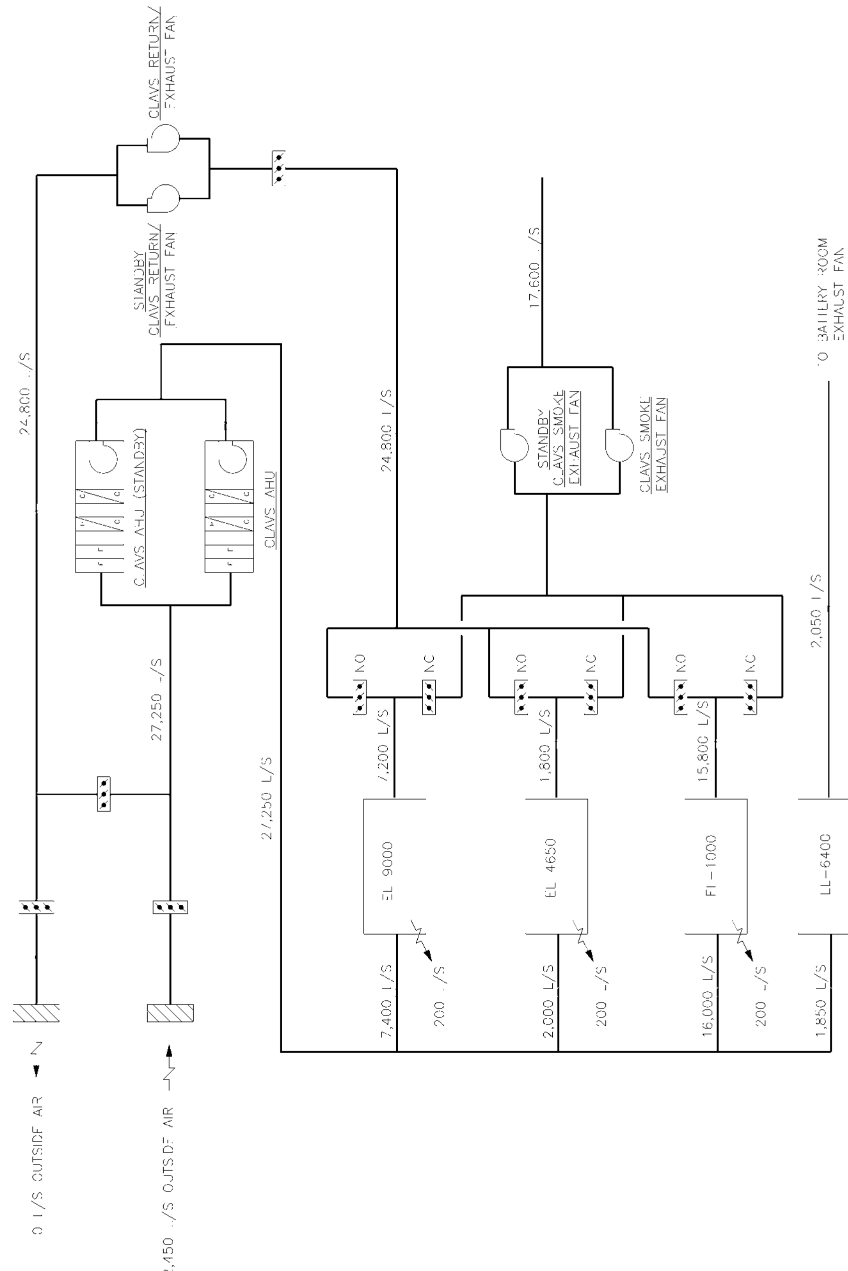


Figure 9.4-10. CONAVS Simplified System Diagram

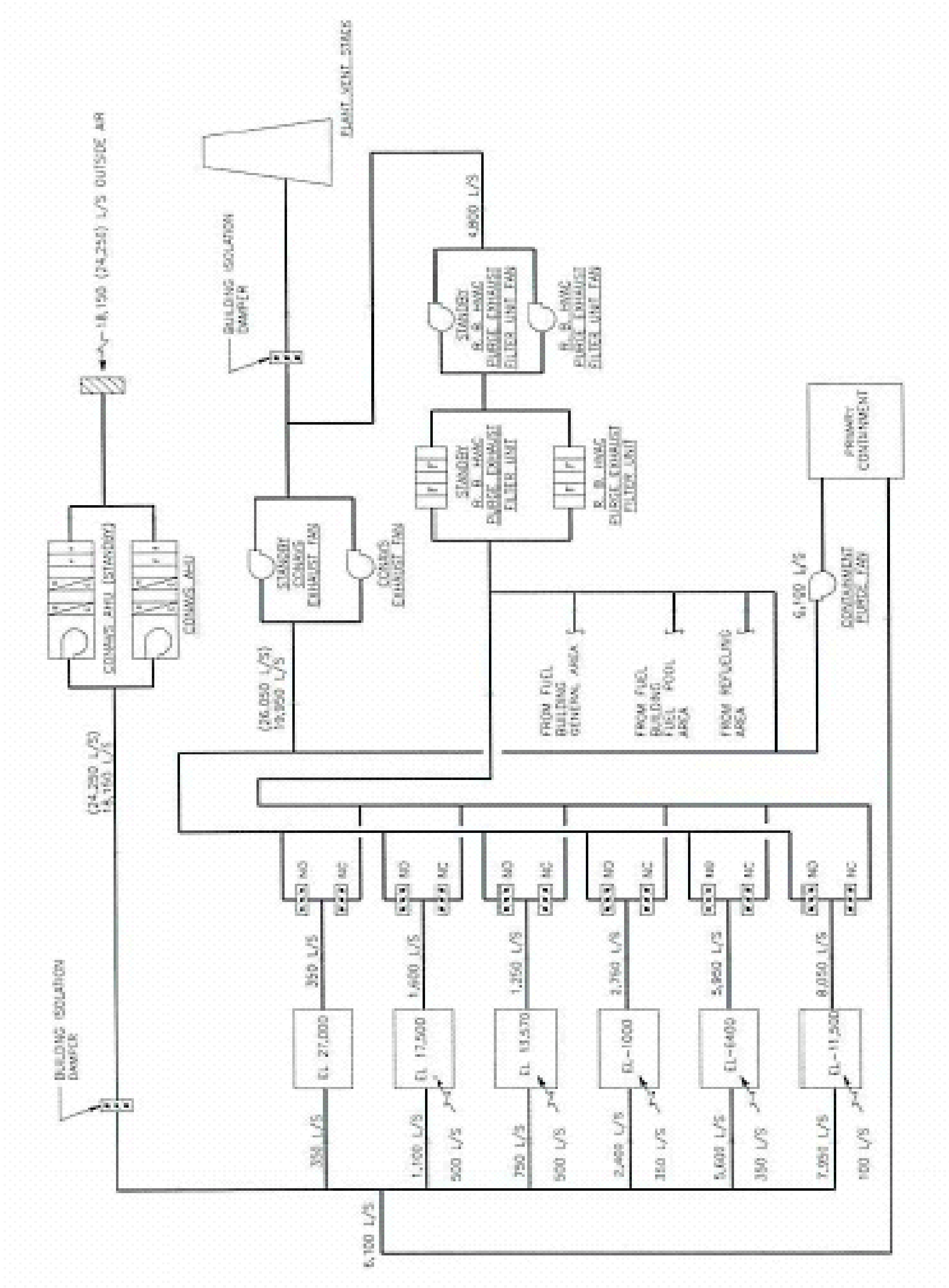


Figure 9.4-11. REPAVS Simplified System Diagram

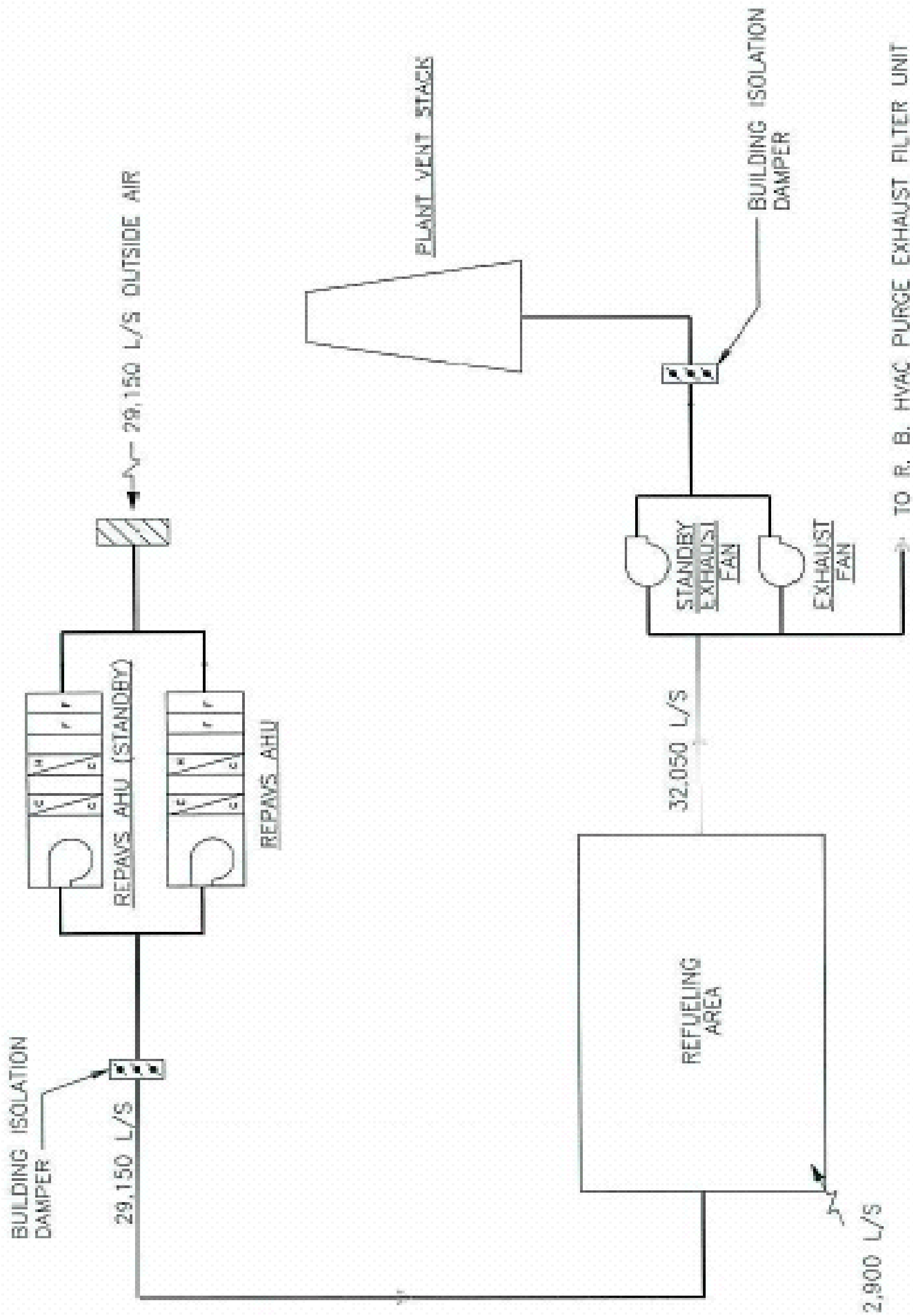


Figure 9.4-12 Electrical Building HVAC System – Sheet 1 of 2

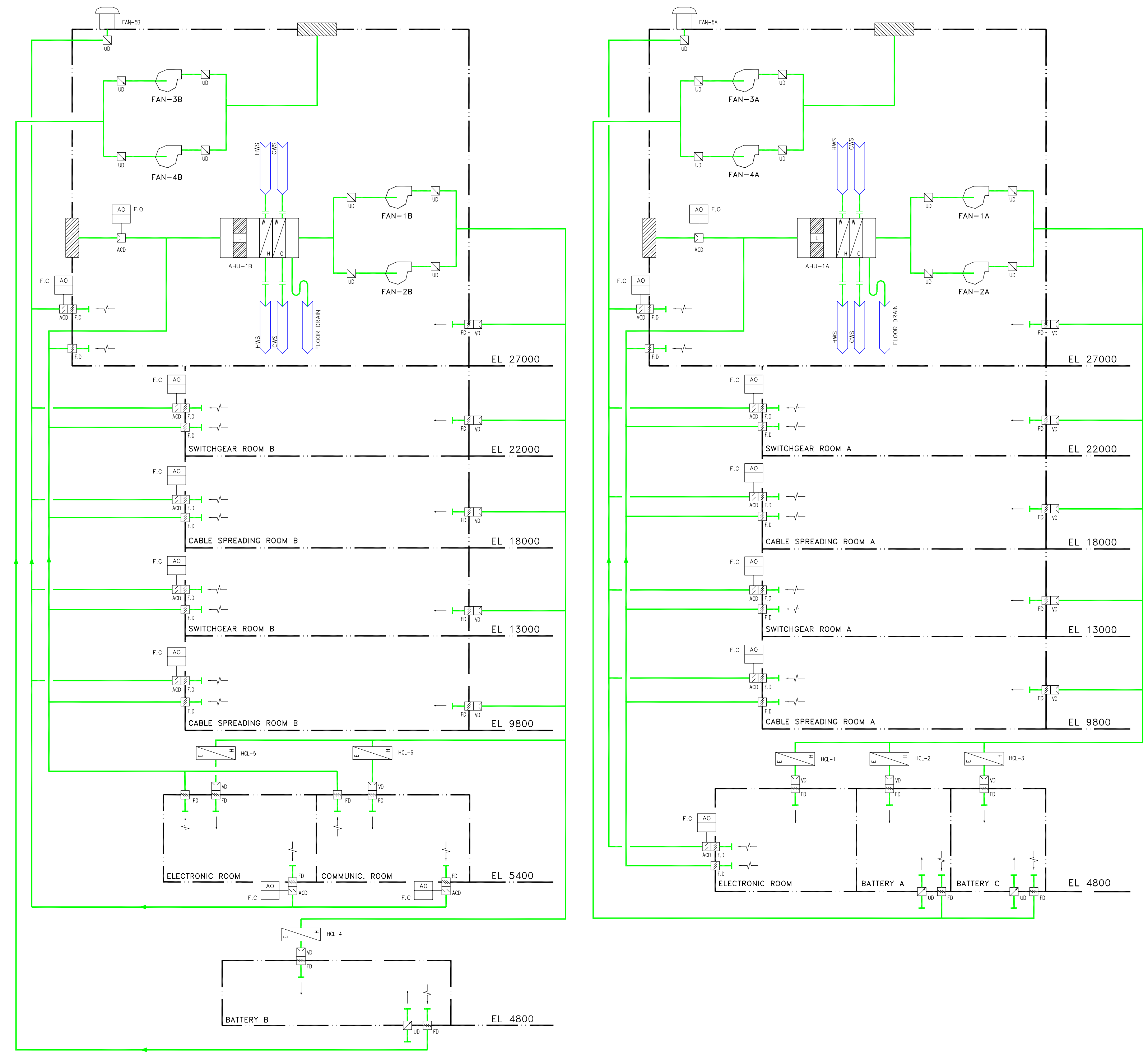


Figure 9.4-12 Electrical Building HVAC System – Sheet 2 of 2

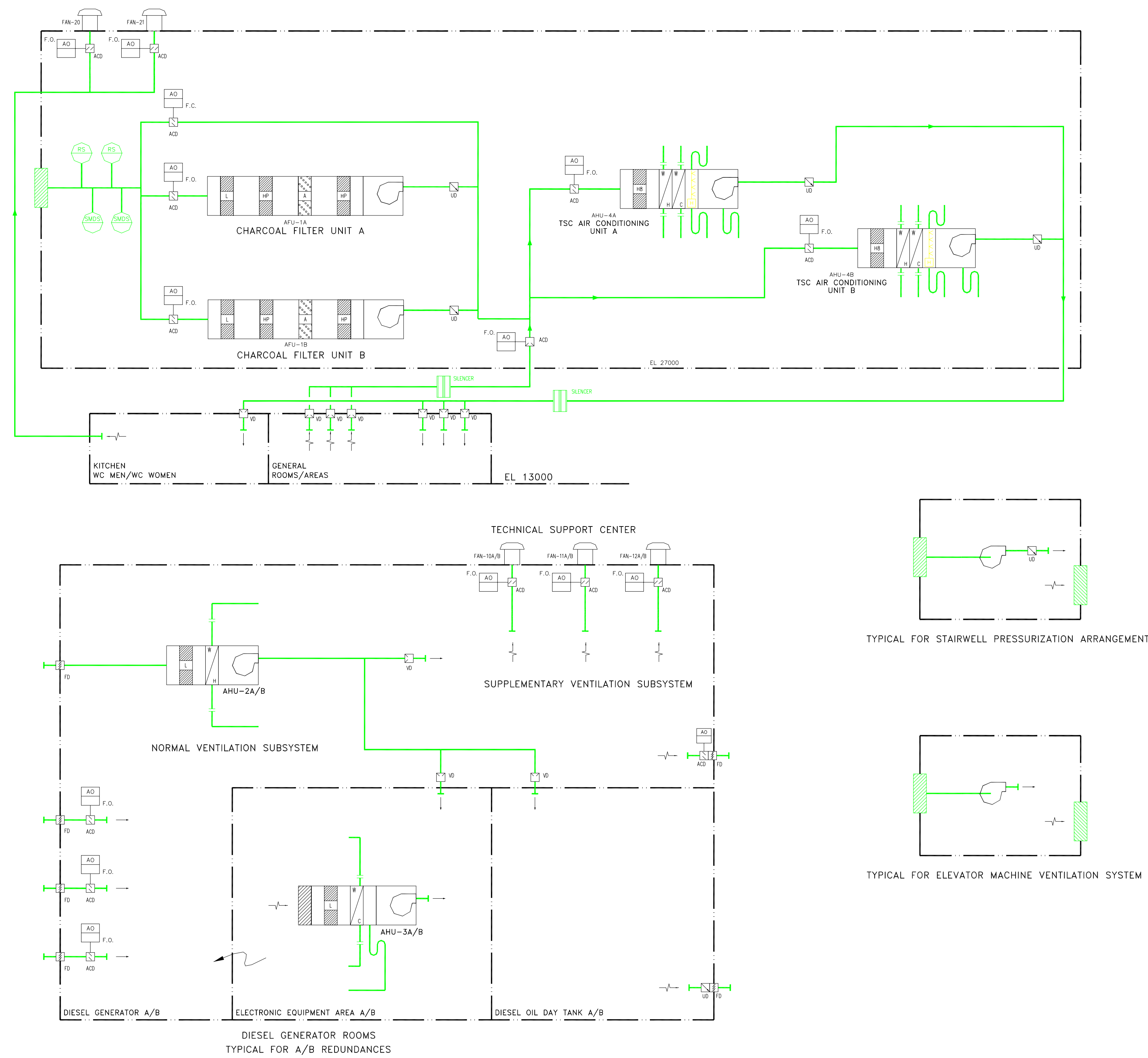


Figure 9.4-13. DCS Simplified System Diagram

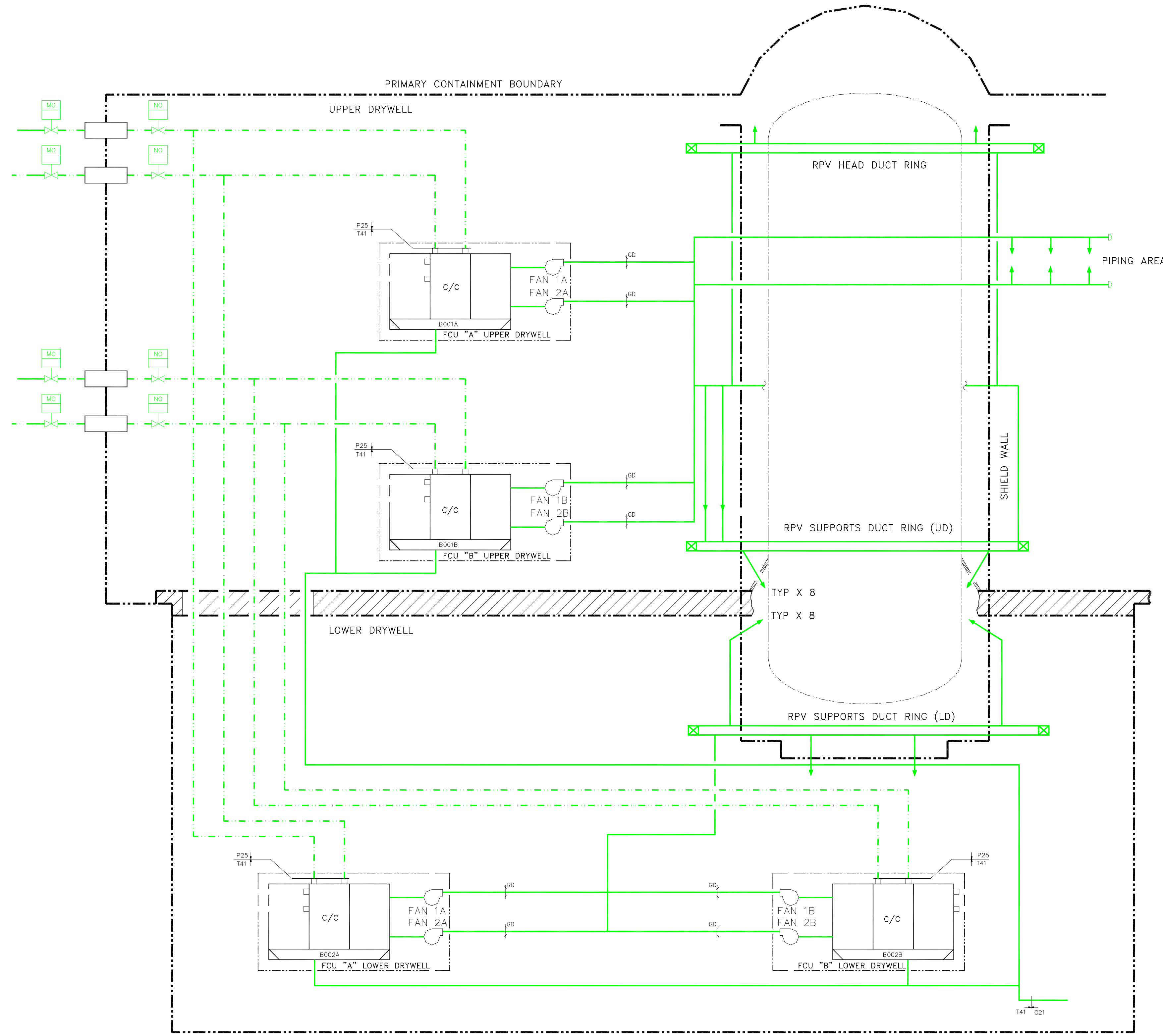
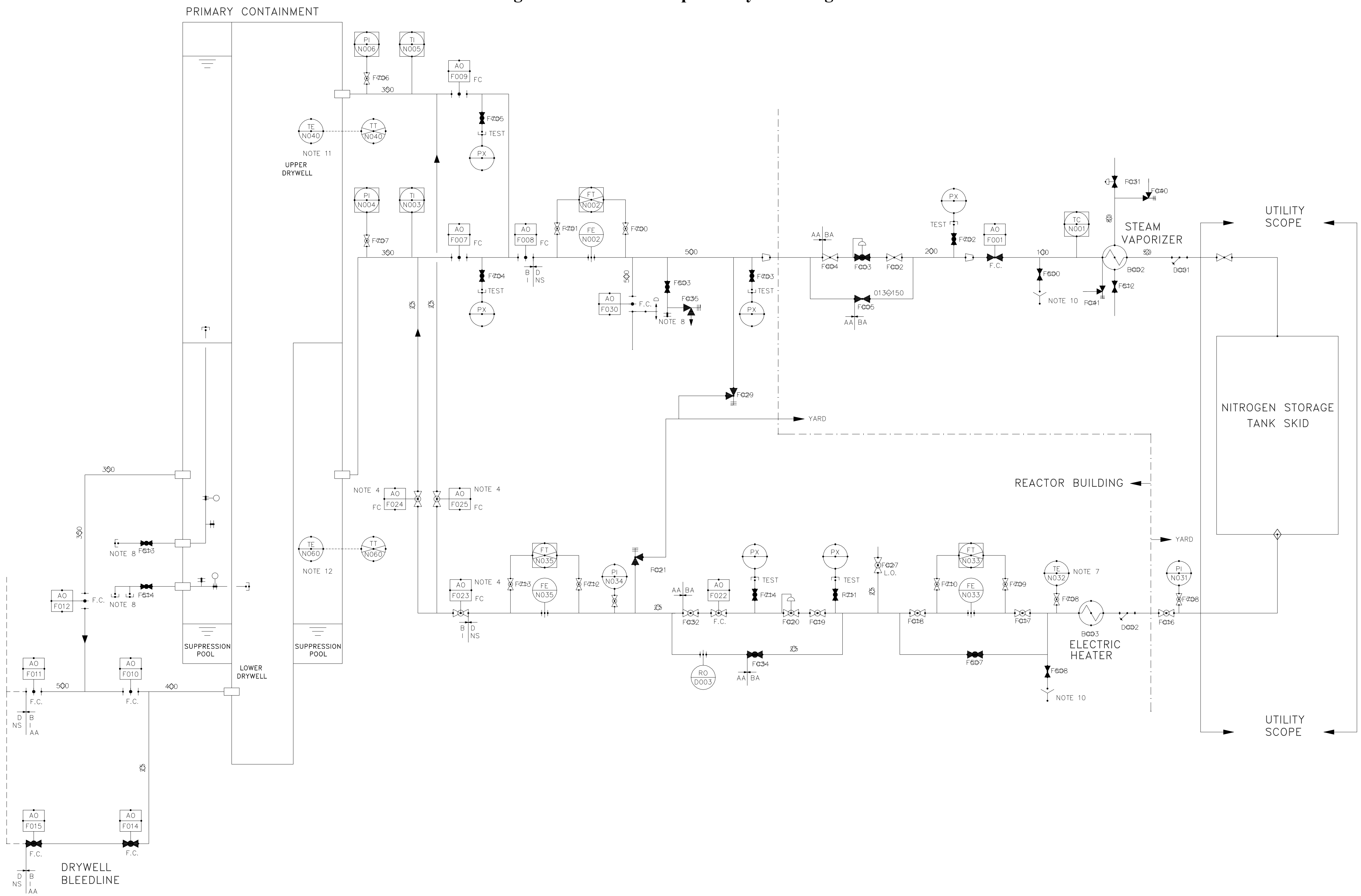


Figure 9.4-14. CIS Simplified System Diagram



9.5 OTHER AUXILIARY SYSTEMS

9.5.1 Fire Protection System

The term "fire protection system" refers to the integrated complex of components and equipment provided for detection, notification, annunciation, and suppression of fires. In addition to this system, the "fire protection program" includes the concepts of design and layout implemented to prevent or mitigate fires, administrative controls and procedures, and the training of personnel to combat fires.

9.5.1.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The Fire Protection System (FPS) does not perform any safety-related function. There is no interface with any safety-related component.

Power Generation Design Bases

In accordance with NUREG-0800 SRP 9.5.1 and Regulatory Guide 1.189, fire protection for nuclear power plants uses the concept of defense in depth to achieve the required degree of reactor safety by using administrative controls, fire protection systems and features, and safe shutdown capability. These defense-in-depth principles achieve the following objectives:

- To prevent fires from starting.
- To rapidly detect, control, and extinguish promptly those fires that do occur.
- To provide protection for structures, systems, and components important to safety so that a fire that is not promptly extinguished by the fire suppression activities does not prevent the safe shutdown of the plant.

The ESBWR fire protection program design bases incorporate the following elements:

- To maintain the ability to safely shut down the reactor and keep it shut down by providing adequate separation of safety-related equipment. This capability is to be achievable during all modes of plant operation.
- To minimize the probability of the spread of fire by the use of fire barriers between areas of significant combustible loading.

The ESBWR Fire Protection System (FPS) design bases incorporate the following elements:

- To maintain the ability to safely shut down the reactor and keep it shut down by providing the capability to control the spread of and extinguish the postulated fires in all plant areas by the use of fixed and/or portable fire fighting equipment. This capability is achievable during all modes of plant operation.
- To provide automatic fire detection and annunciation for selected areas of the plant for personnel safety and fire brigade notification.
- To supply the maximum firewater demand at any point throughout the system, with one fire pump out of service[g1362].

- To prevent inadvertent operation of the FPS from jeopardizing the capability to achieve safe shutdown of the plant[g1363].
- To preclude damage to plant safety-related structures, systems, or components caused by seismic loading of the FPS.
- To keep equipment required for safe shutdown free from fire damage during a safe shutdown earthquake (SSE). To this end, one source of fire water supply, including a water source; one fire pump and its associated suction and discharge lines; and a portion of the yard main piping and fire water lines, including standpipes and hose connections, are designed and analyzed to remain functional after an SSE. This includes analysis to the first isolation valve on all branches connected to the seismically analyzed fire water lines.
- To ensure a continuous fire water supply for the fire pumps in the event of failure of one firewater source. Two separate fire water sources are connected to FPS such that there is no interruption in supply and that failure of one water source or its piping does not drain the other source.
- To provide manual suppression capability to all plant areas, including those that have automatic fire suppression systems.
- To ensure that a single active failure in a moderate-energy line cannot impair both the primary and backup fire suppression systems.
- To permit isolation from the fire main or outside hydrants for maintenance or repair without interrupting FPS water supply.
- To ensure at least one effective hose stream can reach any location containing safe shutdown equipment, for preventing a fire exposure hazard to the equipment.
- To provide an emergency backup source of makeup water for auxiliary refueling pools and reactor water inventory control through a piping connection to the Fuel and Auxiliary Pools Cleaning System (FAPCS).
- To have a useful life of 60 years with normal maintenance and replacement of parts/components subject to normal wear and deterioration.

Codes, Standards, and Regulatory Guidance

Table 9.5-1 lists the codes, standards, and guidelines used in the fire protection program and FPS design.

9.5.1.2 System Description

Figure 9.5-1 shows the FPS simplified system diagram. Table 9.5-2 lists the Component Design Characteristics.

The FPS is the integrated complex of equipment and components that provides early fire detection and suppression to limit the spread of fires. The FPS is part of the overall fire protection program including the plant design and layout to prevent or mitigate fires and includes administrative controls and procedures.

The type of fire suppression is based on the combustible loading and the extent of safety-related equipment within a fire area. Fixed automatic fire suppression systems are installed in areas identified as having a high fire hazard rating by the Fire Hazards Analysis (FHA) (Appendix 9A). Building standpipes and hose stations are provided in major buildings. Portable fire extinguishers are strategically located throughout the plant in accordance with NFPA 10, except in highly radioactive areas.

A comprehensive fire detection, alarm, supervisory control, and indication system is also provided in various locations throughout the plant. The operation of this system is automatic, and is controlled from local panels throughout the plant.

A main fire alarm panel (MFAP), is located in the Main Control Room (MCR), monitors and receives system actuation, supervisory, and trouble alarm signals from the individual local panels.

9.5.1.3 Facility Features for Fire Protection

