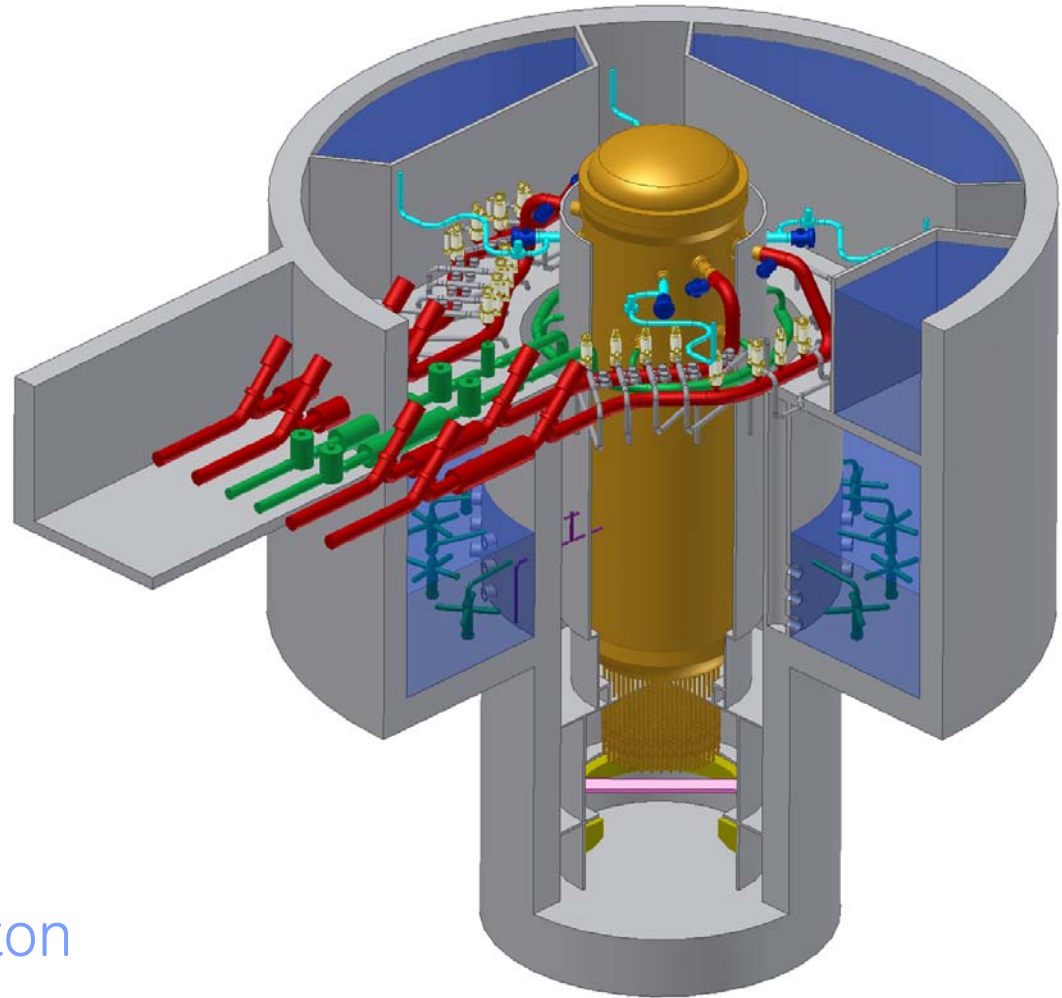


# ESBWR Auxiliary Systems

## Overview



Presented by Hugh Upton  
September 27, 2005

# ESBWR Auxiliary Systems Overview

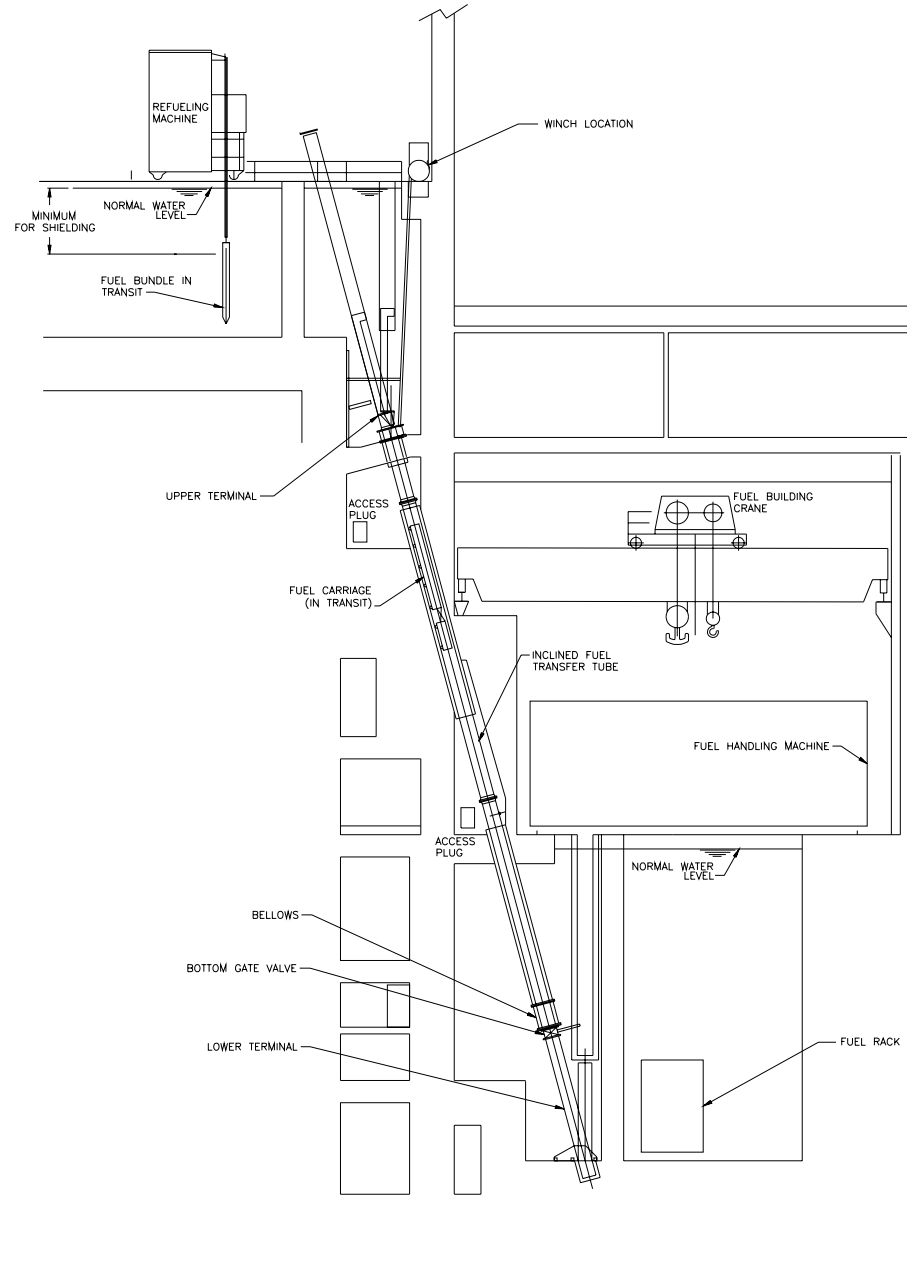
- New Fuel Storage
- Spent Fuel Storage
- Fuel and Auxiliary Pools Cooling System (G21) – J. Deaver
- Reactor Component Cooling Water System (P21)
- Chilled Water System (P25)
- Standby Liquid Control System (C41) – J. Deaver
- Control Building HVAC System (U77)
- Fuel Building HVAC System (U98)
- Reactor Building HVAC System (U40)
- Drywell Cooling System (T41)
- Containment Inerting System (T31)
- Fire Protection System (U43)