Consistent with applicable safety-related requirements, structures, systems, and components are designed and located to minimize the probability and effect of fires. To the maximum extent practical, noncombustible and fire-resistant materials minimize the combustible loading and thereby reduce the expected duration, severity, and intensity of fires.

Within the safety-related structures, interior walls, partitions, structural components, materials for insulation, and radiation shielding are either noncombustible or have low ratings for contribution. The flame spread and smoke development rating of these materials is 25 or less. Materials having a flame spread and smoke development rating of 50 or more are considered to be combustible when analyzing fire hazards.

Exposed structural steel protecting safety-related areas is fireproofed with material with a fire rating of up to 3 hours as determined from the FHA.

Access stairwells are enclosed in minimum 2-hour rated firewalls and equipped with self-closing fire-rated doors. Openings in fire barriers or firewalls are equipped with fire doors, frames, and hardware rated the same as the barriers they penetrate.

Safety-related raceway and circuit routing comply with Branch Technical Position (BTP) SPLB 9.5-1 except that separation by fire barriers rather than distance is used outside the MCR or primary containment. Exceptions to this requirement are analyzed and justified as acceptable on an individual basis. Safety-related cables conform to the IEEE-383 flame test.

9.5.1.4 Fire Protection Water Supply System

Water Source

Water for the Fire Protection System is supplied from a minimum of two reliable sources. Each source has sufficient capacity to meet the maximum water demand of the system for a period of two hours. Water sources that are used for multiple purposes ensure that the required quantity of water is dedicated for fire protection use only.

Fire department connections on all major buildings allow a fire department pumper truck to pump water into the FPS as an additional fire protection water supply source.

Fire Pumps

Each of the three 50% capacity firewater pumps provides 100% of the firewater demand to the worst-case fire within the nuclear island (Reactor Building, Fuel Building, and Control Building) or 50% of the firewater demand to the worst-case fire within the balance of plant. The pumps are capable of delivering the flow and pressure required to the location that is farthest from the firewater supply source. Two of the three pumps are located near the nuclear island power block in a fire pump enclosure (FPE). The third pump is located remote from the other two pumps to avoid any common-location failures.

For the two nuclear island fire pumps, the lead pump is motor-driven and the backup pump is diesel-driven. The backup pump provides firewater in the event of failure of the motor-driven pump or loss of preferred power (LOPP). A motor-driven jockey pump maintains the system pressure to minimize the cycling of the main fire pumps due to minor pressure losses.

The main diesel-driven fire pump, including its suction and discharge piping, meets the requirements of ASME B31.1 and remains functional after an SSE. The diesel-driven fire pump is located in a separate fire-rated compartment from the motor-driven fire pump.

The second diesel-driven fire pump provides a back up to the other two pumps. This back-up diesel-driven fire pump is site specific and is connected to the main yard piping loop.

The fuel oil tanks for the diesel-driven fire pumps have a capacity sufficient to allow operation of the diesel engines for approximately 8 hours before refilling based upon the fuel consumption and margin criteria provided in NFPA 24.

9.5.1.5 Fire Water Supply Piping, Yard Piping, and Yard Hydrants

The fire water supply piping consists of a non-seismic, buried yard main and a suspended ASME B31.1 piping loop. The ASME B31.1 piping loop supplies firewater to the nuclear island buildings and remains functional following an SSE. The main firewater pumps discharge to the ASME B31.1 piping loop. A connection from the ASME B31.1 piping loop supplies firewater to the yard main. The second diesel-driven fire pump supplies firewater directly to the yard main, but is also capable of supplying water to the ASME B31.1 piping loop. Motor-operated isolation valves are provided between the buried, non-seismic, yard piping loop and the suspended, Seismic Category I, ASME B31.1 piping loop.

The yard piping main loop consists of buried Class 200, High-Density Polyethylene (HDPE) piping, FM-approved for fire main service, with concrete thrust blocks or cement-lined ductile iron piping (site specific), in accordance with NFPA 24. Locked open sectionalizing and isolating post-indicator valves installed in the fire yard main permit isolation of any part of the main without completely removing the system from service. Sectionalizing valves between connections separate individual fire pump connections from the yard main. The COL applicant shall determine the design characteristics of the yard piping main loop, including material selection.

Fire hydrants located at approximately 76.2m (250 ft) intervals along the fire main loop provide fire-fighting capability especially in the vicinity of areas or buildings containing combustible materials. The fire hydrants are generally located no closer than 12.2m (40 ft) from the protected buildings.

The fire hydrants are protected against damage from freezing or vehicles.

9.5.1.6 Manual Suppression Means

Manual suppression means are provided for all plant areas. The sprinkler systems and the hose station standpipes have separate connections to the fire water main; therefore, no single failure can impair both systems.

Standpipe and Hose Systems (Wet)

Building standpipes and hose stations are provided in all major buildings. Standpipes and hose stations in areas adjacent to stairways and at other locations provide sufficient hose coverage. Minimum standpipe size is 100 mm (4 inch). Standpipe size for building heights exceeding 30.5 meters (100 feet) is 150 mm (6 inch).

The wet standpipes and hose stations are designed to NFPA 14 Class III Service.

Each Class III hose station is provided with a 65 mm (2-1/2 inch) hose valve with cap and a 40 mm (1-1/2 inch) hose valve. A 6.35-cm (2-1/2 inch) to 3.8-cm (1-1/2-inch) reducer is utilized on the 6.35-cm (2-1/2-inch) hose valve.

Each Class III hose rack has 30.5m (100 ft) of 40 mm (1-1/2-inch) jacket-lined fire hose.

The water supply pressure maintains a gauge pressure of 448.2 kPaG (65 psig) at the most hydraulically remote 40 mm (1-1/2 inch) hose station and 689 kPaG (100 psig) at the most hydraulically remote 65 mm (2-1/2 inch) hose station. If the gauge pressure at a 40 mm (1-1/2 inch) hose station exceeds 689 kPaG (100 psig), orifice discs installed in the hose couplings reduce the reaction force at the hose end.