# New Fuel Storage

- Located in the RB buffer pools on the Operating Floor
  - Capacity 60% of full core
  - Racks are side loaded and have double rows of storage positions
  - Racks are floor mounted
- Designed to ensure fully loaded array is subcritical by at least 5%  $\Delta k/k$
- Designed to protect fuel assemblies/fuel bundles from damage for all credible events
- All racks are constructed in accordance with QA requirements of 10 CFR 50 Appendix B
- Racks are classified as non-safety and Seismic Category I
- Designed to withstand impact from a falling fuel assembly
- Material used for construction meet ASTM specifications

# Spent Fuel Storage

- Spent Fuel Storage Racks are top entry racks
- Designed to ensure fully loaded array is subcritical by at least 5%  $\Delta k/k$
- Neutron-absorbing material (an integral part of the array) assures  $k_{\text{eff}}$  does not exceed 0.95 for all normal and abnormal conditions.
- Located in the spent fuel pool in the FB
  - Provides storage for 10 calendar years of plant operation plus a full core off load
- 154 bundles of spent fuel storage is available in the buffer pool to provide operational flexibility
- Racks are classified as non-safety and Seismic Category I
- Designed to withstand impact from a falling fuel assembly
- Material used for construction meet ASTM specifications
- Spent Fuel Storage Pool has adequate water shielding over spent fuel
  - On loss of FAPCS SFP cooling, sufficient water above spent fuel to allow boiling for 72 hrs and still have 3.0m
- Spent fuel is transferred from the RB Operating floor to the FB spent fuel pool via the Inclined Fuel Transfer Tube (IFTT)



# Inclined Fuel Transfer Tube (IFTT)

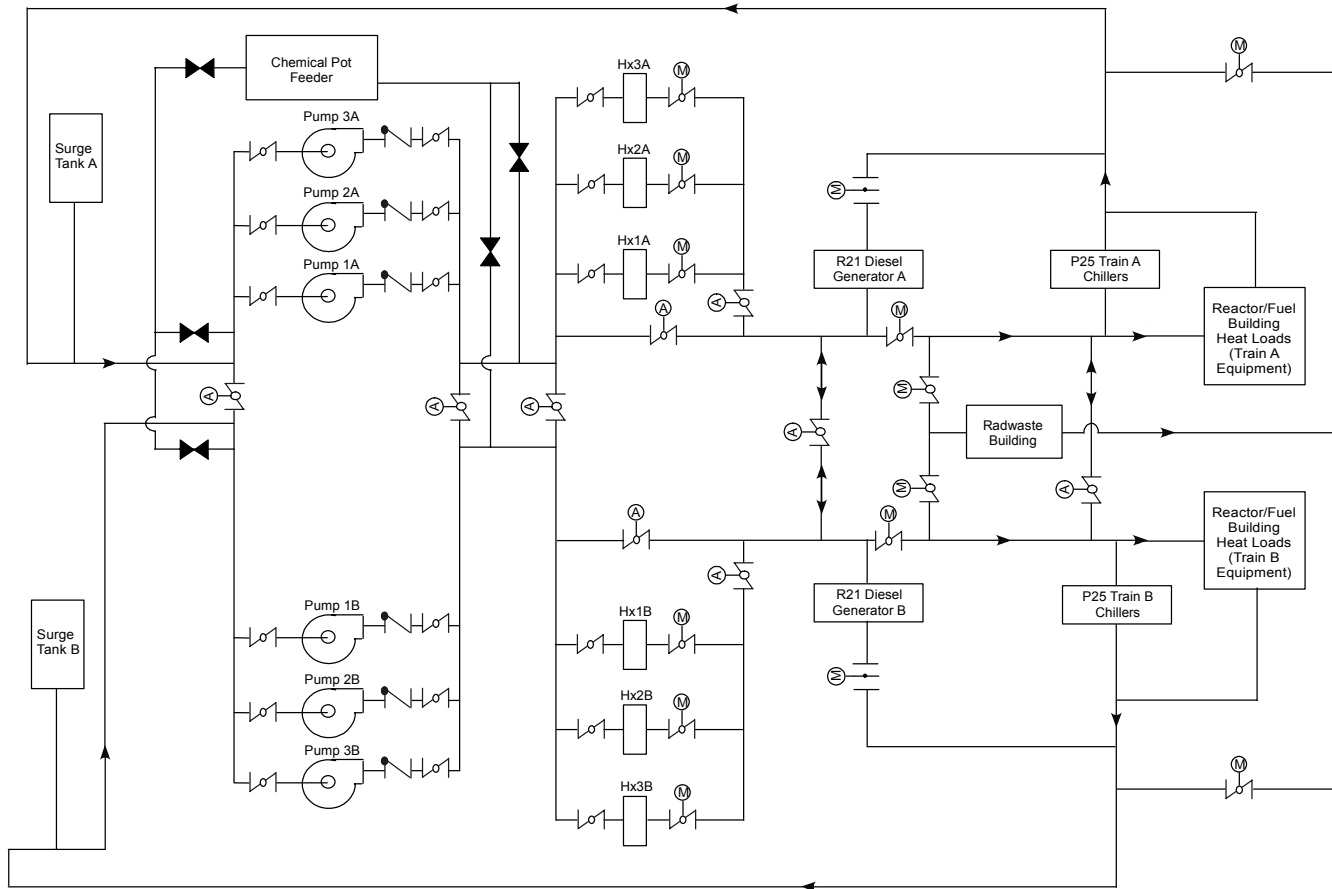
# Fuel and Auxiliary Pools Cooling System (G21)

- FAPCS to be presented by J. Deaver

# Reactor Component Cooling Water System (P21)

- System does not perform any safety-related function.
- Provides cooling water to plant auxiliary equipment during normal operation, cooldown and shutdown operation.
- No single active failure nor credible single passive component failure will result in loss of active nuclear island cooling.
- System is powered from the PIP busses so that it operates during a LOPP.
- Designed to limit leakage of radioactive components to the environment.
- Consists of two 100% capacity independent and redundant trains.
- Heat loads include:

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

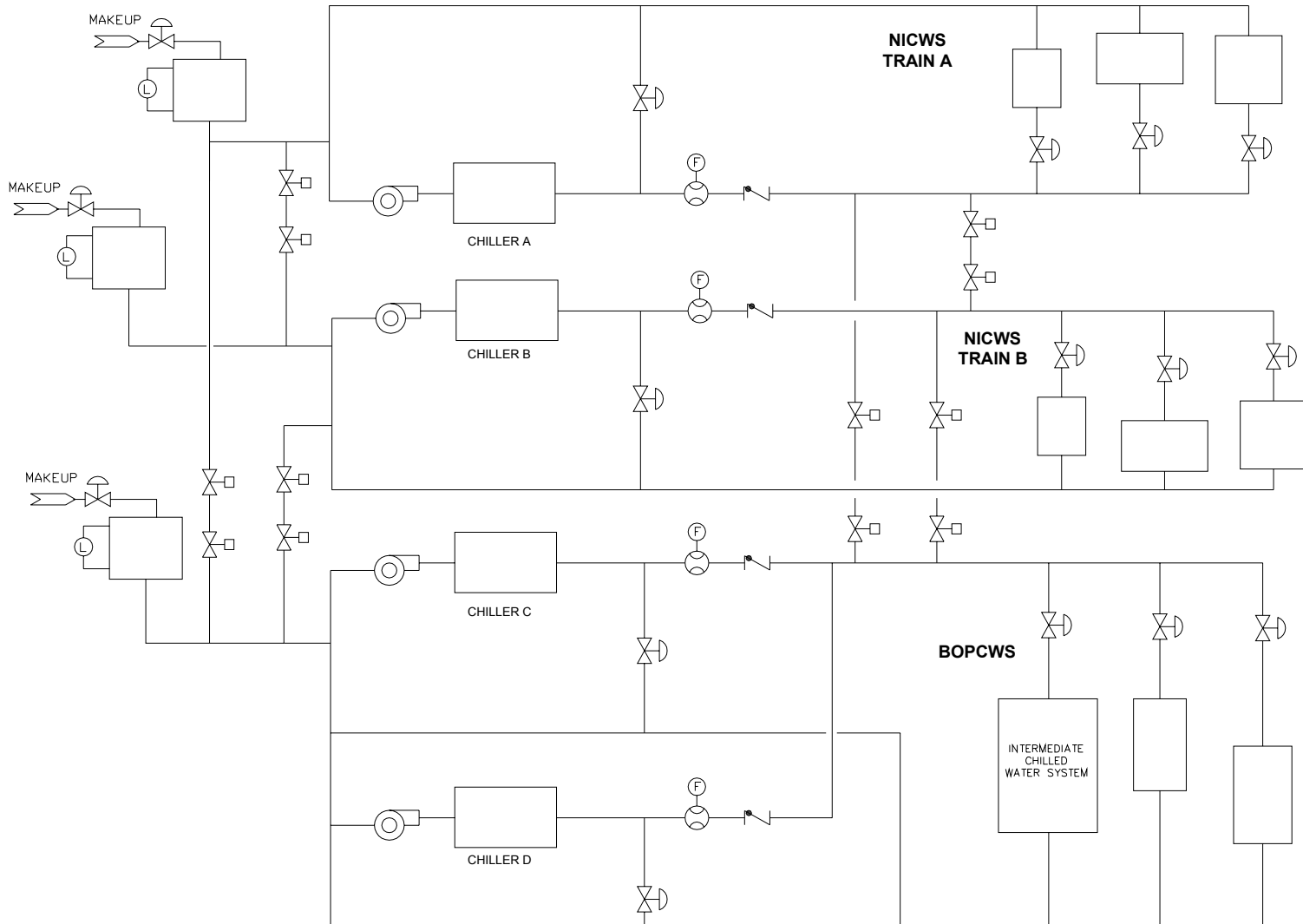


## Reactor Component Cooling Water System (P21)



# Chilled Water System (P25)

- System does not perform any safety-related function.
- CWS consists of Nuclear Island Chill Water Subsystem (NICWS) and Balance of Plant Chilled Water Subsystem (BOPCWS).
- Provides chilled water (7° C (44.6° F)) to plant equipment
  - Assumes 35° C (95° F) RCCWS and TCCWS cooling water
- NICWS is powered from the PIP busses so that it operates during a LOPP.
- CWS is designed as Seismic Cat II criteria when located in Seismic Cat I buildings
- NICWS and BOPCWS are independent subsystems but interconnected
- Chilled water is provided to cooling coils of AHU's and other coolers in RB, CB, TB, RWB, SB, EB, FB, TSC and Hot Machine Shop
- NICWS provides chilled water to the Drywell Cooling System (T41) DW air coolers
- NICWS consists of two 100% capacity redundant and independent trains
- BOPCWS consists of one 100% capacity independent train with crossties to both NICWS trains