For areas containing equipment for safe shutdown, standpipes and hose connections for manual firefighting remain functional following an SSE. The piping system serving these hose stations is analyzed for SSE loading. The piping and valves satisfy ASME B31.1 requirements.

All rooms within the plant buildings are within the reach of at least one effective hose stream from a Class III hose station. A hose station covers each room not covered by a fixed fire suppression system. Effective hose streams from two separate hose stations cover each room that contains equipment required for safe shutdown that is not protected by a fixed fire suppression system. The need for two hose station coverage is also based upon the fire hazard present. Rooms not covered by a fixed fire suppression system and with coverage by only one hose station are furnished with portable fire extinguishers for secondary coverage.

Hose stations also provide secondary coverage for fixed suppression systems.

Hose stations are located outside of highly radioactive areas where possible; however, hose stations are located such that any location that contains or could present a hazard to safety-related equipment can be reached by at least one effective hose stream with a maximum of 30.5 meters (100 feet) of hose.

Fixed fog hose nozzles protecting high-voltage electrical equipment rooms preclude electrical shock hazards with ON/OFF isolation valves. Adjustable fog and straight stream nozzles are provided for all hose stations located away from high-voltage electrical equipment.

Fire Extinguishers

Portable multipurpose Class ABC dry chemical-type fire extinguishers are provided for general hazard areas throughout the buildings in the plant. Portable Carbon Dioxide Class BC fire extinguishers are provided for electrical areas. Special use portable extinguishers are provided based upon the hazard present. The fire extinguishers are located in accordance with NFPA 10.

Water Spray for Charcoal Filters

Charcoal filters in the off-gas and ventilation systems of the plant are provided with water spray systems for fire protection. The water is supplied to the charcoal by means of fixed piping terminating at the exterior of the equipment assembly with manual shutoff valves. In the event of charcoal ignition, the piping can be connected to the fire water supply system through a standard hose or jumper fitting.

9.5.1.7 Fixed Automatic Water Extinguishing Systems

The selection of specific types of fire suppression systems and the areas requiring protection are based on equipment arrangements and combustible loading in each fire area.

Sprinkler piping for safety-related areas meets the requirements of NFPA 13 and Seismic Category I criteria (assurance that any failure of FPS piping caused by an earthquake does not damage a safety-related item).

Wet Pipe Sprinkler System

Automatic sprinklers provide protection for the areas identified in the fire hazard analysis, except where conditions dictate the use of other types of systems or fire suppression agents.

Each system consists of an outside screw and yoke valve with a position switch, an alarm check valve assembly, piping network containing water under pressure, and thermally actuated closed-head sprinklers. Water discharges immediately from sprinklers opened by heat from a fire. The wet pipe sprinkler system meets the requirements of NFPA 13.

Preaction Sprinkler System (Manual or Automatic)

The preaction sprinkler system employs thermally actuated closed-head sprinklers attached to piping containing air under pressure. Fire detectors are installed in the same area as the sprinklers. A preaction system is used in areas where there is danger of serious water damage as a result of a leaking automatic sprinkler head, spurious actuation, or a pipe break. The preaction sprinkler system meets the requirements of NFPA 13.

Deluge System (Manual and/or Automatic)

Deluge systems are actuated automatically or manually depending upon the area and the nature of the equipment being protecting. Deluge systems employ open head sprinklers or nozzles attached to dry piping and water supply. Fire detectors are installed to cover the protected equipment or are in the same area as the nozzles. Deluge systems are normally used for hazards requiring an immediate application of water over an entire hazard area. The deluge system meets the requirements of NFPA 15.

9.5.1.8 Foam System

A foam system is provided for concentrated fuel oil or lube oil hazards.

A combination of infrared/ultraviolet detectors and thermal rate compensated detectors are used for fire detection that actuates preaction foam-water sprinkler or deluge foam-water spray systems to protect against inadvertent actuation.

The foam systems meet the requirements of NFPA 11 and NFPA 16.

9.5.1.9 Smoke Detection and Fire Alarm System

Smoke detectors installed in all rooms containing safety-related equipment, except primary containment, and in areas containing significant amounts as determined by the FHA (Appendix 9A) of combustible materials provide early detection and warning of fires. Primary containment is an inerted space during normal operation. Portable fire detection equipment is used inside primary containment during maintenance outages when the space is not inerted.

Fire detector types are selected on the basis of the nature and burning characteristics of the materials within the room, and on the basis on the FHA (Appendix 9A). The selection of the detector type also includes specific consideration of the combustion products, type of hazard, and fire load expected as well as the effects of humidity, air velocity, temperature, ambient air conditions, radiation, air pressure, area configuration, and response time required. The detector locations are based upon environmental conditions, maintenance access, and As Low as Reasonably Achievable (ALARA) concerns.

A minimum of two detectors isare installed in any single room containing safety-related equipment.

Smoke detection systems for early warning and annunciation of fire conditions are separate from fire detection and releasing devices for suppression system actuation.

Local fire alarm panels continuously monitor the zone and area detection systems and circuits. Upon receipt of an indication of fire from any of the area smoke detectors, the local fire alarm panel activates a visual and audible fire alarm at the panel.

All fire and smoke detection circuits are electrically supervised to detect circuit breaks, ground faults, and power failure. The detector circuits are designed so that the failure, removal, or replacement of a detector does not affect the performance of the fire detection loop. Fire or trouble alarms register on an audible-visual annunciator on a MFAP in the MCR.

Preaction fire detection systems have 90-hour (minimum) backup battery packs located at the local fire alarm panel (releasing panel). Other fire detection and alarm systems have 24-hour (minimum) backup battery packs located at each local fire alarm panel (supervisory panel) and at the MFAP.

Manual fire alarm stations (pull box stations) are provided at the normal exit paths or every 61 meters (200 feet), whichever is less, throughout normally occupied buildings. Manual fire alarm stations (pull box stations) are provided at normal exit paths only for normally unoccupied buildings. Visible fire notification is provided in manned office areas such as in the Control Building and the Service Building.

9.5.1.10 Fire Barriers

Fire barriers of 3-hour fire resistance rating are provided separating:

- Safety-related systems from any potential fires in nonsafety-related areas that could affect the ability of safety-related systems to perform their safety function.
- Redundant divisions or trains of safety-related systems from each other to prevent damage from a single fire.
- Components within a single safety-related electrical division that present a fire hazard to components in another safety-related division.

Penetrations through fire barriers are sealed or closed to provide fire resistance ratings at least equal to that of the barrier. Only noncombustible materials qualified per ASTM E-119 are used for construction of fire barriers. Fire dampers protect ventilation duct openings in fire barriers as required by NFPA 90A.

9.5.1.11 Building Ventilation

Fire protection/smoke control provisions for ventilation for the various building areas are designed as follows:

Control Building (CB) Smoke Removal

The CB HVAC System (CBHVS) provides smoke removal through two CBHVS sub-systems: Control Room Habitability Sub-system (CRHAHVS) and Control Building General Area HVAC Sub-system (CBGAHVS).

Control Room Habitability Area Sub-system (CRHAHVS)

The MCR is separated from the rest of the Control Building by a 1-hour fire barrier and separated from other major plant areas by 3-hour fire barriers.

Manual fire fighting capability in the MCR consists of portable dry Class ABC chemical fire extinguishers. Additionally, hose stations with UL-approved fixed fog nozzles are installed outside both entrances to the MCR. No hose stations are located within the MCR.

The MCR is provided with smoke detectors that actuate audible and visible alarms on the MFAP in the MCR.

Smoke detection capability in the CRHAHVS automatically detects and annunciates the presence of smoke. Upon receipt of the outside air intake smoke alarm, the CRHAHVS automatically isolates and is placed in full recirculation mode to isolate the MCR from the outside air. To purge smoke from the MCR when there is no smoke in the outside air intake, the CRHAHVS is placed in the smoke removal mode, in which the MCR air recirculation path is closed, 100% outside air flows through the MCR, the return/exhaust fan is started, and the exhaust dampers are checked for an open path. The normal ventilation return/exhaust fans are used for smoke removal. The MCR operators manually initiate the smoke removal operating mode of the CRHAHVS.

Safe shutdown of the plant is not dependent on the operation of the CRHAHVS. Two remote shutdown stations are provided inside the Reactor Building, which is serviced by a separate ventilation system. Plant shutdown and maintenance of shutdown conditions may be accomplished from these stations.

Control Building General Area HVAC Sub-system (CBGAHVS)

The smoke removal mode of the CBGAHVS is manually initiated from the MCR by closing the recirculation damper, de-energizing the normal exhaust fans, and energizing the smoke exhaust fan after its isolation dampers are opened to allow outside air purging of the affected room(s).

Reactor Building (RB) Smoke Removal

The RB HVAC System (RBHVS) provides smoke removal through three RBHVS sub-systems: Reactor Building Clean Area HVAC Sub-system (CLAVS), Reactor Building Contaminated Area HVAC Sub-system (CONAVS), and the Refueling and Pool Area HVAC Sub-system (REPAVS).

Reactor Building Clean Area HVAC Sub-system (CLAVS)

The CLAVS provides smoke removal in the clean areas of the Reactor Building. The CLAVS is a recirculation-type ventilation system that uses minimal outside air for fresh air makeup for exhaust fans. Fire, in any of the areas served by CLAVS, is isolated by the closure of the fire dampers in the supply and return air ducts serving the fire area. Area fire detectors annunciate the fire condition in the MCR. After the fire is extinguished, smoke is removed by placing the CLAVS in the smoke removal mode, which closes the recirculation damper, stops the exhaust fan, opens the exhaust fan bypass damper, and starts the smoke removal fan. This changes the HVAC operation from recirculating to once through and vents smoke and heat from the clean areas to the outside atmosphere.

Reactor Building Contaminated Area HVAC Sub-system (CONAVS)

The CONAVS provides smoke removal in the potentially contaminated areas of the Reactor Building. The CONAVS is a once-through ventilation system. In areas served by CONAVS, a fire is isolated by the closure of the fire dampers in the supply and return air ducts serving the fire area. Area fire detectors annunciate the fire in the MCR. After the fire is extinguished, CONAVS provides smoke removal by exhausting air through the exhaust fan to the outside atmosphere through the plant vent stack and by drawing in fresh air from outside. During a radiological event, the exhaust airflow is diverted to the purge exhaust filter unit to remove airborne contamination prior to discharge through the plant stack.

Refueling and Pool Area HVAC Sub-system (REPAVS)

Fire on the refueling floor or pool areas is annunciated in the MCR. Fire dampers in the supply and return ducts close during a fire. After the fire is extinguished, smoke is removed by placing the REPAVS in the smoke removal mode. REPAVS provides smoke removal by exhausting air through the exhaust fan to the outside atmosphere through the plant vent stack and by drawing in fresh air from outside. During a radiological event, the exhaust airflow is diverted to the purge exhaust filter unit to remove airborne contamination prior to discharge through the plant stack.

Fuel Building (FB) Smoke Removal

The FB HVAC System provides smoke removal for the Fuel Building. Following a recovery from a fire, the exhaust fans remove smoke from the area by exhausting air to the outside atmosphere.

Electrical Building (EB) Smoke Removal

The EB HVAC System provides smoke removal for the Electrical Building. The smoke removal mode of the EB HVAC System provides smoke removal from the diesel generator engine rooms and diesel generator day tank rooms.

Turbine Building (TB) Smoke Removal

The TB HVAC System provides smoke removal for the Turbine Building. A fire in the Turbine Building is annunciated in the MCR. Fire dampers in the supply and exhaust ducts close to preclude the spread of a Turbine Building fire to other areas. Following fire suppression in the Turbine Building, fire dampers are opened as appropriate for smoke removal. The smoke removal mode of the TB HVAC System provides smoke removal from the Turbine Building areas. Turbine Building Exhaust (TBE) fans can be operated to expedite smoke removal as described in Subsection 9.4.4.

9.5.1.12 Safety Evaluation

The FHA, contained in Appendix 9A, demonstrates the adequacy of the ESBWR fire protection design to provide the required protection in the event of a postulated fire.

The methodology for performing the FHA consistent with the level of ESBWR design completion is described in the FHA.

The FHA includes the following information:

- Fire Protection System description;
- Comparison of the ESBWR Fire Protection Program with NRC Branch Technical Position SPLB 9.5-1, demonstrating conformance of the ESBWR program and design with the guidance in the Branch Technical Position;
- Methodology for evaluation of potential fire hazards; and
- Safe shutdown analyses on a fire area by fire area basis.

Included in the above are complete descriptions of the fire areas, fire loadings in the areas, and fire detection and suppression capabilities provided in each area.

The COL licensee referencing the ESBWR Standard Plant conducts a compliance review of the as-built design against the assumptions and requirements stated in the FHA. Based on this review, the FHA is updated as necessary. Any non-compliance is evaluated and documented if acceptable, or is revised to be compliant if evaluated as unacceptable.

The ESBWR design satisfies the following guidance from the NUREG-0800 SRP 9.5.1 and BTP SPLB 9.5.1:

Guidance — "Therefore, the designers of standard plants have been informed that they must demonstrate that safe shutdown of their designs can be achieved, assuming that all equipment in any one fire area has been rendered inoperable by fire and that reentry to the fire area for repairs and for operator actions is not possible. The control room should be excluded from this approach, subject to the need for an independent alternate shutdown capability that is physically and electrically independent of the control room."

Conformance — The design of the fire barrier system and safe shutdown systems for the ESBWR are such that complete burnout of any single fire area without recovery does not prevent safe shutdown of the plant.

Safe shutdown is achieved primarily by using the Isolation Condenser System (ICS), described in Subsection 5.4.6. This is a system employed for both hot standby and long-term core cooling modes, which can operate at full reactor coolant system pressure, and is thereby able to place the reactor in the long-term cooling mode immediately after reactor shutdown. Operation of the plant in the long-term cooling mode is automatic. The system does not require any ac power or other support systems such as cooling water. Operation does not require any pumps or valve operation once initial alignment is established.

The system initiation is based on a two-out-of-four logic. Actuation does still occur with one division failed due to a fire.

A Remote Shutdown System is provided to ensure safe shutdown capability. The Remote Shutdown System is physically and electrically independent of the MCR.

Guidance — "Fire protection for redundant shutdown systems in the reactor containment building should ensure, to as great an extent as possible, that one shutdown division is free of damage."

Conformance — The ESBWR design conforms to this guidance in that the relevant redundant systems are separated by fire barriers, or, in the case of the primary containment, as much separation as possible and by inerting the containment atmosphere during operation to preclude the initiation or propagation of a fire.

Guidance — "Consideration should be given for safety-grade provisions for the fire protection systems to ensure that the remaining shutdown capabilities are protected."

Conformance — Fire protection piping and associated components that could become a hazard during an earthquake are seismically supported. Manual suppression capability for safe shutdown equipment areas remains functional following an earthquake. The fire barriers in safety-related areas of buildings are Seismic Category I.

Guidance — "In addition, it should be demonstrated that smoke, hot gases, or the fire suppressant does not migrate into other fire areas to the extent that safe shutdown capabilities, including operator actions, could be adversely affected."

Conformance — The ESBWR fire protection design satisfies this guidance with a combination of fire dampers and other barriers, smoke evacuation capabilities, and minimal required operator actions. Details are provided in the 9.5.1.2.9.

9.5.1.13 Inspection and Testing Requirements

Preoperational inspection and testing requirements for each fire protection system are described in Section 14. Periodic inspection and testing to assure system operability is conducted in accordance with applicable codes and approved procedures.

9.5.1.14 Instrumentation Requirements

Controls and instrumentation are provided for a fully functioning system. There are three main types of FPS instrumentation: instrumentation supporting fire detection, instrumentation supporting automatic suppression systems, and instrumentation supporting fire water delivery.

Instrumentation for the Fire Detection System

Instrumentation for the fire detection system provides signals for early detection and warning of fires. Local fire alarm panels per NFPA 72 supervise fire and smoke detectors. The local fire alarm panels are in turn connected to the alarm MFAP via a dedicated data link. Signals transmitted include detector status (normal, alarm, supervisory, trouble) as well as local fire alarm panel status.

Upon receipt of a signal from any of the area fire detectors, audible and visual annunciation is activated at the MFAP in the MCR and at the local fire alarm panel.

All instrumentation for fire detection is either FM approved or UL listed, where available.

Instrumentation Supporting Fire Suppression Systems

Each fire suppression system automatically actuated by a fire detection system has the control logic and capability for manual actuation available at the local fire alarm panel for the protected area. Remote manual actuation of these suppression systems is also available from the MCR. Automatic sprinkler systems that do not require separate detection systems for actuation are not equipped with manual actuation means.

Instrumentation for fixed fire suppression systems provides local and remote monitoring capability for the suppression system status. All instruments for automatic suppression systems are wired to the local fire alarm panels for control. Dedicated data links transmit command and status information to and from the local fire alarm panels and the MFAP in the MCR.

All instrumentation for automatically actuated fire suppression systems is either FM approved or UL listed, where available.

Instrumentation Supporting Fire Water Delivery

Instrumentation supporting firewater delivery provides status indication of fire water tank level, fire water main pressure, jockey pump status, and main fire pump status conditions.

When a portion of the firewater system activates, the motor-driven fire pump automatically starts on low-pressure. If the motor-driven pump fails to start or cannot maintain pressure, the main diesel-driven pump starts from a different pressure switch. The second diesel-driven pump is designed to start last if the two main pumps fail to start or cannot maintain the required system pressure. All pumps are stopped manually. Any pump can be started manually from the MFAP in the MCR or locally.

A pressure switch is used to automatically start and stop the motor-driven jockey pump.

9.5.2 Communications Systems

The communication systems provide the means to conveniently and effectively communicate between various plant locations and with off-site locations.

9.5.2.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The communication systems are nonsafety-related.

Power Generation Design Bases

The communication systems power generation design bases are as follows:

- The integrated design of the systems provides effective communication between plant personnel in all vital areas during normal plant operation and during the full spectrum of accident or incident conditions (including fire) under maximum potential noise levels.
- Emergency off-site communication systems are independent of the normal off-site communication system.
- The communication systems are operable during a loss of off-site power.

9.5.2.2 System Description

Summary Description

The plant communication systems consist of the plant page/party-line (PA/PL) system, the private automatic branch telephone exchange (PABX), the plant sound-powered telephone system, the plant radio system, and the evacuation alarm and remote warning system.

The PA/PL, PABX, and plant radio systems are physically independent systems powered from diverse nonsafety-related power supplies backed from the standby on site AC power supply system. They serve as backup to one another in the event of system failures. These three independent voice communication systems are designed and installed to provide assurance that any single event does not cause a complete loss of intraplant communication. This is accomplished by the use of diverse technology, separate routing of cables, and separate standby diesel-generator-backed power supplies.

Particular attention is given to the supports and anchoring of emergency communication system components and components of the other communication systems located in normally occupied areas or in areas containing safety-related equipment so as to enhance the earthquake survivability of these components and ensure that they do not present a personnel or equipment hazard when subjected to seismic loading.

The plant simulator, the Emergency Operations Facility (EOF) and the Technical Support Center (TSC) will connect to the plant Distributed Control and Instrumentation System (DCIS) firewall via high speed dedicated data lines.

The COL applicant is responsible for the connection between the plant simulation, EOF, and TSC with the DCI/S.

Refer to subsection 9.5.2.5 for COL licensing requirements.

Descriptions of these systems are given in the following sections.

In-Plant Page/Party Line (PA/PL)

This system provides communication means such as ringing, mutual telephonic communication, and simultaneous broadcasting in various select buildings and areas including outdoor locations

of the plant. The system permits merging with and separation from other units of the plant. The system is primarily used for intraplant communications. It is a hard-wired communication system used during plant operations, testing, calibration, startup, and limited emergencies.

The PA/PL system is a nonsafety-related system and mounting of system components is in accordance with standard design engineering practices. The PA/PL system components are mounted to Seismic Category II requirements in safety-related areas if located above safety-related equipment.

The PA/PL system consist of handsets, speakers, branch boxes, main distribution boards, a control board, amplifiers, amplifier boards, battery, battery chargers, dc distribution board, cable wiring materials, junction boxes and jacks. The system is a 5-channel, multiple-system-split-type design with a separate set of amplifiers and a distribution board for each branch. This permits simultaneous use of a page line and four party lines for in-plant use. The block diagrams of the systems are shown in Figures 9.5-2., 9.5-3 and 9.5-4.

Handsets and speakers are installed in places which are important for plant operation and necessary for personnel safety, and where communication is frequent, including the areas below:

- Main Control Room (MCR)
- Electrical equipment rooms
- Refueling area
- Turbine operating area
- Periphery of control rod hydraulic units areas
- Feedwater pump rooms
- Elevators;
- Exterior of plant buildings
- Technical Support Center (TSC)
- Electric building; and
- Cooling tower area

Each handset station can be used to communicate with any other handset station or the central station of another unit.

One circuit of the handset station is connected to a telephone line, thereby permitting simultaneous broadcasting from a security telephone unit. In addition to the basic function, the equipment can be used for an automatic surveillance of main amplifier output alarm indication in the event of failure of main equipment and manual switching to spare amplifier as necessary.

The system is operated from a battery source with a normal and a spare battery charger. The chargers are powered from a 480 VAC nonsafety-related power supply backed from the standby on site AC power supply system. The PA/PL equipment is backed by an exclusive DC power supply with a dedicated battery. The battery has capacity for 10 hours of operation following the loss of AC power. The charger is sized to recharge the battery from a fully discharged condition within 10 hours while supplying the normal DC loads.

The handsets are located at the same relative position on each floor, at a conspicuous location in personnel routes, at uniform intervals in corridors and large rooms, close to panels where possible, and low level radiation areas.

Paging equipment for outdoor facilities is designed to automatically limit the sound volume at night to a level manually set from the MCR. The manual volume settings can be 10, 20, 30 or 40 dB.

Speakers and handsets are installed at the farthest practical distance from noise sources. However, in rooms where the noise level increases during equipment operation (such as the feedwater pump room, diesel generator room, etc.), handsets are enclosed within a soundproof booth.

Box-type speakers are installed in small rooms where reverberations make hearing difficult. The speakers are of two different types as described below:

- Horn shaped (trumpet shaped): output of 20 to 100 watts; and
- Cone shaped (box type): output of 5 to 10 watts.

Their signal-to-noise (S/N) ratio is approximately 6 to 10 dB. The interconnecting cables consist of a standard pair of conductors with cross-linked polyethylene insulation, a static electricity shield and an overall sheath of flame and heat resistant insulating material. The cables conform to IEEE 383.

The circuits from the main paging equipment to each junction box are ring-wired to preclude loss of system function in the event of a single cable failure. Wiring is routed in dedicated conduits.

Private Automatic Branch Telephone Exchange (PABX)

The private automatic branch telephone exchange (PABX) equipment and cabling is supplied and installed by the telephone company. The PABX is a multinode system with telephones located throughout the plant. The nodes of the PABX are located in separate communication rooms.

The PABX is connected to the commercial telephone system and the utility private network that allows off-site communications for normal and emergency conditions.

Public and utility private network telephone lines provide emergency communication lines connected directly to specific telephones located in critical areas of the plant and support facilities. Noise-canceling handsets are used in high-noise areas. Emergency telephones are color-coded to distinguish them from normal telephones and include, but are not limited to, the following:

- Emergency Notification System (ENS) - Provides a communications link with the Nuclear Regulatory Commission (NRC) or country-specific regulatory agency
- Health Physics Network (HPN) - Provides a communications link with the NRC's (or country-specific regulatory agency) health physics personnel
- Ringdown Phone System -Provides a communications link with local and state agencies

The PABX is powered from the plant nonsafety-related buses and consists of independent chargers and batteries for each node with the capability of operating the entire plant telephone system for approximately 8 hours after a loss of the normal AC supply.

Sound-Powered Telephone System

A separate telephone communication system using portable sound-powered telephone units, independent of the PA/PL and PABX systems, is provided for normal and abnormal/accident conditions. This sound-powered system allows uninterrupted private communication between the MCR and the control rod drive equipment area; refueling platform area; turbine-generator operating deck; areas containing switchgear, load centers, motor control centers; and other high-maintenance activity areas.

The communication facilities for use during plant maintenance consist of local terminal jacks and boxes and a system main communication board with storage for patch cords. Terminal jacks are attached to the central control boards and to local panels and racks where communication links are frequently required. The portable sound-powered telephones are site-specific components.

The system provides communication capability between boards in the MCR, between the MCR and field stations, or between field stations during testing and periodic inspection of the plant. The communication between field stations is by means of portable telephone units and patch cords at the system main communication board.

Plant Radio System

Normal and emergency communications within the plant can be maintained independent of the PA/PL and PABX systems through the plant radio system. This system consists of antennas distributed throughout the plant with a centralized rebroadcast transmitter. Lower power portable radios with approximately 1-watt output are used with this system. The lower power of the radios ensures that there is no interference to low-level control and instrument circuits. The system is designed to permit radio to radio and radio to console communications from any location within the plant and satellite buildings.

Communication consoles are located at selected plant locations including the MCR and remote shutdown rooms. Communications between consoles is through hardwire, therefore providing a means of communication between selected areas of the plant even with the failure of the radio base station, PA/PL system, and PABX. The power for the base station and consoles is from the security system power supply that is backed by batteries and a standby generator.

Portable, hand-held radios provide two-way voice communications between the various units for personnel who need mobility. The radios are equipped with eight channels as follows:

Security

Emergency (alternate security)

Fire brigade (alternate security)

Operations

Maintenance (alternate operations)

Management

Health physics and

Crisis management (or Unassigned).

The radios are equipped with tone-coded squelch so that a message cannot be received unless the message contains the proper address code. Therefore, individual, all-channel (zone), and all-system calls can be made. The emergency channel is not coded. Calls are made between the telephone system and the in-plant radio system by dialing through the PABX to a radiotelephone interconnect panel.

The portable, handheld radios are site-specific components.

Any portable radio systems operate at frequencies within the EMI/RFI test envelope for DCIS components.

Evacuation Alarm and Remote Warning System

The evacuation alarm and remote warning system is provided to warn personnel of emergency conditions. This system supplements the Area Radiation Monitoring System described in Subsection 12.3.4.

The evacuation alarm system consists of a siren tone generator, public address system speakers, and an outdoor siren. A selector switch in the MCR is used to manually initiate the evacuation alarm. This selector switch also selects the evacuation alarm coverage in the drywell or the entire plant including the initiation of the outdoor siren and the remote broadcast speakers.

The remote warning system consists of a tape recorder, microphone, remote broadcast speakers, and an output/feedback monitoring system. The tape recorder transmits recorded messages and the microphone transmits warning instructions through the remote broadcast speakers. An initiation signal from the MCR starts the tape recorder or opens the microphone available for transmission.

The output/feedback monitoring system monitors the output of the remote broadcast speakers and retransmits the output back to the monitoring speaker when the tape recorder is initiated or to the sound level (VU) meter when the microphone is activated. The monitoring speaker and sound level (VU) meter are located in the MCR.

Power for this system is supplied from a nonsafety-related bus backed from standby on site AC power supply system and backed by the station batteries.

Emergency Communication Systems

Normal and emergency off-site communications are provided by public telephone lines and the private utility network connected to the PABX.

In addition, the following radio systems provide both in-plant and plant-to-off-site emergency communications:

- Security radio system in accordance with 10 CFR 73.55(f)
- Crisis management radio system in accordance with the intent of NUREG-0654 and
- Fire brigade radio system in accordance with BTP CMEB 9.5.1, position C.5.g(4)

The security and crisis management radio systems are powered from the security system power supply that is backed up by batteries and a standby generator.

The off-site security radio system and the crisis management radio system are site specific.

The fire brigade radio system consists of a base unit, mobile units, and portable units. The fire brigade radio system is site-specific.

9.5.2.3 Safety Evaluation

The communications systems are not safety-related and are classified as non-Class 1E. The failure of any communications system does not adversely affect safe shutdown capability. It is not necessary for plant personnel in safety-related areas of the plant to communicate with the MCR in order to achieve safe shutdown of the plant.

Diverse non-Class 1E power supplies connected to the plant standby generators power the PA/PL telephone, PABX and plant radio systems. Failure of any or all of its components does not affect any nuclear safety-related equipment.

9.5.2.4 Inspection and Testing Requirements

The communications system is preoperational tested. The systems described above are conventional and have a history of successful operation at similar plants. These systems are used and maintained routinely to ensure their availability.

The power sources for the PA/PL telephone system and the PABX are tested separately during the preoperational and startup test program. Measurements or tests required to identify long-term deterioration are performed on a periodic basis.

9.5.2.5 COL Information

Connection between plant simulator, EOF and TSC with DCIS is site specific and the responsibility of the COL applicant.

9.5.3 Lighting System

This section covers all on-site systems that provide artificial illumination for rooms, spaces, and outdoor areas of the plant. These systems include a normal lighting system, a standby lighting system, an emergency lighting system, and a security lighting system.

9.5.3.1 Design Bases

9.5.3.2 Safety (10 CFR 50.2) Design Bases

The safety design bases for the emergency lighting system in the MCR are as follows:

- The system is Class 1E
- The system is integrated with the standby lighting system and designed so that alternate emergency lighting fixtures are supplied from separate safety divisions
- The system maintains the lighting levels for at least 72 hours following a design basis event including the loss of all AC power sources

9.5.3.3 Power Generation Design Bases

The lighting system design provides the illumination required for the performance of activities in the various areas and is equal to or greater than those recommended by the Illuminating Engineering Society of North America (IESNA) .

The lighting circuits of the normal, standby, and emergency lighting subsystems are routed in separate conduits.

The design of the lighting system for areas containing rotating equipment includes special provisions to eliminate the risk of stroboscopic effects caused by flicker.

The circuits to the individual lighting fixtures (other than the DC self-contained battery-operated lighting units) are staggered as much as possible and the staggered circuits are supplied from separate power supplies to ensure that some lighting is retained in each room even in the event of a circuit failure.

Normal Lighting Design Bases

The normal lighting system, as supplemented by the standby lighting system, is designed to meet the visual requirements of all occupied and unoccupied plant areas to assure objects, centers of attention and interest are adequately lighted to permit personnel to perform required tasks in these areas in a safe and efficient manner.

Normal system operation is not affected by the failure or unavailability of a single lighting transformer.

Standby Lighting Design Bases

The standby lighting system is powered from the PIP nonsafety-related buses. The standby lighting system is energized as long as power from the normal power source or a standby source is available.

As a minimum, standby lighting in the Reactor Building is provided in stairwells, aisle ways, the MCR, the technical and operational support centers, remote shutdown rooms, auxiliary switchgear rooms, DCIS equipment rooms, diesel generator rooms, diesel generator control rooms, and the Class 1E DC equipment rooms.

Emergency Lighting Design Bases

The MCR emergency lighting system contributes to the normal lighting levels in the MCR.

Security Lighting Design Bases

The security lighting system is supplied from uninterruptible power supplies connected to nonsafety-related batteries.

The security lighting system provides a minimum illumination of 2 lux (0.2 foot-candle) when measured horizontally at ground level.

9.5.3.4 System Description

Summary System Description

The plant lighting systems furnish the illumination required for safe performance of plant operation, security, shutdown, and maintenance activities. Emergency lighting is provided in

essential areas for the safety of personnel during a power failure. Table 9.5-32 summarizes the lighting system illumination ranges for normal illumination.

The block diagrams of the plant lighting system are shown in Figures 9.5-5, 9.5-6, 9.5-7 and 9.5-8 and are composed of the following systems:

- Normal lighting system
- Standby lighting system
- Emergency lighting system and
- Security lighting system

The normal lighting system, as supplemented by the standby lighting system, is used to provide normal illumination under normal plant operating, maintenance, and testing conditions.

The standby lighting system, in addition to supplementing the normal lighting system, supplements the emergency lighting system in selected areas of the plant where emergency operations are performed, including the access and egress routes to and from those areas.

The emergency lighting system is used to provide acceptable levels of illumination throughout the station and, particularly, in areas where emergency operations are performed, such as control rooms, battery rooms, containment, etc., upon loss of the normal lighting system.

The security lighting system provides the minimum illumination required: (1) for operation of the security center and selected indoor security zones, and (2) to monitor isolation zones and all outdoor areas within the plant protected perimeter, under normal plant conditions as well as upon loss of all AC power.

The electrical power systems that support the plant lighting systems include the following:

- The low voltage AC distribution system provides power for the normal and standby lighting systems through distribution panels and
- The DC and low voltage vital AC power supply systems provide DC power to the emergency and security lighting systems in the event of a total loss of AC power

The lighting systems are designed in accordance with applicable industry standards for lighting fixtures, cables, grounding, penetrations, conduits, and controls

Lighting fixtures are selected with consideration for environmental conditions and ease of maintenance. Incandescent lamps are the only type of lamp used within the primary containment, the main steam tunnel, and the refueling level of the Reactor Building. Mercury vapor fixtures and mercury switches are not used within these areas or any other area where there is a potential for introduction of mercury into the reactor coolant system.

MCR lighting is designed with special attention to the reduction of glare and shadows at the operating consoles.

Small rooms (room with three or less lighting fixtures and not control rooms) with on/off switches may be supplied from one power bus.

The luminaires are a proven design with long life and low maintenance requirements, such as fluorescent and high intensity discharge (HID). Incandescent luminaires generally are only used

in areas with infrequent operation. Fluorescent luminaires are normally used in the following cases:

- Plant stairs and stairwells
- Around switchgear, motor control centers, and instrumentation racks and
- To supplement HID luminaires in order to provide partial illumination in areas where starting times (or restarting following a momentary loss of power) of HID luminaires is objectionable

Indoor lighting is designed for continuous operation. Switching is by individual panel circuit breakers except in office areas. Outdoor lighting is controlled by photocells.

Particular attention is given to the supports and anchoring of lighting fixtures and other components of the lighting systems located in normally occupied areas or in areas containing safety-related equipment to enhance the earthquake survivability of these components and to ensure that they do not present a personnel or equipment hazard when subjected to seismic loading.

Normal Lighting System Description

Power for the normal lighting system is supplied from the nonsafety-related buses that are described in Subsection 8.3.1. This system provides lighting for all indoor and outdoor areas..

The normal illumination level in any area is comprised of light from all lighting fixtures except the emergency DC self-contained battery-operated lighting units.

Table 9.5-32 illustrates the typical ranges of illumination that are achieved, based on current recommendations.

The HID and fluorescent lighting fixtures in this subsystem are powered from 480/277 VAC; 3-phase, 4-wire, grounded neutral system distribution panels supplied from the normal 480VAC motor control centers. The incandescent lighting fixtures on refueling platforms are powered from the 480/277 VAC, 3-phase, 4-wire, grounded neutral system distribution panels. Other incandescent lighting fixtures are powered from dry-type transformers rated at 480-208/120VAC, 3-phase, 4-wire, grounded, or 480-240/120VAC, single-phase, 3-wire, grounded.

The circuits to the individual lighting fixtures are powered from separate load groups and staggered as much as possible to ensure some lighting is retained in a room in the event of a power or a circuit failure in one load group.

The normal lighting system in conjunction with the standby lighting system and with the MCR emergency lighting is used to provide normal illumination under all conditions of operation, maintenance and testing.

Standby Lighting System Description

The standby lighting system is designed to provide a minimum level of illumination to selected areas of the plant to aid in emergencies, safe shutdown, or in restoring the plant to normal operation. This system consists of fluorescent lighting fixtures powered from 480/277 VAC, 3-phase, 4-wire, grounded neutral system lighting distribution panels normally supplied by the PIP nonsafety-related buses. The primary areas served by this system are as follows:

- Main Control Room
- Remote shutdown rooms
- Operational support center
- Technical support center
- Auxiliary switchgear rooms
- Class 1E dc equipment rooms and
- Stairwells and aisle ways
- DCIS equipment rooms
- Diesel generator room
- Diesel generator control room

The standby lighting distribution panels also serve as the preferred power supply to the 8-hour emergency lighting units and the stair lighting units.

The standby lighting system is connected to the PIP nonsafety-related buses of the plant auxiliary AC power distribution system as described in Subsection 8.3.1.1.2. The standby lighting system is energized as long as power from an off-site source or a standby on-site AC power supply system is available.

The circuits to the individual lighting fixtures are powered from different load groups and staggered as much as possible to ensure some lighting is retained in a room in the event of a power or a circuit failure in one load group.

The standby lighting system is limited to those areas of the plant where power can be supplied from the standby on-site AC power supply system, insofar as practical, and could be involved in emergencies, shutdown or recovery operations.

The standby lighting system and the normal lighting system provide normal illumination. Standby lighting is maintained as long as power is available from the PIP nonsafety related buses.

Emergency Lighting System Description

The emergency lighting system is comprised of the following:

- Control room emergency lighting and
- DC self-contained battery-operated lighting units for exit lights, emergency lighting units, and stair lighting units

The emergency lighting system provides illumination of at least 10 foot-candles in those areas of the plant where emergency operations are performed and could require the reading of printed or written material or the reading of scales and legends. These areas are typically control rooms or local control stations. In other areas of the plant, the emergency lighting achieves a minimum level of illumination necessary for safe access and egress.