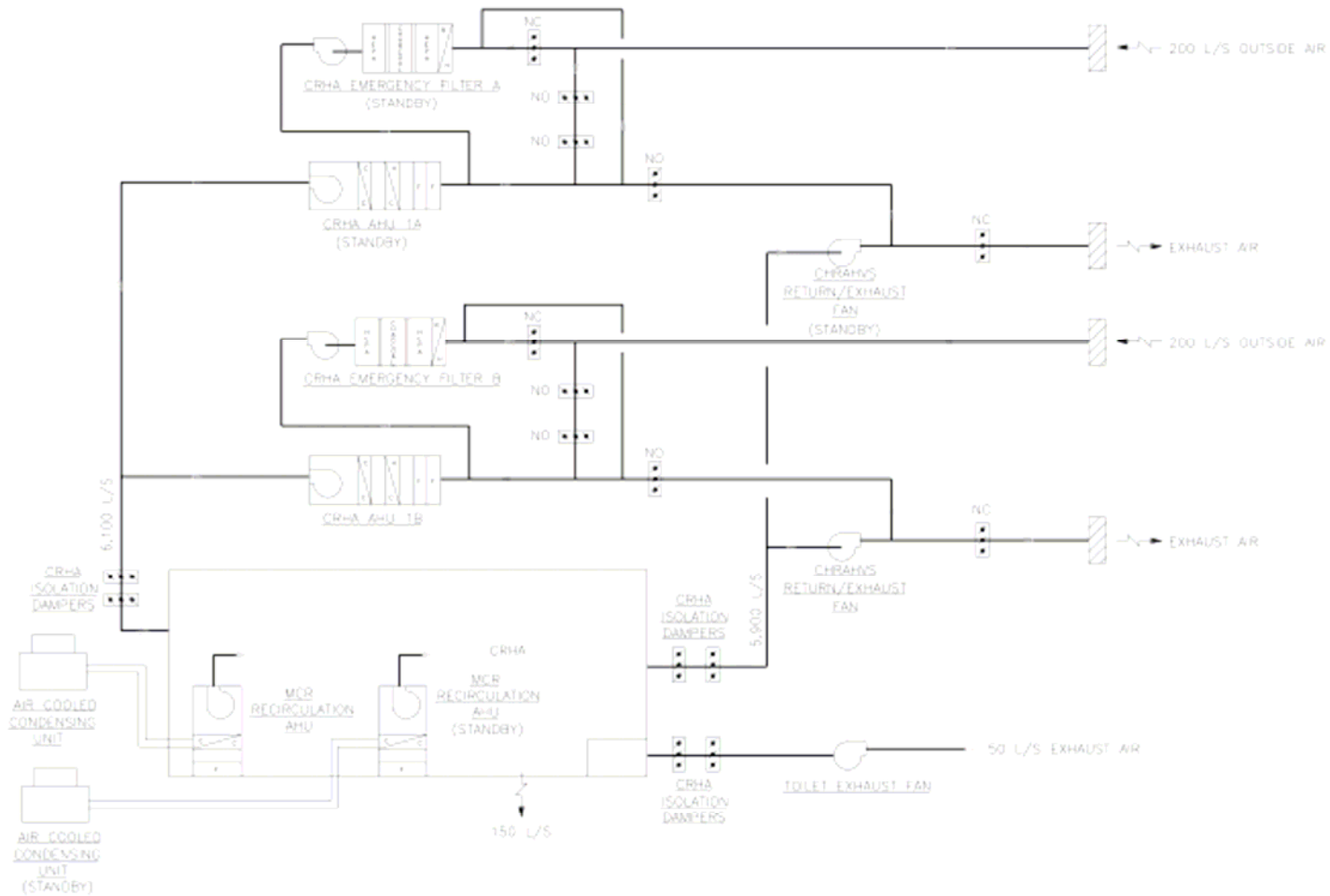
## Chilled Water System (P25)

# Standby Liquid Control System (C41)

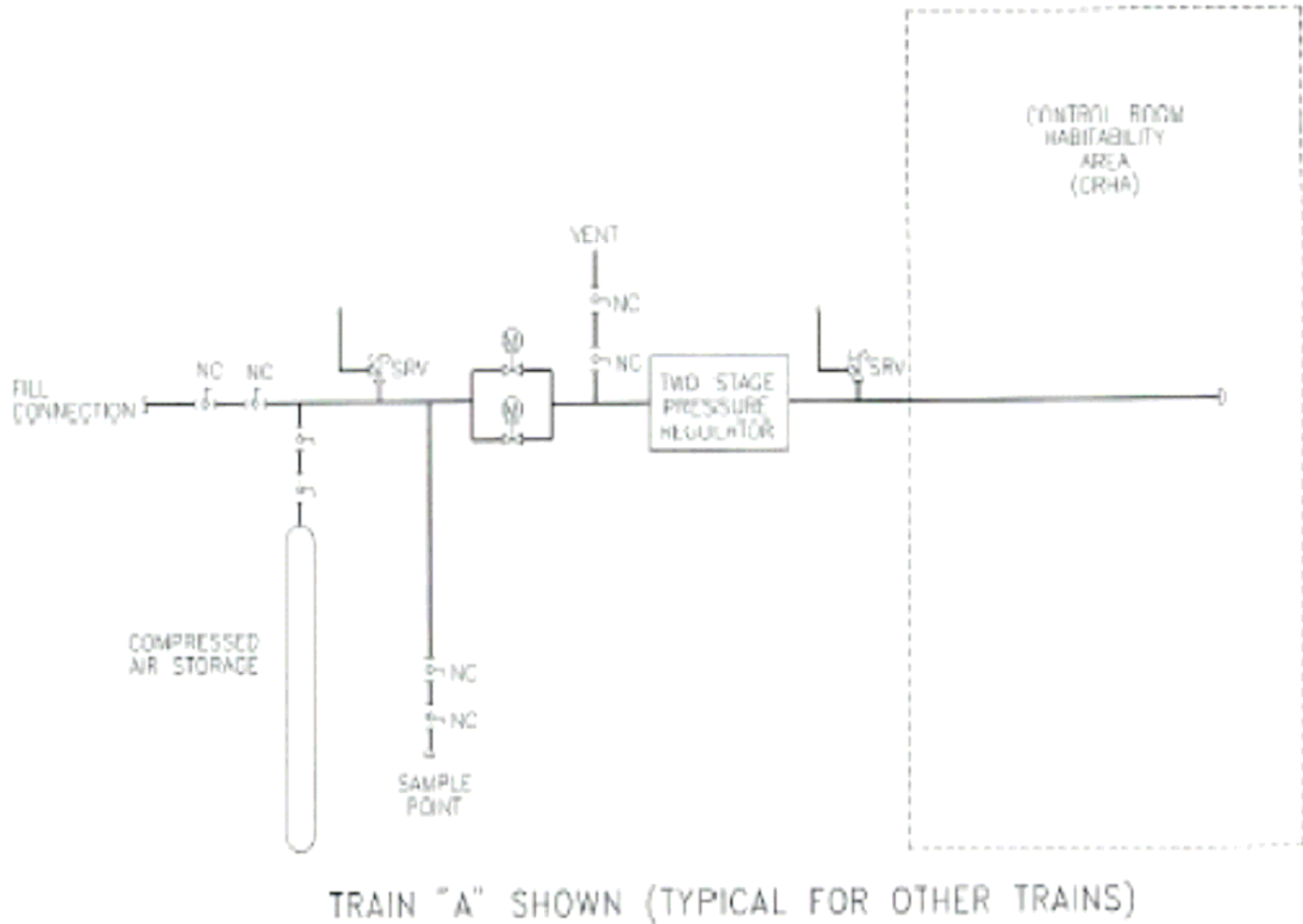
SLCS to be presented by J. Deaver

# Control Building HVAC System (U77)

- Consists of three subsystems: CR Habitability Area HVAC Subsystem (CRHAHVS), Emergency Breathing Air System (EBAS) and CB General Area HVAC (CBGAHVS)
- CRHAHVS serves the MCR and associated support areas
- EBAS provides pressurized bottled air to the Control Room Habitability Area (CRHA) during radiological events and in the event of a SBO.
- Most of the components of U77 are non-safety related
  - CRHA envelope, isolation dampers and EBAS are safety related
  - EBAS is automatically initiated on isolation of the CRHA envelope
  - CRHA structures and components are Seismic Cat I
- On detected high radiation or toxic gas the air inlet and exhaust dampers of CRHAHVS will close and MCR air is recirculated with no outside air makeup.
- An Emergency Filter Unit (EFU) with a HEPA filter and charcoal filters is available to serve the CRHA if power is available
- No single active failure can result in loss of system performance
- During SBO MCR temperature rise is only 8.3° C (15 ° F) after 72 hours.