In those areas of the plant that are not normally occupied and where no emergency operations are performed, the emergency lighting system provides silhouette lighting to the nearest egress path.

The circuits to emergency lighting fixtures are continuously energized and are not switched.

The emergency lighting system components and installation inside and outside the MCR remain functional during design basis events and in particular withstand the seismic loads of a design basis earthquake. In those buildings that are not seismic category, the components do not necessarily withstand the DBE seismic loads.

Control Room Emergency Lighting

The control room emergency lighting is integrated with the standby lighting and is supplied from the four divisions of Class 1E Uninterruptible AC power supply system (UPS). The Class 1E batteries and the standby on-site AC power supply system provide backup to the Class 1E UPS. The divisional circuits to the lighting fixtures are staggered as much as possible to ensure some lighting is retained at essential locations in the event of a circuit failure. The MCR emergency lighting provides a minimum of 108 lux (10 foot-candles) with two out of four divisions of emergency lighting operable. The MCR emergency lighting is Class 1E Seismic Category I.

DC Self-Contained Battery-Operated Lighting Units

The DC self-contained battery-operated lighting units provide the required minimum level of illumination for the required duration considering their environment. The 8-hour rated units are used in those areas (including access and egress paths) that could be involved in shutdown or recovery operations, or are required to satisfy the requirements of BTP SPLB 9.5-1. Two-hour rated units as a minimum are used in other areas of the plant.

The DC self-contained battery-operated emergency and stair lighting units are powered from the same circuit that powers the normal or standby lighting fixture whose loss of power then causes the operation of the particular emergency or stair lighting unit.

Emergency exit lighting consists of battery-powered self-contained "exit" light units. Each unit consists of a 90-minute battery, a battery charger and exit sign and is normally energized by 277 VAC or 120 VAC from the normal lighting system power supply.

Emergency lighting units provide emergency lighting instantaneously and automatically upon the failure or interruption of the normal or standby lighting power supply, as applicable. Each emergency lighting unit consists of a battery, a charger, and control and monitoring circuits, enclosed in a self-contained unit. Each emergency lighting unit is capable of supplying sealed beam lamps locally mounted on the battery pack unit, remotely mounted near the battery pack unit, or a combination thereof for 8 hours without the charger.

The emergency lighting units are provided with a time delay following restoration of AC power, the emergency lighting only turns off after adequate time for the normal or standby lighting to restart. The units are normally energized from the same circuit whose loss of light requires the operation of the unit. Each stair lighting unit consists of a 90-minute battery, a charger, and adjustable sealed beam lamps, except where 8-hour battery operated emergency lighting units are required. The same circuit that supplies power to the nearest stair lighting fixture normally energizes these units.

Security Lighting System Description

The security lighting system provides illumination required:

- For operation of the security center and selected indoor security zones and

- To monitor isolation zones and all outdoor areas within the plant-protected perimeter, under normal plant conditions as well as upon loss of all AC power

Lighting of the protected outdoor area permits effective visual inspection to facilitate nighttime television surveillance and patrol of the protected perimeter under normal conditions as well as upon loss of all AC power. The security lighting system complies with the intent of NUREG CR-1327.

The security lighting system is considered a nonsafety-related system and is supplied from a security power system. Components of the security power system will be a COL specific item. Power is provided to the security power system from the 480VAC PIP nonsafety related buses of each load group through a manual transfer switch. The security lighting system remains energized as long as power from the off-site power source, a standby on-site AC power supply system, or the security system backup power sources is available.

The COL applicant shall determine a security power system to supply the security lighting system. Refer to subsection 9.5.3.5 for COL licensing requirements.

Outdoor security and roadway lighting is provided by HID luminaires. Outdoor lighting is controlled by photocells. The lighting illuminates the "security area" and the security fence to a minimum illumination of 2 lux (0.2 foot-candle) when measured horizontally at ground level. The yard lighting is designed to provide, as a minimum, the illumination requirement of the closed circuit TV cameras.

The outdoor yard lighting is a high mast lighting system consisting of high pressure sodium fixtures mounted on lighting poles not exceeding 130 feet in height and having a lowering system with a portable drive unit. The transformer yard utilizes a similar system on poles not exceeding 40 feet without a lowering system. All exterior lighting poles are designed in accordance with LTS-4, 1986 AASHTO standard for structural supports for luminaires (Reference 9.5-2) and applicable local building codes that consider severe weather conditions (e.g., hurricane and tornado).

9.5.3.5 Safety Evaluation

The MCR emergency lighting system is safety-related and classified as Class 1E. The remaining lighting systems are not safety-related and are classified as non-Class 1E. Components of the lighting systems associated with safety-related systems are supported to Seismic Category I requirements.

During normal plant operation, lighting systems are energized from on-site buses and off-site feeders. MCR emergency lighting permits the operators to safely operate and maintain the plant and to safely shutdown the plant and maintain it in a safe shutdown condition. The lighting system provides lighting at all times in areas used during reactor shutdown or emergency.

In the event of a loss of AC power from both load groups of the unit auxiliary buses, the normal lighting system is inoperable. The standby lighting system is temporarily inoperable until the standby generators reenergize the permanent nonsafety-related buses. The emergency lighting system remains operable and is energized from the permanent nonsafety-related buses and the batteries of the self-contained lighting units. The security lighting system remains energized from the security system uninterruptible power supply (UPS) and standby generators.

In the event of a loss of AC power from both load groups of the unit auxiliary buses, the standby generators are signaled to start and energize their respective PIP nonsafety-related buses within two minutes. During the 1-minute delay (standby generator startup time), the emergency lighting system in the MCR remains energized from the station Class 1E 250VDC battery, and the self-contained battery-operated lighting units immediately turn on. After the standby generators have started and reenergized their respective PIP nonsafety-related buses, the standby lighting system is available. After an additional time delay, the DC self-contained battery-operated lighting units connected to the standby lighting power supply automatically turn off. This system design ensures continuity of illumination in all indoor and essential operating areas including all emergency access and exit routes.

9.5.3.6 Tests and Inspections

The lighting systems are preoperational tested. System operability is demonstrated by normal use during plant operation.

The AC lighting systems are normally energized and maintained continuously and require only routine testing. The emergency lighting system is tested to ensure the operability of the DC self-contained battery-operated lighting units and other major components of the system.

9.5.3.7 COL Information

The COL applicant will define the security power system to supply the security lighting system.

9.5.4 Diesel Generator Fuel Oil Storage and Transfer System

9.5.4.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The diesel generator (DG) and auxiliary systems are not safety-related and have no safety design basis.

Power Generation Design Bases

Each DG is supplied by a separate fuel oil system. The diesel generator systems are standby power supply systems. The fuel oil and transfer systems for the diesel generators design bases are as follows:

- Provide day tank of sufficient capacity to supply fuel oil to the DG for a minimum of 8 hours of operation at full load
- Provide a long-term fuel oil storage capacity sufficient to support continuous operation at full load for a minimum of 7 days without refueling
- Ensure adequate separation between the two Diesel Generators Systems including their auxiliary and fuel oil supplies so that failure in one DG does not incapacitate the other diesel-generator
- Provide protection against contamination of the ground or ground water through failure of tanks

9.5.4.2 System Description

Summary Description

The COL applicant shall specify the DG fuel oil system design. A typical simplified diagram of the DG fuel oil system is provided as Figure 9.5-9 (See Subsection 9.5.10 for COL information).

The DG fuel oil system for each of two engines consists of a yard storage tank, fuel oil day tank, fuel oil transfer pumps, suction strainer, duplex filter, instrumentation and controls, and the necessary interconnecting piping.

Detailed System Description

There are two diesel generators, DG-A and DG-B, each housed in a separate enclosure in the Electrical Building adjacent to the Turbine Building. The units are identical and are held in reserve to furnish standby AC power in the event of LOPP. Each DG set has its own day tank, which holds sufficient fuel oil to operate its corresponding DG set for a minimum of 8 hours at full load. Transfer pumps supply fuel oil to each day tank from the yard storage tank. A bleed line returns excess fuel oil from the day tank for recirculation to the yard storage tank.

An engine-driven fuel oil pump supplies fuel from the day tank to the diesel engine fuel manifold. Day tank elevation is such that the engine fuel oil pump operates with flooded suction. There are no intermediate powered components to fail. A suction strainer prevents foreign matter from entering the pump and causing malfunction.

Underground piping is covered with protective coatings and wrapping to protect against corrosion. The system is provided with protection from external and internal corrosion. The piping buried portion is provided with waterproof protective coatings and an impressed current-type cathodic protection to control the external corrosion of the underground piping system. The impressed current-type cathodic protection system complies with RG 1.137 to prevent the ignition of combustible vapors or fuel oil present in the fuel oil system.

A single DG can meet full site standby power demands. Fuel oil transfer system piping and components up to the engine skid connection are designed and constructed in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, and ASME B31.1. The diesel fuel oil storage and transfer systems are capable of supporting the rapid start requirements of the diesel-generators (refer to Subsection 8.3.1). ANS 59.51"Fuel Oil Systems for Safety-Related Emergency Diesel Generators" issued as a reference but not formally applied to these non-safety related DGs. The stored fuel oil meets the requirements of the ASTM D975 "Standard Specification for Diesel Fuel Oils" and the requirements of the diesel engine manufacturer. The quality of the fuel oil used for diesel engine is assured by routine testing per Appendix C of ANS 59.51.

System Operation

Transfer pumps supplying fuel oil to the day tanks from the yard tanks can be operated by manual actuations; however, level sensors on the day tanks normally operate them automatically. A "low" level signal starts the first transfer pump, a "low-low" level signal starts the standby transfer pump and a "high" level signal stops both pumps. Engine rotation drives the engine-driven fuel oil pump to supply fuel to the diesel engine fuel manifold from the day tank.

9.5.4.3 Safety Evaluation

The DG and its auxiliary systems are not safety-related, and are not credited in any safety analysis. The storage tanks are located at a sufficient distance away from other plant buildings or, if required, buildings and are protected with 3-hr rating barriers. The fuel oil day tank is located in a separate room with 3-hr fire rated concrete walls.

9.5.4.4 Tests and Inspections

The DG fuel oil storage and transfer system permits periodic testing and inspection.

DG fuel oil storage and transfer system operability is demonstrated during the regularly scheduled operational tests of the DG. Periodic testing of instruments, controls, sensors and alarm assures reliable operation.

The ASTM standard fuel sample tests are conducted at regular intervals to ensure compliance with fuel composition limits recommended by the diesel engine manufacturer. The "Standard Specification for Diesel Fuel Oils" ANSI/ASTM D975 is the governing specification. Fuel oil may be stored for a minimum of six months without deterioration.

Each fuel oil storage tank is emptied and accumulated sediments are removed every 10 years to conform to the ASME Section XI, Article IWD-2000 examination requirements.

Periodic surveillance of the cathodic protection for the underground piping system is performed, not to exceed a 12-month interval, to ensure that adequate protection exists.

New fuel oil is tested for specific gravity, cloud point and viscosity and visually inspected for appearance prior to addition to ensure that the limits of ASTM D975 are not exceeded. Analysis of other properties of the fuel oil is completed within two weeks of the fuel transfer.

9.5.4.5 Instrumentation Requirements

Fuel supply levels in the storage and day tanks are indicated locally and in the Main Control Room (MCR). Also, alarms on the local DG panel annunciate low level and high level in the day tanks. The setting of the low level alarm provides fuel for at least 60 minutes of DG operation at 100% load with 10% margin between the alarm and the suction line inlet Level sensors in the day tank signal automatic start and stop of the fuel oil transfer pump.

9.5.5 Diesel Generator Jacket Cooling Water System

9.5.5.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The DG and auxiliary systems are not safety-related and have no safety design basis.

Power Generation Design Bases

A separate jacket cooling water system supplies each DG.

The DG jacket cooling water system is self-contained and sized to meet the full load cooling demands of the diesel-generator.

The jacket cooling water system can operate at full load for a minimum of 7 days without any makeup.

9.5.5.2 System Description

Summary Description

The COL applicant shall specify the design of the DG jacket waste water system. A typical DG jacket waste water system is shown in Figure 9.5-10.

The DG systems are standby power supply systems. The DG jacket cooling water system is a self-contained, closed-loop system that circulates cooling water to the diesel engine, lube oil and engine components to maintain system operating temperature. The cooling water is cooled by a heat exchanger. The system incorporates a keep-warm system to maintain the diesel in a pre-warmed state while in the standby mode to facilitate rapid starting.

Detailed System Description

Each DG unit is supplied with a complete closed-loop cooling system mounted integrally with the engine-generator package. Included in each cooling package are a jacket water heater and keep warm pump, temperature regulating valve, lube oil cooler, jacket water pumps (one motor-driven, one engine-driven), jacketed manifold and a jacket water heat exchanger that rejects heat to the Reactor Component Cooling Water System (RCCWS). RCCWS water supply is from the same train as that of the DG served. Jacket water cools the turbocharger, the governor, the engine air coolers, the exhaust manifold and the lube oil cooler.

An electric heater is installed in each loop to keep the engine jacket water at a temperature near the normal operating level when the diesel-generators are in standby.

The heat exchanger for the DG jacket cooling water system is designed for a total heat removal rate based on the maximum permissible overload output of the DG. Additional margin is included to assure reliable system operation. The Cooling water system piping up to the engine connection is designed and constructed in accordance with ASME B31.1.

The system is filled with high quality, treated water from the Make Up Water System to prevent long-term deterioration of the system internal surfaces. A long-interval periodic cleaning of the jacket water heat exchanger may be necessary to restore the heat transfer capacity of the system in case of excessive fouling.

System Operation

During the standby mode, the jacket water temperature is maintained at 48.9ºC (120°F) , based on 10ºC (50°F) normal ambient temperature, by the heater. The heated water is circulated through the engine by the keep-warm pump to maintain a uniform engine temperature.

Two jacket water circulating pumps are provided to circulate the cooling water through the system during DG operation. One pump is driven by the diesel engine. The other pump is motor driven and starts on a high engine outlet cooling water temperature signal. The jacket cooling water passes through a three-way temperature control valve that modulates the flow of water through or around the jacket water heat exchanger to maintain required water temperature.

9.5.5.3 Safety Evaluation

The DG jacket cooling water system serves no safety-related function.

9.5.5.4 Tests and Inspection

To ensure the availability of the DG cooling water system, scheduled inspection and testing of the equipment are performed, as part of the overall engine performance checks. Instrumentation is provided to monitor cooling water temperatures, pressure, and head tank level. Instruments receive periodic calibration and inspection to verify their accuracy. During standby periods, the keep-warm feature of the engine water jacket cooling closed-loop system is checked at scheduled intervals to ensure that the water jackets are warm. The cooling water in the engine water jacket cooling closed-loop system is analyzed at regular intervals and is treated, as necessary, to maintain the desired quality.

9.5.5.5 Instrumentation Requirements

Pressure, temperature, and level instrumentation is provided for monitoring of system operating parameters. Alarms in the MCR provide warning in case of system low or high water temperature, low pressure, or low water inventory. The diesel-generators trip on high-high cooling water temperature.

9.5.6 Diesel Generator Starting Air System

9.5.6.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The DG and its auxiliary systems are not safety-related and have no safety design basis.

Power Generation Design Bases

Each DG is supplied by a separated starting air system. The DG systems are standby power supply systems. The DG starting air system meets the following design bases:

- Provides a supply of compressed air for starting the generator diesel engines without external power
- Contains sufficient air storage capacity for five consecutive starts of the engine and perform the starting function so that the DG meets the readiness criteria defined in Subsection 8.3.1

9.5.6.2 System Description

Summary Description

Each system includes two air compressors, an air receiver, and redundant air admission valves. When standby DG electric power is required, the air admission valves are opened to initiate engine cranking.

The COL applicant shall specify the DG air starting system design. A typical diagram of the DG air starting system is provided as Figure 9.5-11 (See Subsection 9.5.10, for COL information).

Detailed System Description

Each of the two standby DGs is provided with its own starting air system, consisting of two redundant 100% capacity air compressors, an air receiver, a 100% capacity air dryer, associated piping, and valves. Two redundant starting air valves, one in each engine starting air manifold, are provided for each engine. Failure of one valve does not affect the ability of the other valve to start the engine.

The air compressors are motor driven. Each compressor is equipped with an air-cooled aftercooler and has sufficient capacity to recharge a depleted storage system in 30 minutes. Each air receiver is sized so each air starting system has sufficient capacity for cranking its engine for five automatic or manual starts without recharging. Each air receiver is provided with a blowdown connection. A connection at the receiver bottom is used to remove any water accumulated in the tank.

Each DG air start system is provided with an air dryer to ensure clean dry air for engine starting. The dryer is capable of controlling the dew point as recommended by the diesel engine manufacturer. It is equipped with prefilters and after filters to remove oil, dust and pipe scale from the air stream.

The air receiver, valves, and piping up to the first connection on the engine skid are designed to the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 and ASME B31.1.

System Operation

Normally, the air compressors operate automatically and are controlled by pressure sensors located on their respective air receivers. The pressure sensors signal the start and stop of the compressors, as necessary to maintain the required system pressure. Manual override of the automatic sequence is provided for emergency operation.

The starting air valves are operated by solenoids powered from uninterruptible DC power. The valves receive a signal to open and initiate the engine starting sequence in the event of LOPP.

9.5.6.3 Safety Evaluation

The DG and its starting air system serve no safety-related function.

9.5.6.4 Tests and Inspection

Periodic tests and inspections are performed on the following

- Air receiver pressure control switches
- Low pressure alarm signal for low receiver pressure
- Engine air start valves and the admission line vent valve
- Pressure gages on the receivers
- Air receivers to clear accumulated moisture using the blowdown connection

9.5.6.5 Instrumentation Requirements

An air receiver low-pressure alarm is provided to alert the MCR operator of low starting air pressure.

9.5.7 Diesel Generator Lubrication System

9.5.7.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The DG and its auxiliary systems are not safety-related and have no safety design basis.

Power Generation Design Bases

Each DG is supplied by a separate lubrication system. The DG lubrication system meets the following design bases: supplies clean filtered oil to the engine and generator bearings at controlled pressure and temperature.

9.5.7.2 System Description

Summary Description

Each of the two DGs includes a self-contained lubrication system including lube oil sump tank, circulating pump, filtering elements, and a cooler. The system filters the lubricating oil and delivers it at controlled pressure and temperature to the engine and generator bearing surfaces. Built-in lube oil storage capacity ensures adequate lubrication of wearing surfaces and cooling as necessary. An electric heater and a keep-warm circulating pump continuously circulate warm oil to maintain the engine in standby readiness.