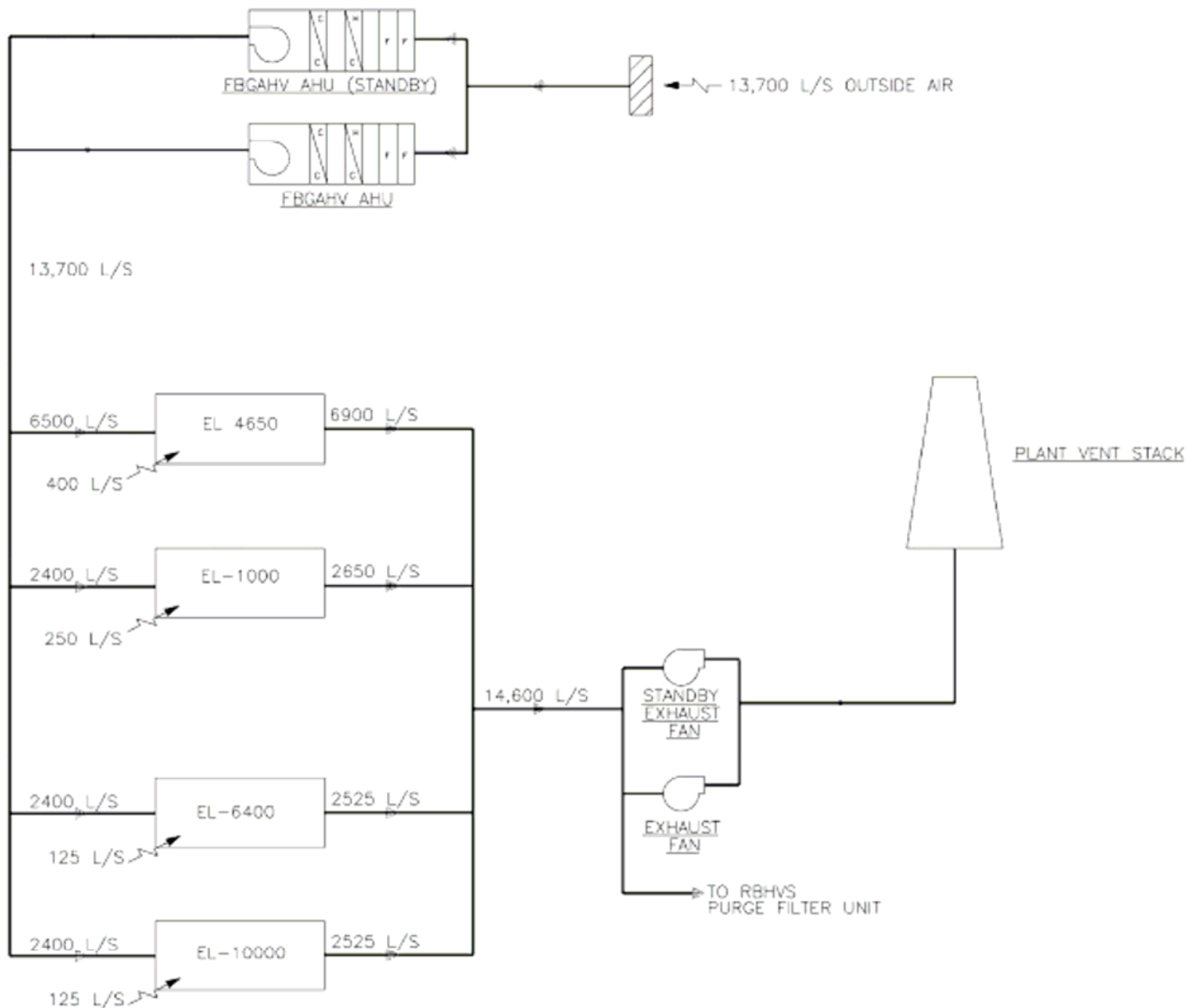
## Control Building HVAC System (U77)



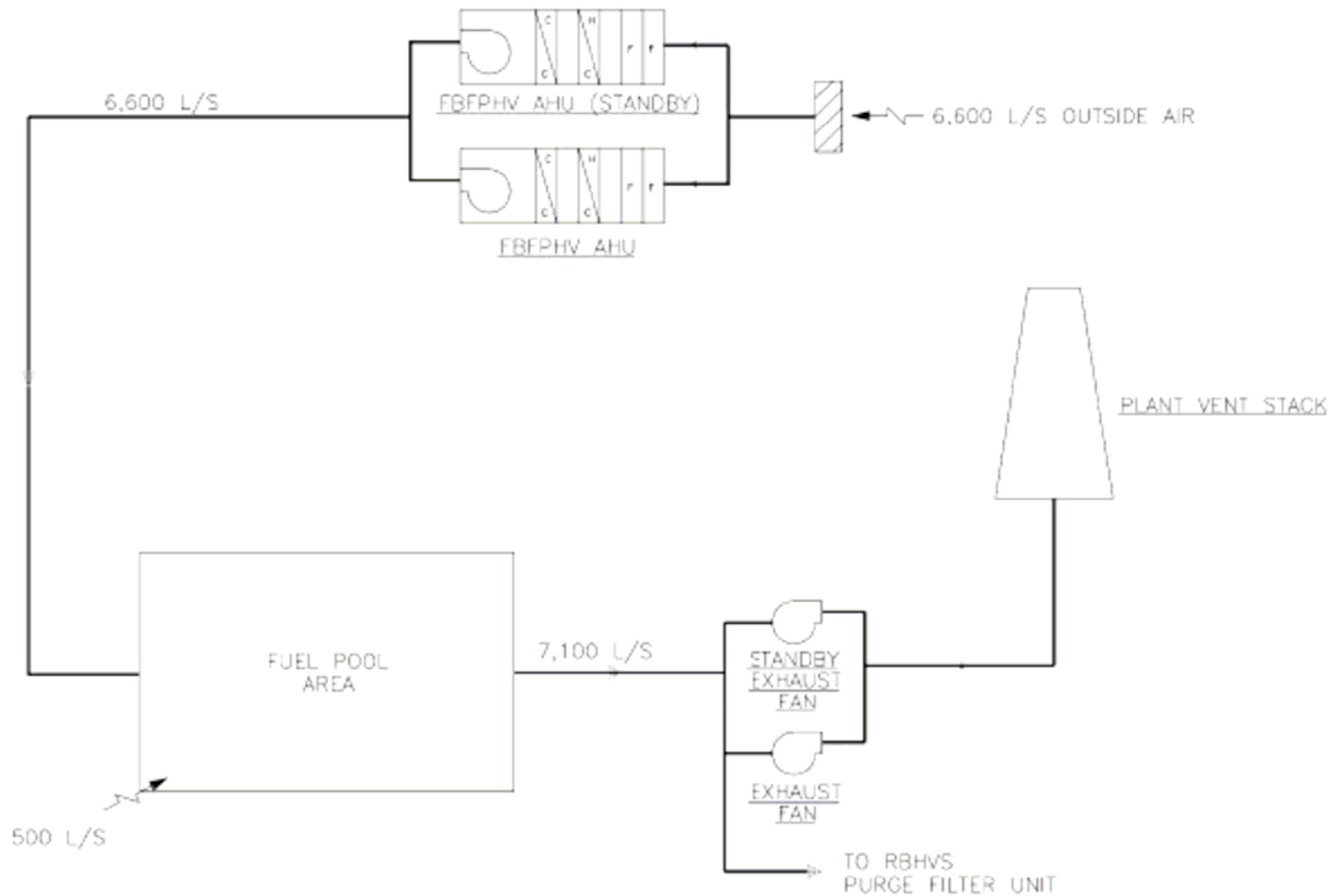
## Emergency Breathing Air System (EBAS)