The COL applicant shall specify the lubrication system design. A typical diagram of the DG lubrication system is provided as Figure 9.5-12 (See Subsection 9.5.10, for COL information).

Detailed System Description

Each of the two DG lubrication systems consists of an oil sump in the engine frame, an engine-driven positive displacement pump, a cooler, a main header, a strainer, and a filter. The main engine-driven lube oil pump takes oil from the lube oil sump tank, passes it through the lube oil cooler and lube oil filter, through a strainer, through the main header, through the lube oil loads and back to the lube oil sump tank. A second feed line from the strainer supplies oil to the combustion air turbochargers through the rocker lubrication system. Pressure-regulating valves maintain constant oil pressure to the main header by bypassing excess oil back to the lube oil sump tank.

Each lube oil cooler is a shell and tube type heat exchangers, built to TEMA Class C. Cooling water for the coolers comes from the DG jacket cooling water system.

The DG sets have lube oil heating systems to keep the oil warm during standby. An electric lube oil heater heats the oil, which is then circulated through the engine oil circuit by a motor-driven keep-warm circulating pump. The keep-warm system circulates oil through a filter to ensure cleanliness. The engine lube oil sump is provided with level indication and can be manually replenished. The lube oil may be added to the engine oil sump during engine operation. The tanks, pumps, piping, and valves up to the engine connections are built to ASME Section VIII, Division 1, or ASME B31.1.

System Operation

The lube oil keep-warm systems are in operation when the DGs are in their normal standby mode. In the event of the LOPP or other condition requiring DG operation, the lube oil keep-warm system shuts down. When each DG is started, the engine-driven lube oil pump begins circulating oil through the filters and manifold to the engine and generator bearing surfaces. Circulation continues until engine shutdown.

9.5.7.3 Safety Evaluation

The DG and its lubrication system serve no safety-related function.

9.5.7.4 Tests and Inspection

The operability of the DG lubrication system is tested and inspected during scheduled operational testing of the overall engine. Instrumentation is provided to monitor lube oil temperature, pressure and sump level, ensuring proper operation of the system. During standby periods, the keep-warm system is checked at scheduled intervals to ensure that the oil is warm. The lube oil is periodically sampled and analyzed to ensure quality.

Instruments are periodically calibrated and tested to verify their accuracy.

The lubrication systems are located in the DG rooms, which are provided with personnel control access, precluding unauthorized personnel from interfering with system operation. Also, any contamination of the lubricating oil is thereby prevented.

9.5.7.5 Instrumentation Requirements

Pressure, temperature, and level instrumentation is provided for monitoring of important system operating parameters. Alarms in the MCR provide warning in case of system low or high temperature, low pressure, or low oil inventory. The diesel-generators trip on low-low lubricating oil pressure.

9.5.8 Diesel Generator Combustion Air Intake and Exhaust System

9.5.8.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The DG auxiliary systems are not safety-related and have no safety design basis.

Power Generation Design Bases

Each DG is supplied by a separate air intake and exhaust system.

The DG systems supply standby electric power. The DG combustion air intake and exhaust system is designed to meet the following design bases:

- Provide a supply of combustion air for operating the diesel engines
- Prevent ingress to the diesel engines of contaminating substances that could degrade the diesel engine performance
- Provide a diesel engine exhaust system capable of exhausting the products of combustion to the atmosphere

9.5.8.2 System Description

Summary Description

The combustion air intake and exhaust system supplies air for fuel combustion in the two DG engines. The system also exhausts combustion products out of the DG enclosures to atmosphere. It includes intake and exhaust silencers to quiet engine operation.

The COL applicant specifies the DG air intake and exhaust system design. A typical diagram of the DG air intake and exhaust system is provided as Figure 9.5-9 (See Subsection 9.5.10, for COL information).

Detailed System Description

Each engine takes combustion air from its own inlet air cubical adjacent to the DG room. Air enters the cubical through the outside wall and is filtered before entering the air intake plenum. Combustion air is drawn from the intake plenum through an air intake silencer and into the diesel engine combustion air manifold and the engine turbochargers.

The outside air is supplied through intake grills in which the air passes vertically upward. This protects against plugging and damage of the filters by gross debris picked up by events such as a tornado or hurricane. Inlet filters stop particulate matter small enough to pass through the grills. A differential pressure gage is installed across each of the filters to monitor the filter condition.

The engine exhaust is collected in the exhaust manifold and ducted to the roof of the DG building where the silencers are mounted. Each engine has its own exhaust system. The exhaust outlet is well removed from the air inlet to prevent any recirculation of exhaust gases. Crankcase ventilation is accomplished by means of vacuum blowers that vent the crankcase to atmosphere outside the DG enclosure.

Nitrogen tank and hydrogen storage are located at a sufficient distance away from the DG air inlet to preclude engine malfunction or explosions.

System Operation

There are no active components in the combustion air intake and exhaust system. Air is drawn from the outside atmosphere by manifold vacuum when the diesel engine is started and exhausted after combustion. Turbochargers pressurize the intake manifold gases prior to entry to the cylinders to improve combustion and overcome the potential effects of such reduced atmospheric pressure conditions as may result in a tornado.

9.5.8.3 Safety Evaluation

The DG and its auxiliaries, including the combustion air intake and exhaust system, serve no safety-related function.

9.5.8.4 Inspection and Testing Requirements

Visual inspection of the DG combustion air intake and exhaust system is performed concurrently with regularly scheduled DG testing and inspection. Inspection of the integrity of the ducting and joints, filter condition, intake and exhaust silencer condition is included in DG maintenance procedures.

9.5.8.5 Instrumentation Requirements

The air intake filters are equipped with differential pressure gages to monitor the filter condition. An alarm is provided in the MCR to signal a high differential pressure condition. Engine high combustion air exhaust temperature or high crankcase pressure provide also alarms in the MCR.

9.5.9 COL Information

9.5.9.1 Fire Protection System

The following to be determined by the COL applicant:

- Detailed fire-resistive barrier design requirements for drywell piping penetration assemblies, including construction and testing requirements
- Type of fire detection within Primary Containment
- Criteria for locating manual pulls throughout plant
- Backup fire water supply (existing or new, shared or separate)
- Non-seismic diesel-driven fire pump (existing or new)
- Fire Protection System requirements associated with Yard Structures, and Equipment, and Piping
- Fire Protection System requirements associated with the Service Water Pump House and Service Building

The COL licensee shall conduct a compliance review of the as-built design against the assumptions and requirements stated in the FHA, and update the FHA as necessary.

9.5.9.2 Communication Systems

All communication connections between the plant simulator, EOF, TSC with the DCIS are site specific and the responsibility of the COL applicant.

9.5.9.3 Site Lighting

The COL applicant will define the layout of the plant lighting system, including security lighting and power supply.

9.5.9.4 Diesel generator Auxiliary Systems

The COL applicant will select the specific Diesel Generator manufacturer, which will establish the following design details:

- DG Fuel Oil Storage and Transfer System
- DG Jacket Cooling Water Supply System
- DG Starting Air System
- DG Lubrication System
- DG Combustion Air Intake and Exhaust System

9.5.10 References

9.5-1 Illuminating Engineering Society (IES) of North America, IES Lighting Handbook, Application Volume, 1987; and Reference Volume, 1984.

9.5-2 LTS-2, 1986 AASHTO, Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals.

Table 9.5-1

Lists of Applicable Codes for Fire Protection

American Society of Mechanical Engineers (ASME)
A17.1, Safety Code for Elevators and Escalators B31.1, Power Piping NQA-1, Quality Assurance Programs Requirements for Nuclear Facilities
American Society for Testing and Materials (ASTM)
ASTM E-84, Method of Test of Surface Burning Characteristics of Building Material ASTM E-119, Fire Test of Building Construction Materials ASTM E-814, Standard Test Method for Fire Tests for Through-Penetration Fire Stops
Applicable Building Codes
International Building Code International Fire Code American Disability Act (ADA) Accessibility Guidelines – 28 CFR 36
Factory Mutual
Factory Mutual (FM) Approval Guide
Institute of Electrical and Electronics Engineers (IEEE)
C2, National Electric Safety Code IEEE 383, Standard for Type Test of Class 1E Electric Cables IEEE 384, Criteria for Independence of Class 1E Equipment and Circuits
National Fire Protection Association (NFPA) NFPA 10, Standard for Portable Fire Extinguishers NFPA 11, Standard for Low-, Medium, and High-Expansion Foam NFPA 12, Standard for Carbon Dioxide Extinguishing Systems NFPA 13, Standard for Installation of Sprinkler Systems NFPA 14, Standard for Standpipe and Hose Systems NFPA 15, Standard for Water Spray Fixed Systems NFPA 16, Standard for the Installation of Foam-Water Sprinkler Systems and Foam-Water Spray Systems NFPA 20, Standard for the Installation of Stationary Pumps NFPA 22, Standard for Water Tanks for Private Fire Protection NFPA 24, Standard for the Installation of Private Fire Service Mains and their Appurtenances NFPA 30, Flammable and Combustible Liquids Code NFPA 37, Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines NFPA 70, National Electric Code NFPA 72, National Fire Alarm Code NFPA 80, Standard for Fire Doors and Fire Windows NFPA 80A, Recommended Practice for Protection of Buildings from Exterior Exposure Fire

Table 9.5-1
Lists of Applicable Codes for Fire Protection (continued)

NFPA 24, Standard for the Installation of Private Fire Service Mains and their Appurtenances
NFPA 30, Flammable and Combustible Liquids Code
NFPA 37, Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 70, National Electric Code
NFPA 72, National Fire Alarm Code
NFPA 80, Standard for Fire Doors and Fire Windows
NFPA 80A, Recommended Practice for Protection of Buildings from Exterior Exposure Fire
NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems
NFPA 92A, Recommended Practice for Smoke Control Systems
NFPA 101, Life Safety Code
NFPA 204, Standard for Smoke and Heat Venting
NFPA 251, Standard Method of Tests of Fire Endurance of Building Construction and Materials
NFPA 252, Standard Method of Fire Tests of Door Assemblies
NFPA 255, Standard Method of Test of Surface Burning Characteristics of Building Materials
NFPA 497, Recommended Practices for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas
NFPA 804, Standard for Fire Protection for Advanced Light Water Reactor Electric Generating Plants
NFPA 1961, Standard for Fire Hose
NFPA 1963, Standard for Fire Hose Connections
NFPA 1964, Standard for Spray Nozzles
Occupational Safety and Health Act (OSHA)
29 CFR 1910, Safety and Health Regulations for General Industry
29 CFR 1926, Safety and Heath Regulations for Construction
Underwriters Laboratories (UL)
Underwriters Laboratories (UL) Fire Protection Equipment List
NRC Regulations and Guidance
10 CFR 50.48, Fire Protection
10 CFR 50, Appendix A, GDC 3, Fire Protection
NUREG-0800, Standard Review Plan (SRP) 9.5.1 Fire Protection Program
NUREG-0800, Branch Technical Position SPLB 9.5-1, Guidelines for Fire Protection for Nuclear Power Plants
NUREG-0800, Branch Technical Position SPLB 9.5-1, Appendix B, Supplemental Fire Protection Review Criteria for Advance Reactors
Regulatory Guide 1.189, Fire Protection for Operating Nuclear Power Plants

Table 9.5-2

FPS Component Design Characteristics

Fire Water Pumps	
Motor-driven fire pump	454.2 m^3/hr (2,000 gpm)
Primary diesel-driven fire pump	454.2 m^3/hr (2,000 gpm)
Secondary diesel-driven fire pump*	454.2 m^3/hr (2,000 gpm)
Motor-driven jockey pump	4.54 m^3/hr (20 gpm) minimum as required to maintain the fire water main pressure 68.8 kPa (10 psi) above the start pressure of the fire pumps
Fire Water Storage Tanks	
Primary storage tank minimum fire water storage	2081.8 m^3 (550,000 gallons)
Secondary storage minimum fire water storage**	2081.8 m^3 (550,000 gallons)

* Secondary diesel-driven fire pump may be new or existing depending upon available site-specific provisions.

** Secondary fire water storage may be a tank, cooling tower basin, or a large body of water depending upon available site-specific provisions. Storage volume listed is the minimum storage volume to be dedicated for fire protection use.

Table 9.5-32

Typical Luminance Ranges for Normal Lighting

Location	Luminance Range (Lux)	(Foot-candles)
Auxiliary Building and Uncontrolled Access Areas	150-200	15-20
Controlled Access Areas		
– Count Room	750-1000	75-100
– Laboratories	750-1000	75-100
– Health Physics Office	1500-2000	150-200
– Medical Aid Room	1500-2000	150-200
– Hot Laundry	300-500	30-50
– Storage Room	150-200	15-20
– Engineered Safety	300-500	30-50
Features Equipment		
– Battery Rooms	300-500	30-50
Electrical Building (w/ DG)	300-500	30-50
Fuel Handling Area		
– Operating Floor	300-500	30-50
– Below Operating Floor	150-200	15-20
Off Gas Building	150-200	15-20
Radwaste Building	300-500	30-50
Reactor Building		
– Operating Floor	300-500	30-50
– Below Operating Floor	150-200	15-20
Control Room		
– Main Control Boards	300-500	30-50
– Auxiliary Control Panels	300-500	30-50
– Operator's Station	750-1000	75-100
Turbine Building		
– Operating Floor	300-500	30-50
– Below Operating Floor	150-200	15-20
Switchgear and Motor Control Centers	300-500	30-50
HVAC Equipment Areas	50-75	5-7.5
Exterior Areas	10-20	1-2

Figure 9.5-1. Fire Protection System Simplified Diagram

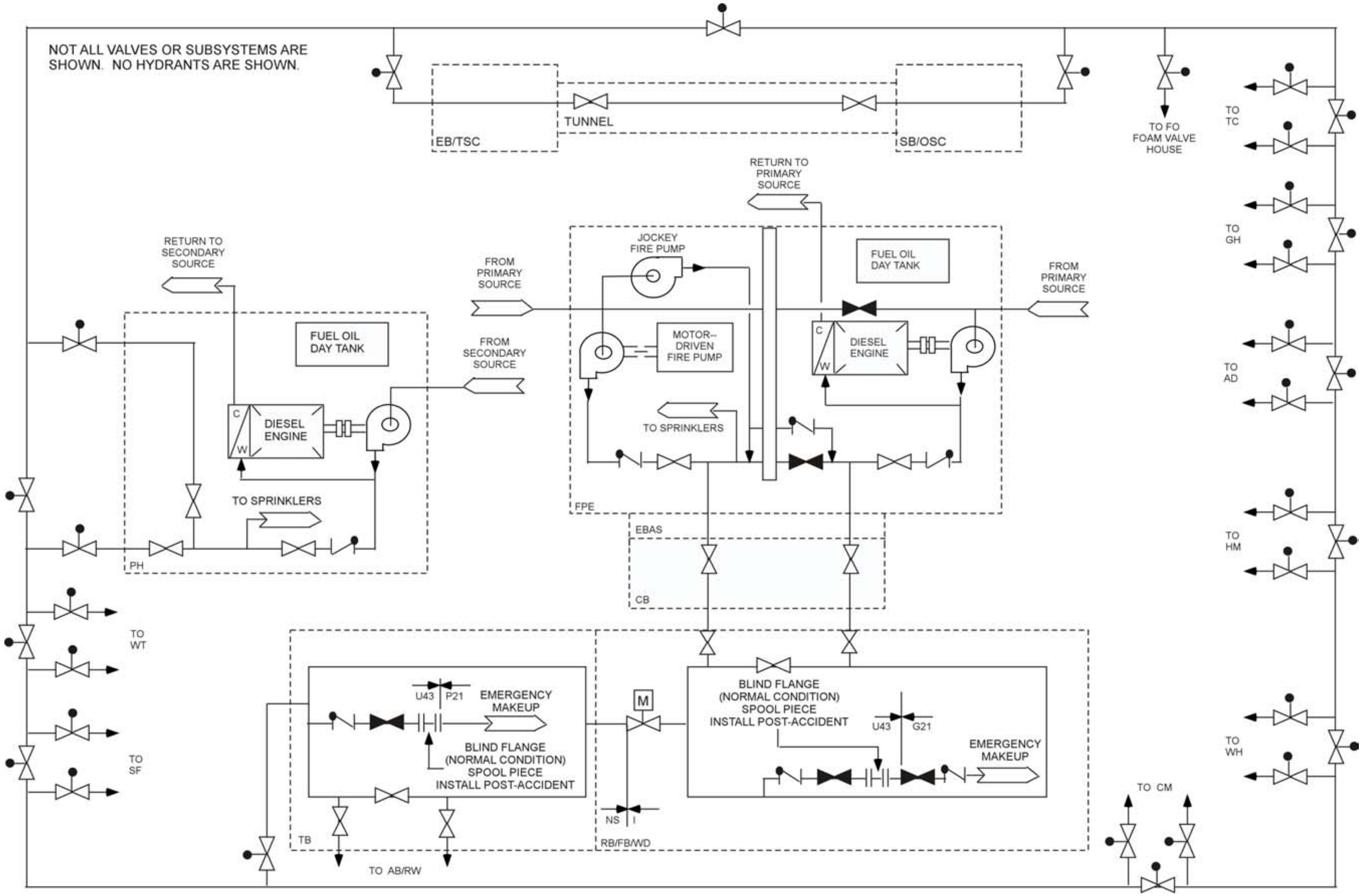


Figure 9.5-2. Page/Party-Line System Simplified Block Diagram

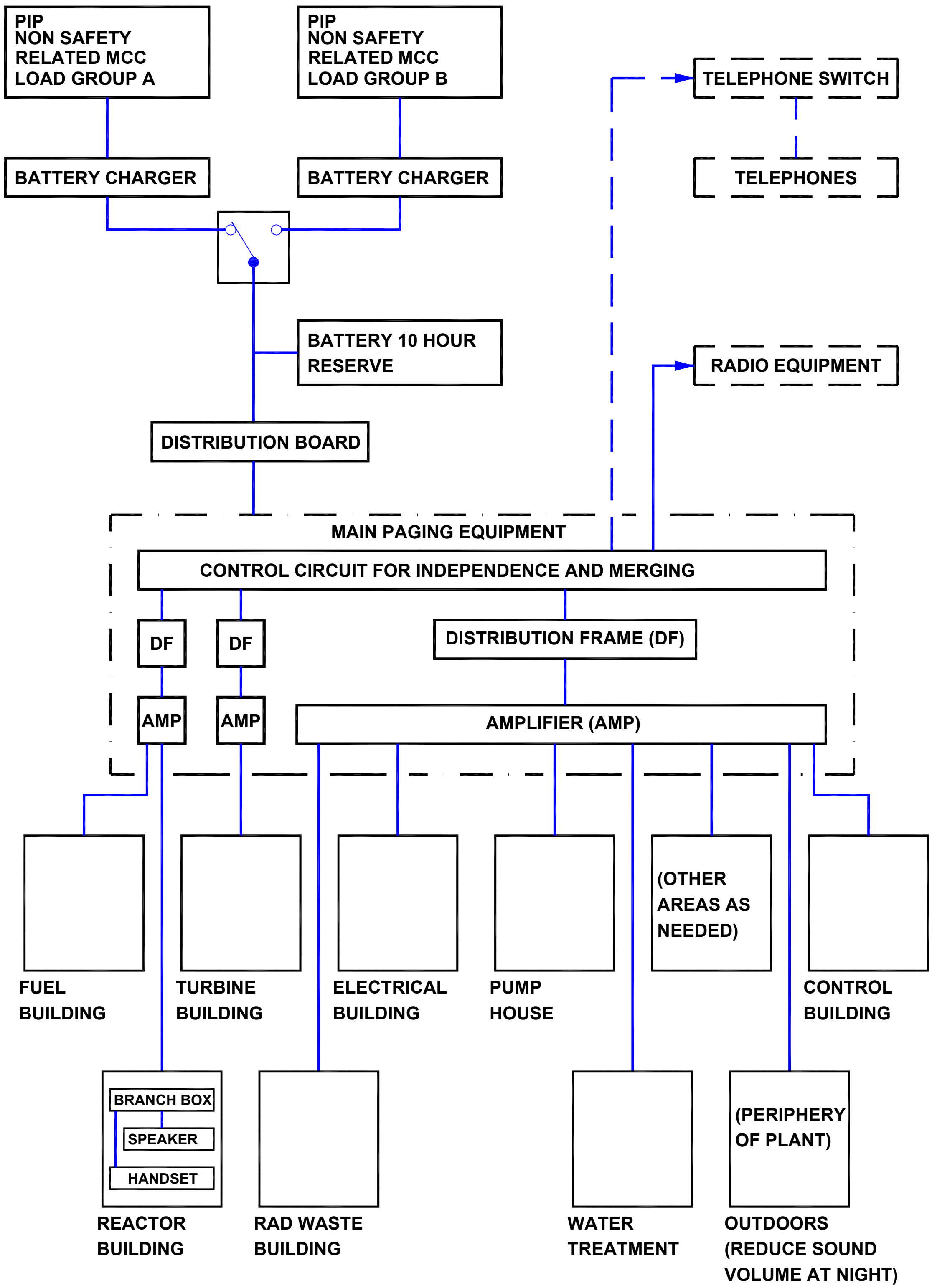


Figure 9.5-3. Private Automatic Branch Exchange (PABX) Telephone System Simplified Block Diagram

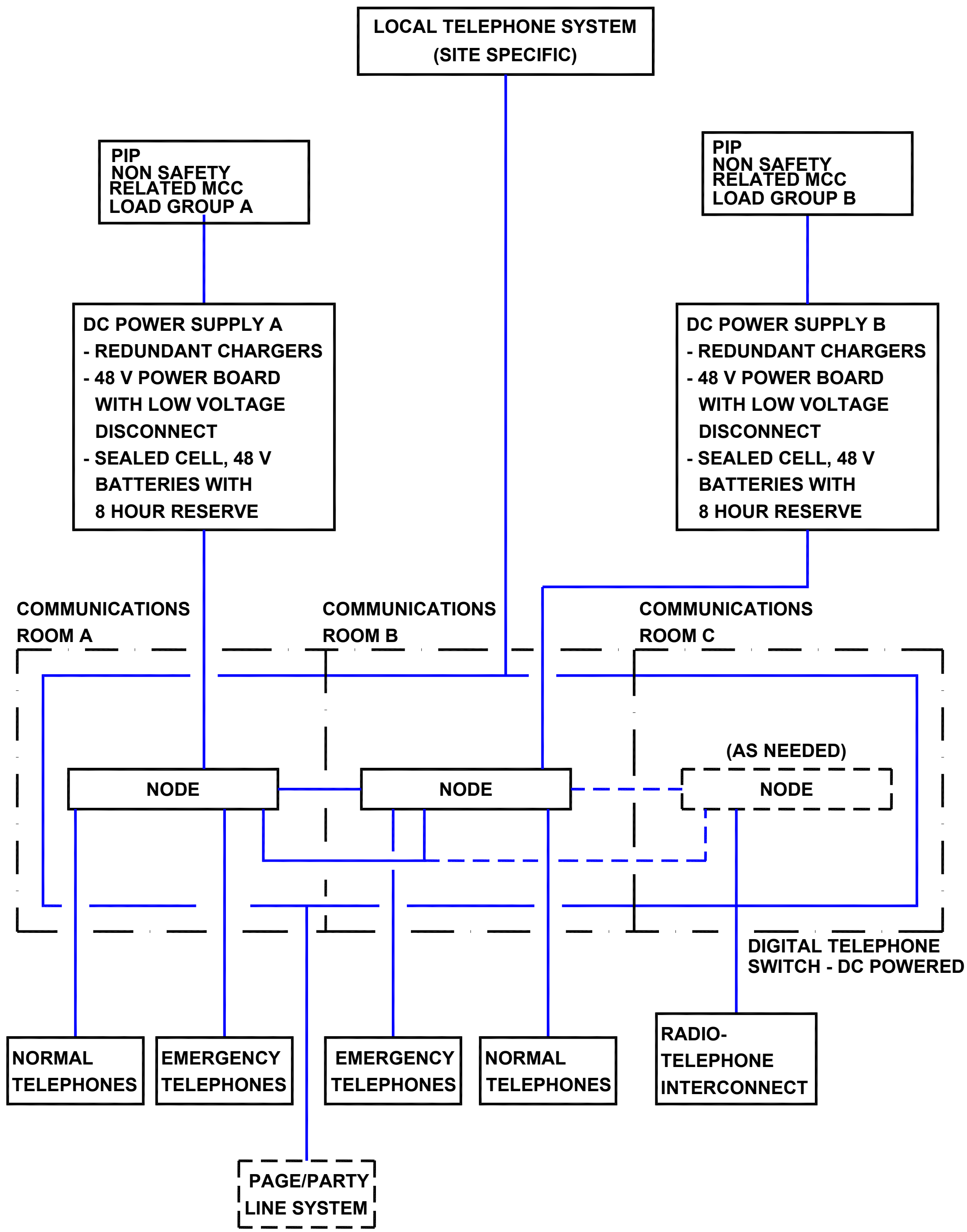


Figure 9.5-4. In-Plant Radio System Simplified Block Diagram

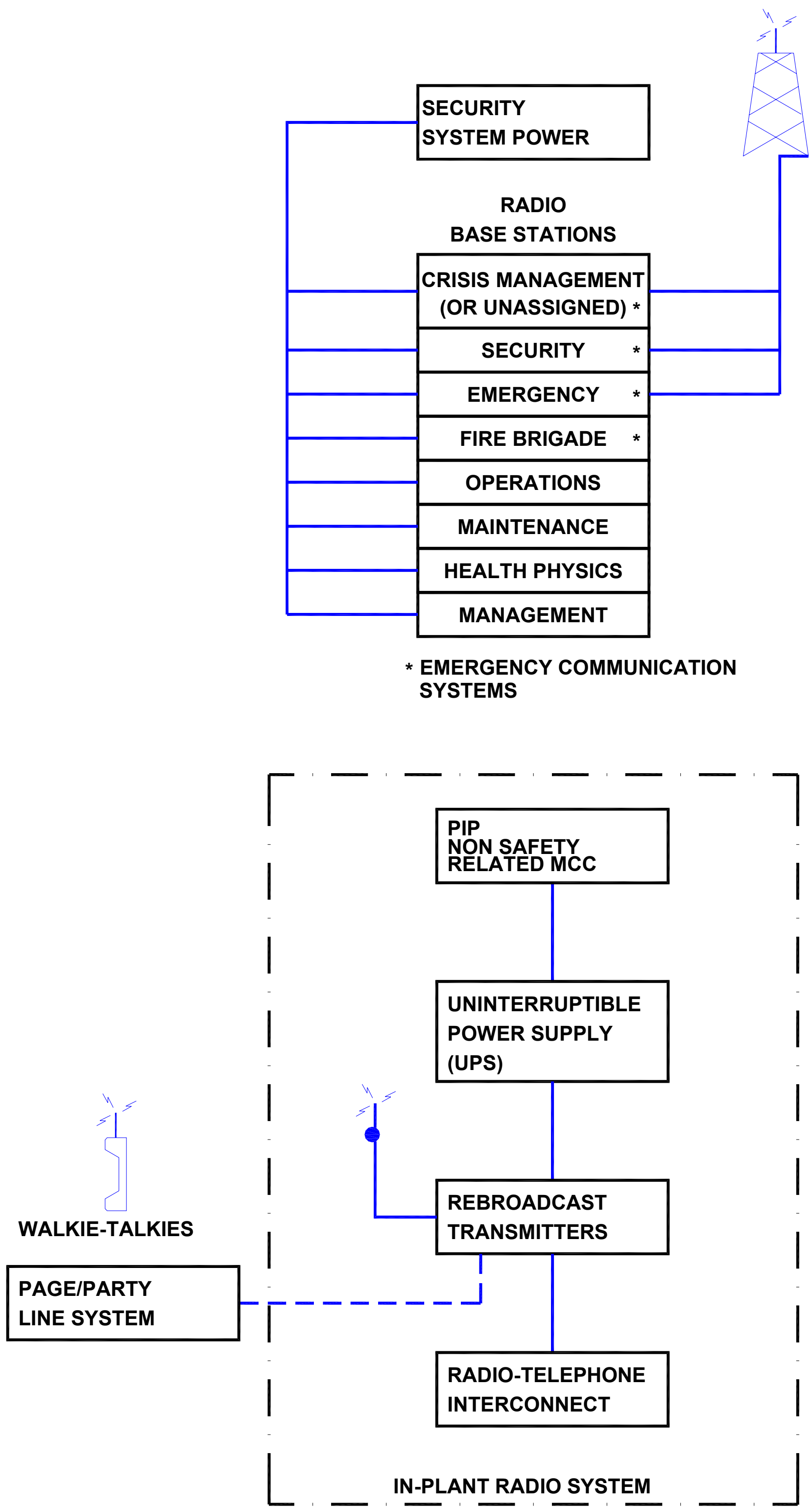


Figure 9.5-5. Normal Lighting System Simplified Block Diagram

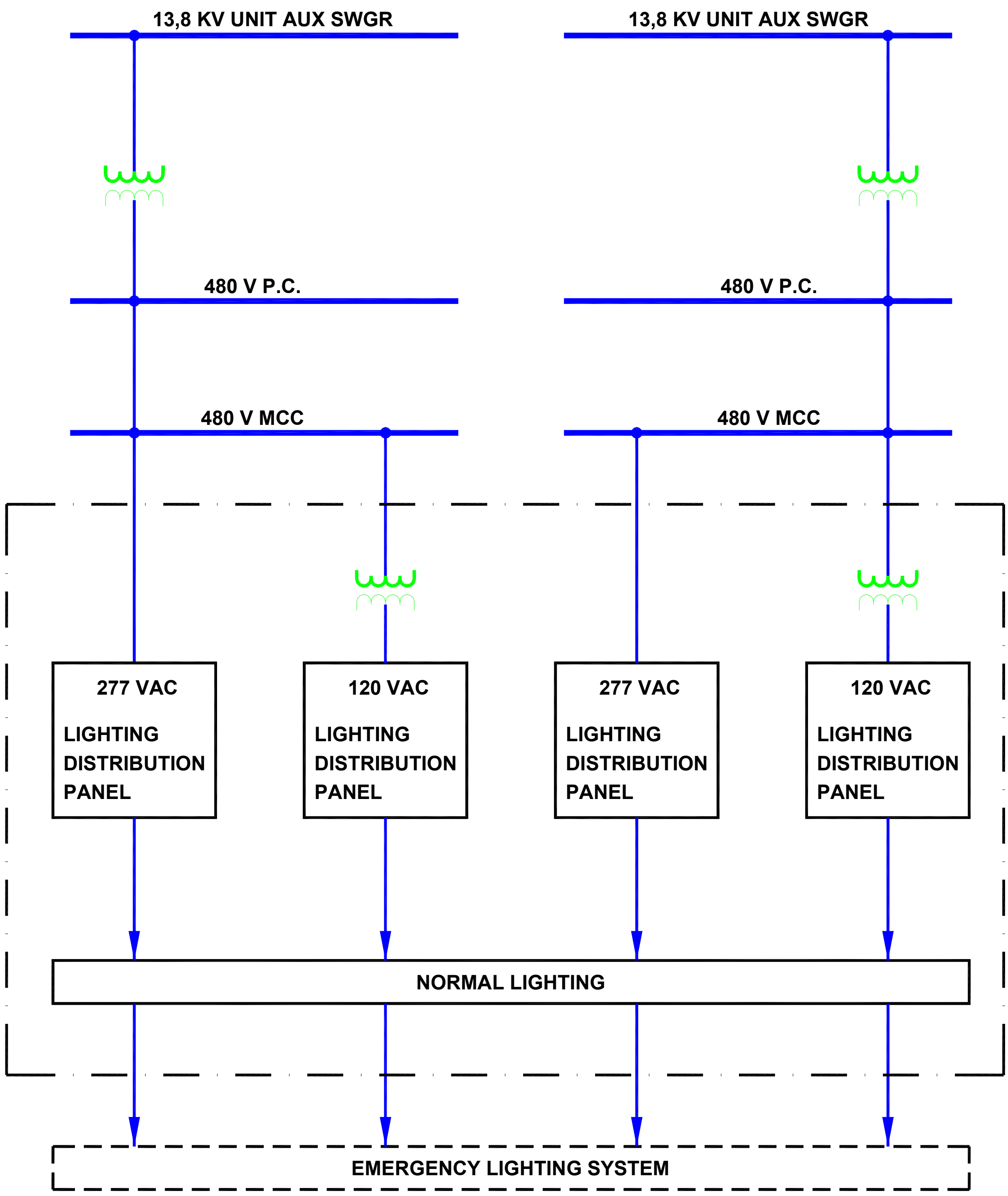


Figure 9.5-6. Standby Lighting System Simplified Block Diagram

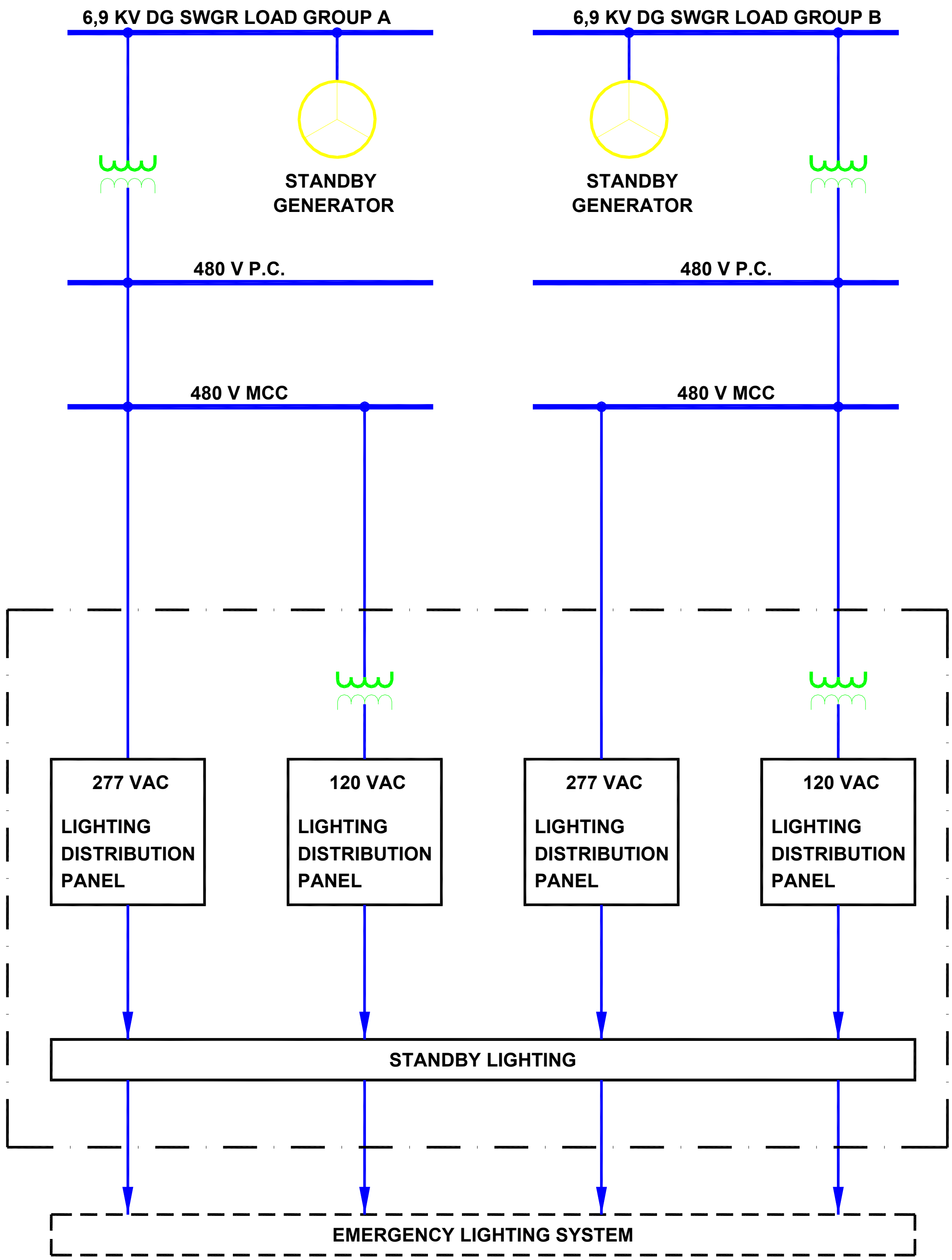


Figure 9.5-7. Emergency Lighting System Simplified Block Diagram

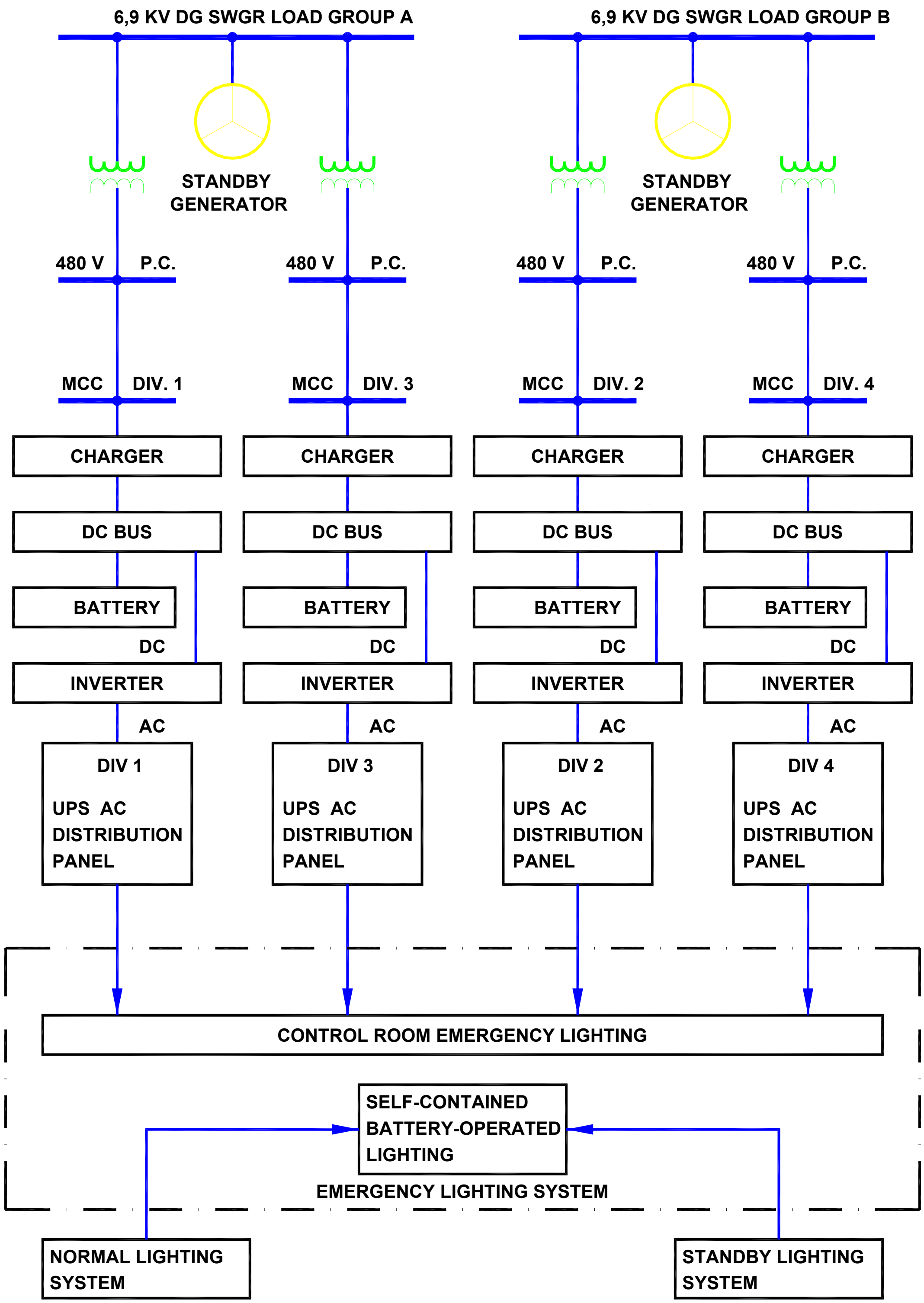