# Fuel Building HVAC System (U98)

- Fuel Building Heating Ventilation and Air Conditioning System (FBHVS) provides HVAC to FB General Areas, Spent Fuel Pool and equipment area.
- FBHVS is nonsafety-related except isolation dampers and ducting penetrating FB boundary.
- The system automatically isolates in the event of fuel handling accident or other radiological accident.
- Consists of two subsystems: FB General Area Heating Ventilation and Air Conditioning Subsystem (FBGAHV) and FB Spent Fuel Pool Heating Ventilation and Air Conditioning Subsystem (FBFPHV)



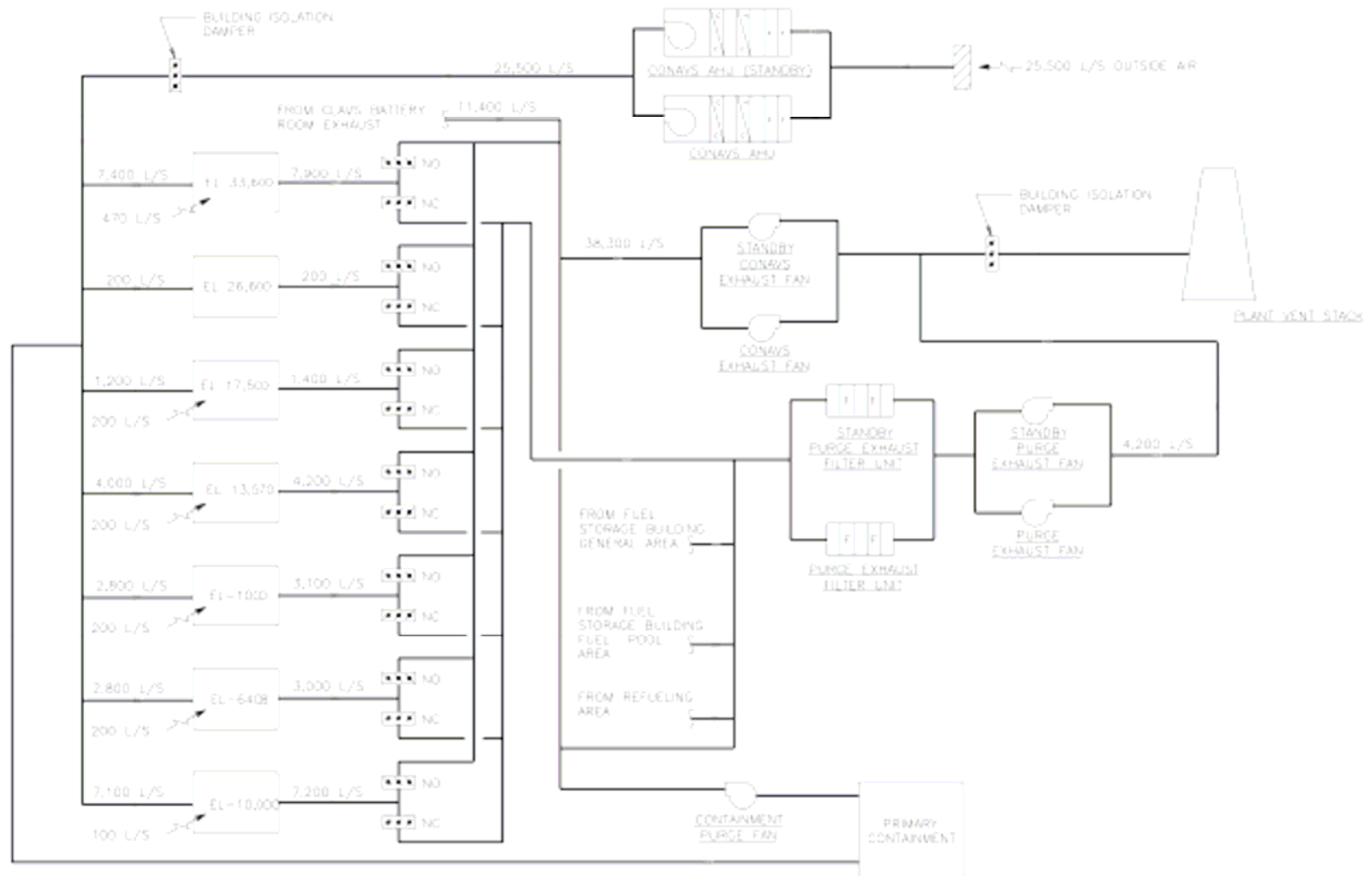




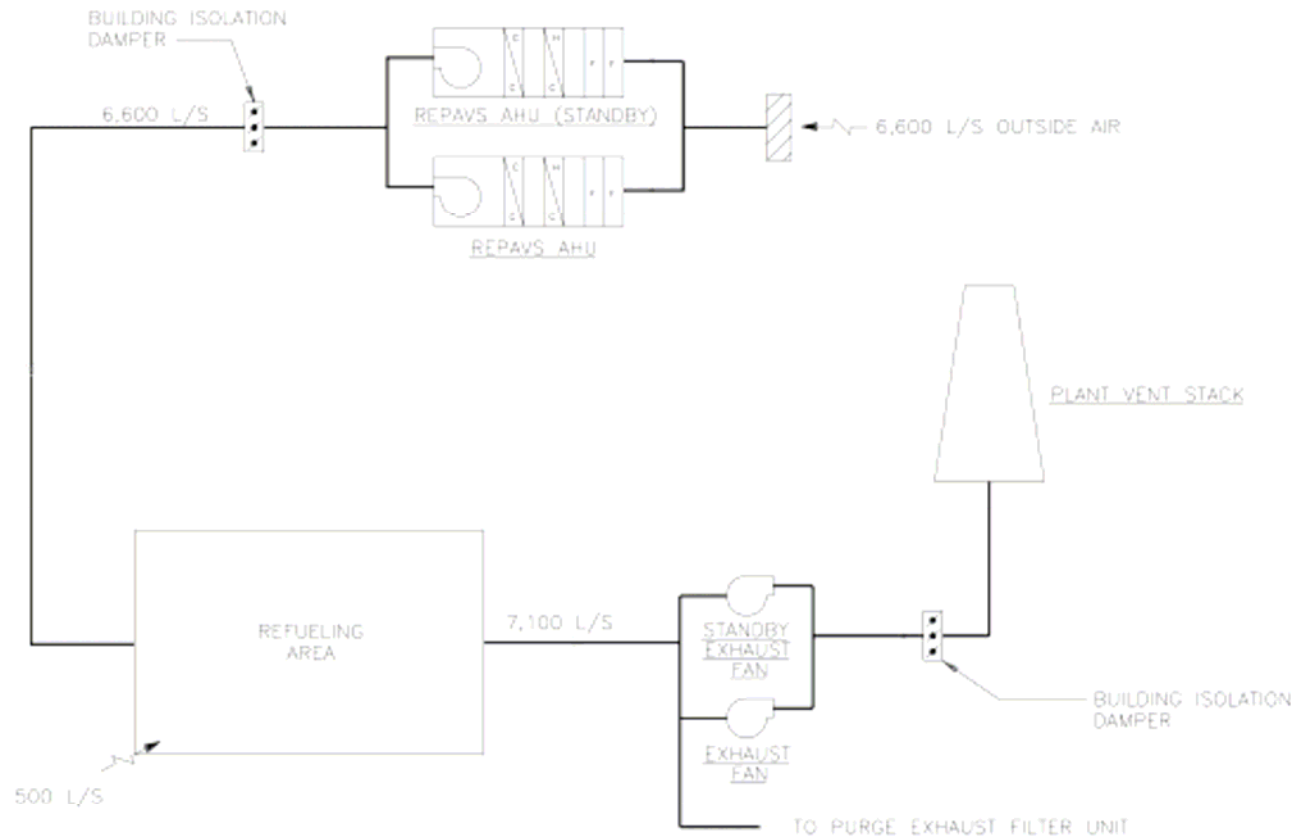
## FB Spent Fuel Pool HVAC Subsystem

# Reactor Building HVAC System (U40)

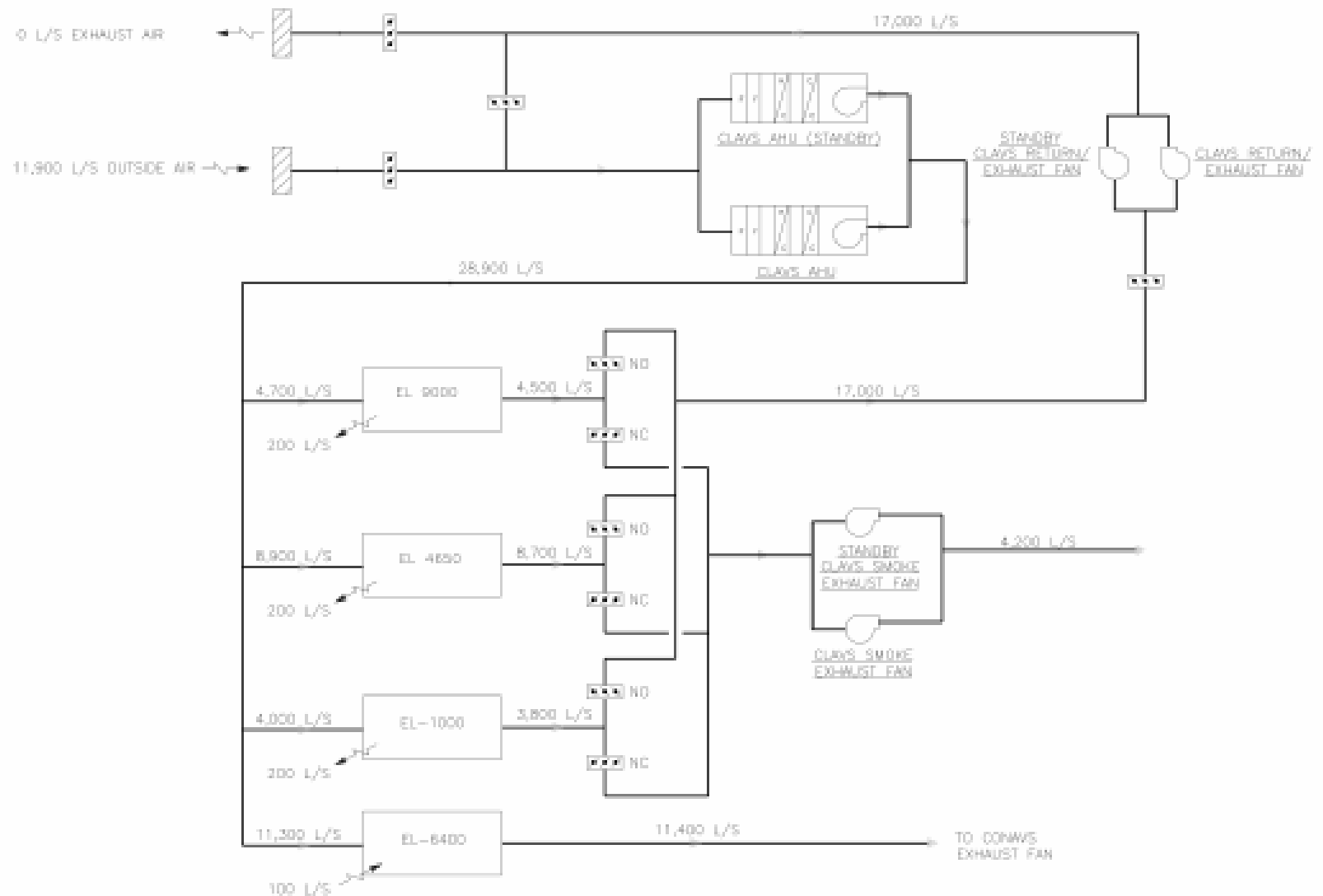
- RB Heating, Ventilation and Air Conditioning System (RBHVS) serves RB potentially contaminated areas, the refueling area and non-radiologically controlled areas of the RB.
- RBHVS is nonsafety-related except isolation dampers and ducting penetrating RB boundary and associated controls
- System consists of three Subsystems: RB Contaminated Area HVAC Subsystem (CONAVS), Refueling and Pool Area HVAC Subsystem (REPAVS) and the RB Clean Area HVAC Subsystem (CLAVS)
- CONAVS and REPAVS are once thru systems and consist of redundant AHUs, exhaust fans and building isolation dampers.
  - CONAVS Includes primary containment purge exhaust fan, recirculation AHUs and unit heaters
  - Air is exhausted from potentially contaminated areas of RB via purge exhaust fan to plant stack
- CLAVS is a recirculation ventilation system with redundant AHUs, return/exhaust fans and smoke exhaust fans
- In the event of a fire fire dampers close to isolate the fire area - exhaust fans are used for smoke removal