Figure 9.5-8. Security Lighting System Simplified Block Diagram

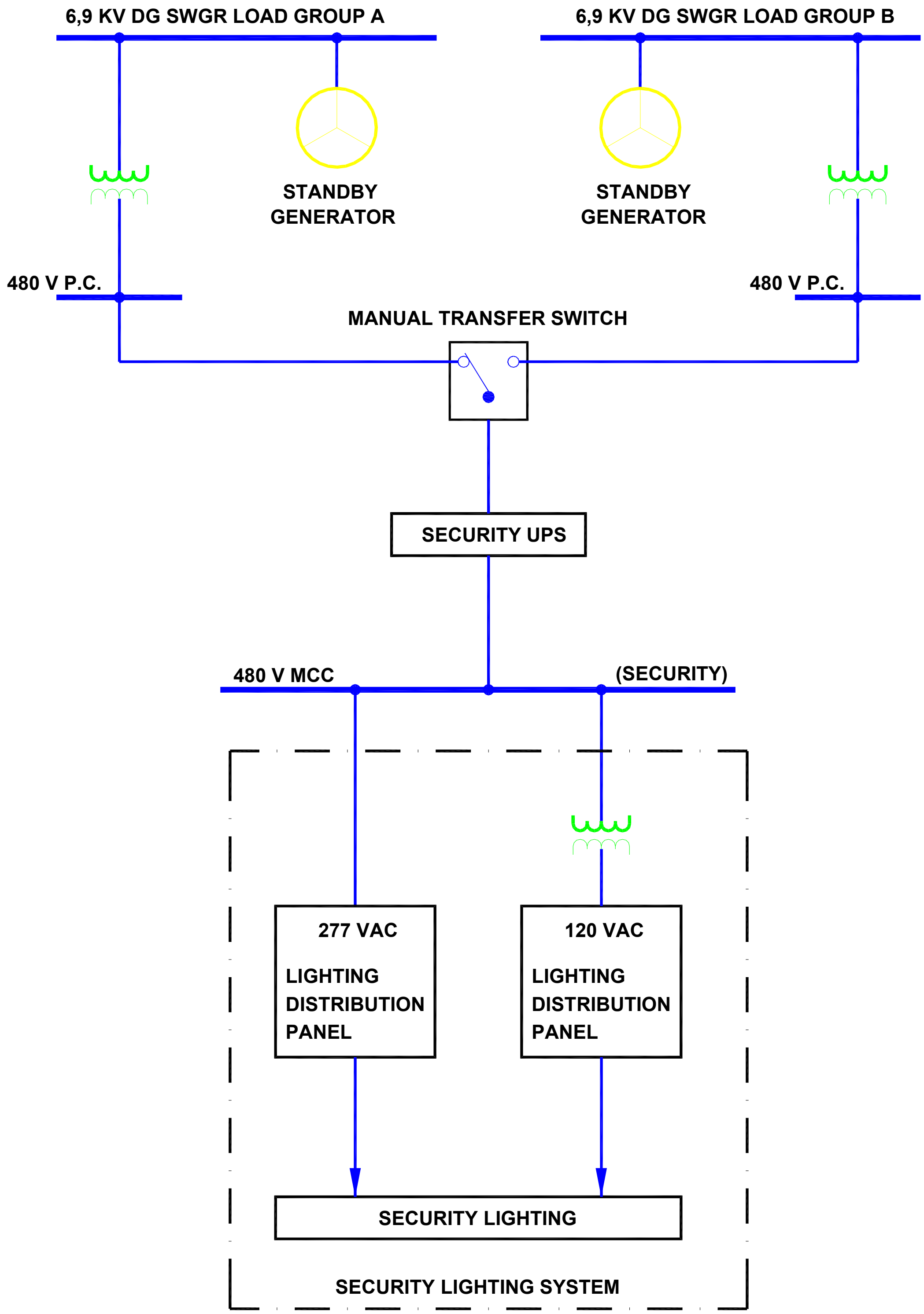


Figure 9.5-9. Diesel Generator Fuel Oil Storage and Transfer System & Air Intake and Exhaust System Diagram

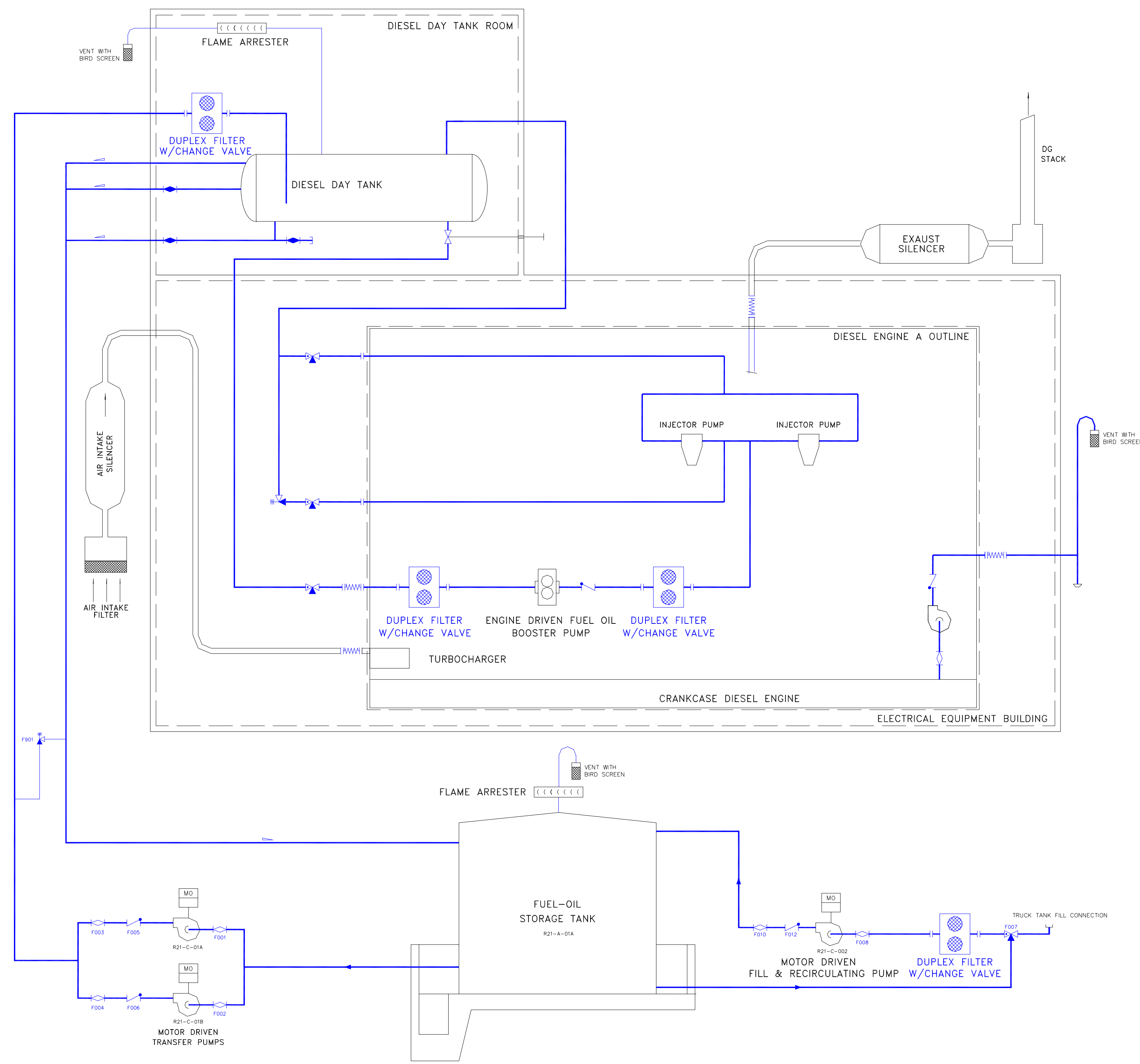


Figure 9.5-10. Diesel Generator Jacket Cooling Water System Diagram

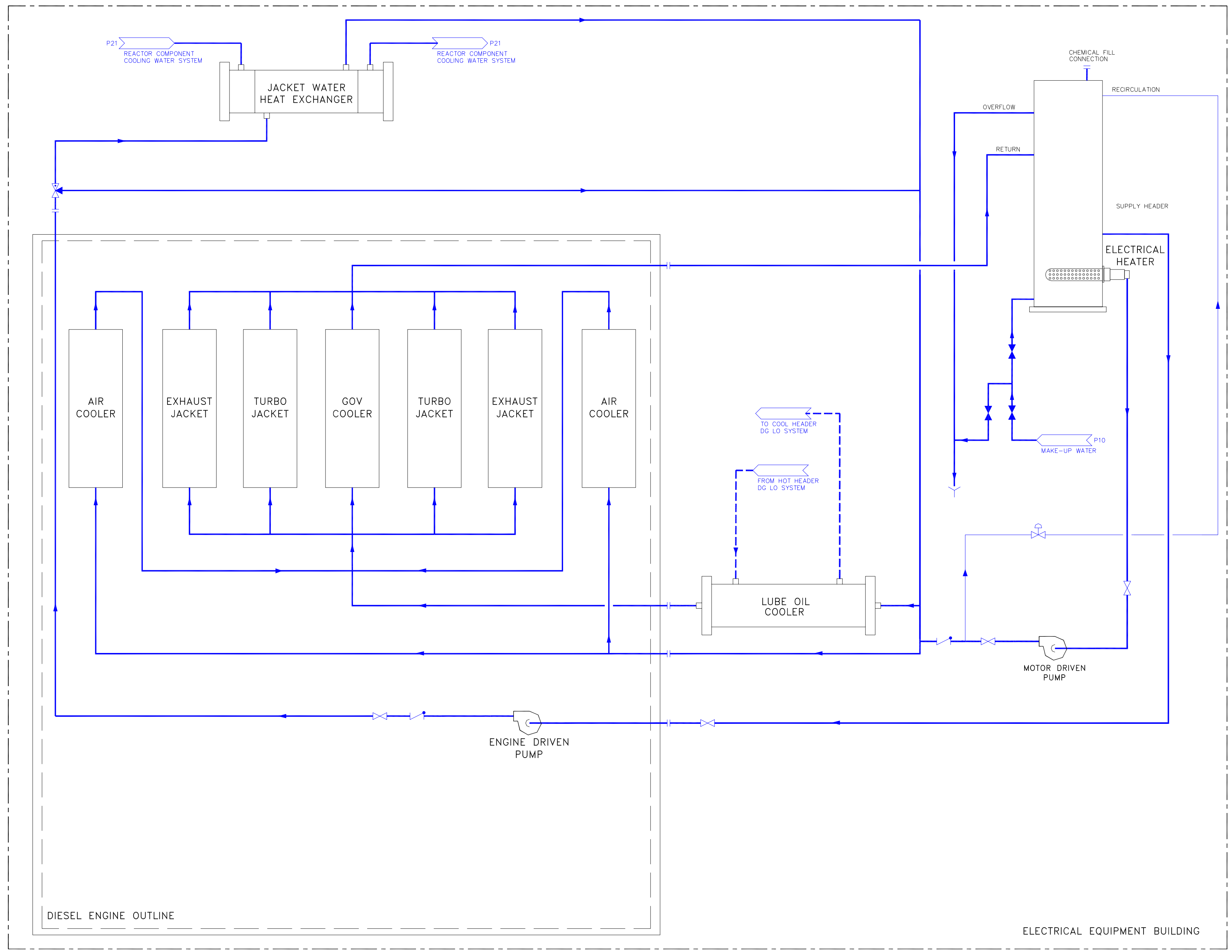


Figure 9.5-11. Diesel Generator Starting Air System Diagram

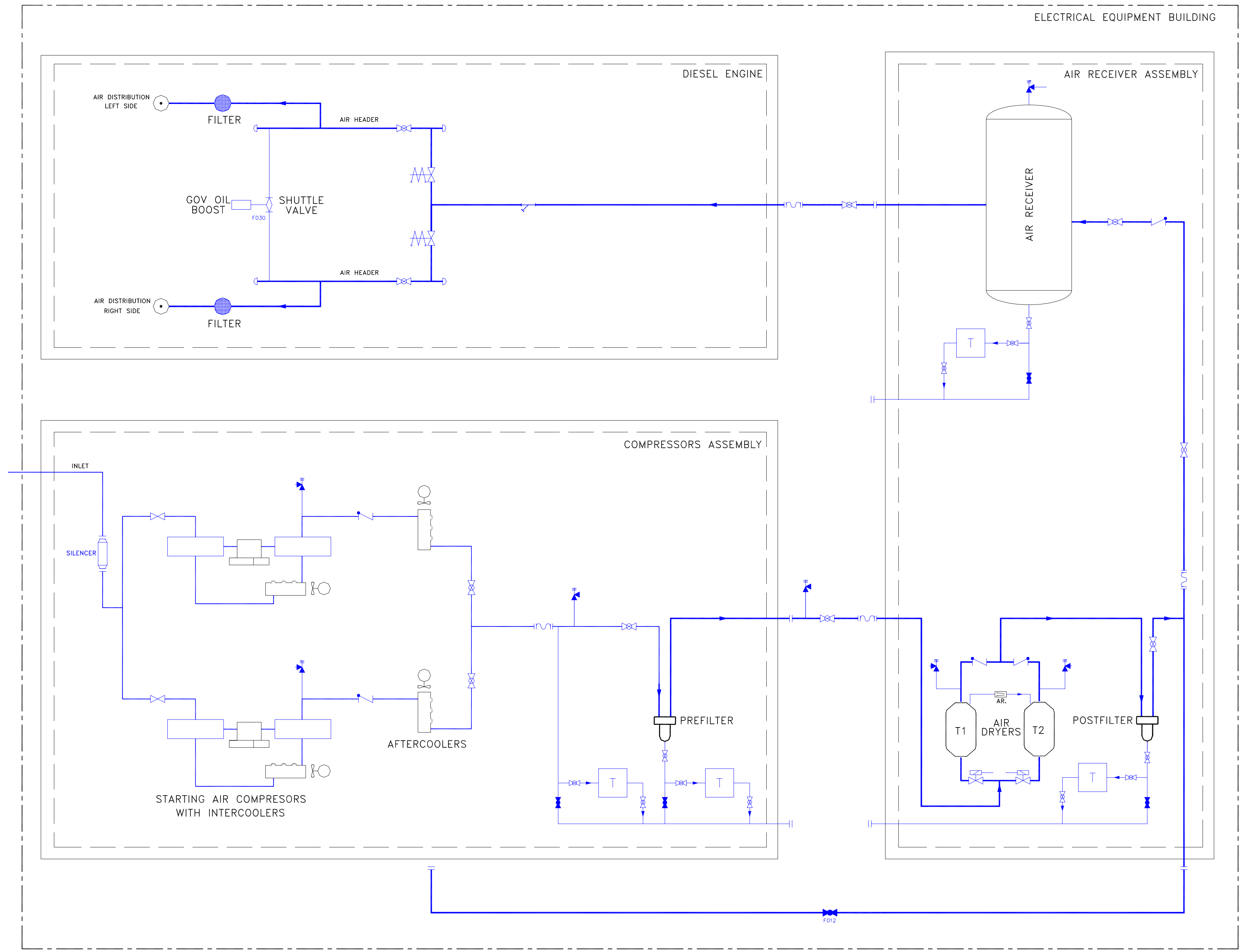


Figure 9.5-12. Diesel Generator Lubrication System Diagram