## RB Contaminated Area HVAC Subsystem (CONAVS)



## RB Refueling & Pool Area HVAC Subsystem (REPAVS)



## RB Clean Area HVAC Subsystem (CLAVS)

# Drywell Cooling System (T41)

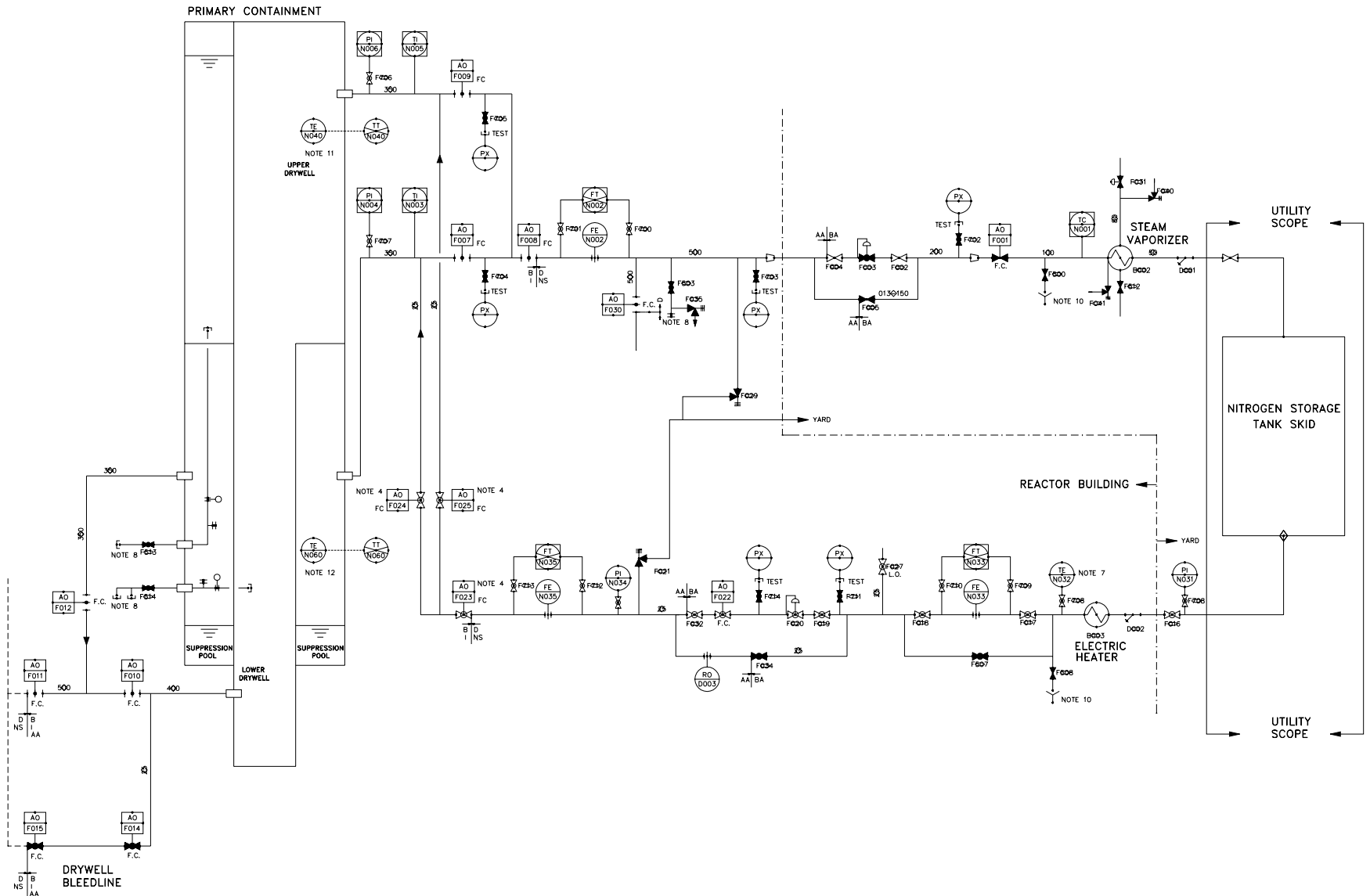
- Drywell Cooling System (DCS) is classified as a nonsafety-related, Seismic Cat II system
- DCS maintains upper and lower drywell temperatures within limits during normal operation, accelerates DW cool down going from hot to cold shutdown, assists in purging DW  $N_2$  during shutdown, maintains DW environmental conditions during outages and limits DW temperatures during a LOPP
- DCS is a closed loop recirculation air/ $N_2$  cooling system with no outside air/ $N_2$  introduced
- Ducts distribute cooled, recirculated air/ $N_2$  thru diffusers and nozzles
- DCS consists of four FCUs, two 50% capacity FCUs in the upper and two 50% capacity FCUs in the lower DW
- Each FCU consists of a cooling coil and two fans – only one is normally in operation the other is in standby
- Chilled Water System provides cooling water to the FCU cooling coils
- The DCS is power off of the PIP busses and is supplied power by the standby DG on a LOPP



# Containment Inerting System (T31)

- Containment Inerting System (CIS) is classified as a nonsafety-related system.
- System is design to establish containment inerted atmosphere of  $< 4\% \text{ O}_2$  by volume in  $< 4$  hours and  $< 2\% \text{ O}_2$  in the next 8 hrs.
- Maintains containment  $\text{O}_2$  level  $< 3\%$  during normal, abnormal and accident conditions.
- Maintains slight positive pressure during normal, abnormal and accident conditions to prevent air in-leakage.
- $\text{N}_2$  gas makeup supply has capacity to maintain  $+ 4.8 \text{ kPaG}$  ( $0.7 \text{ psig}$ ) in containment.
- System has sufficient capacity to replenish  $0.5\%$  RCCV volumes per day based on the containment operating pressure.
- CIS permits de-inerting the containment for safe access in  $< 12$  hrs.
- CIS is design to relieve containment pressure during a severe accident before uncontrolled containment failure could occur.
  - This operation is performed manually
  - Function was previously performed by Containment Over Protection System





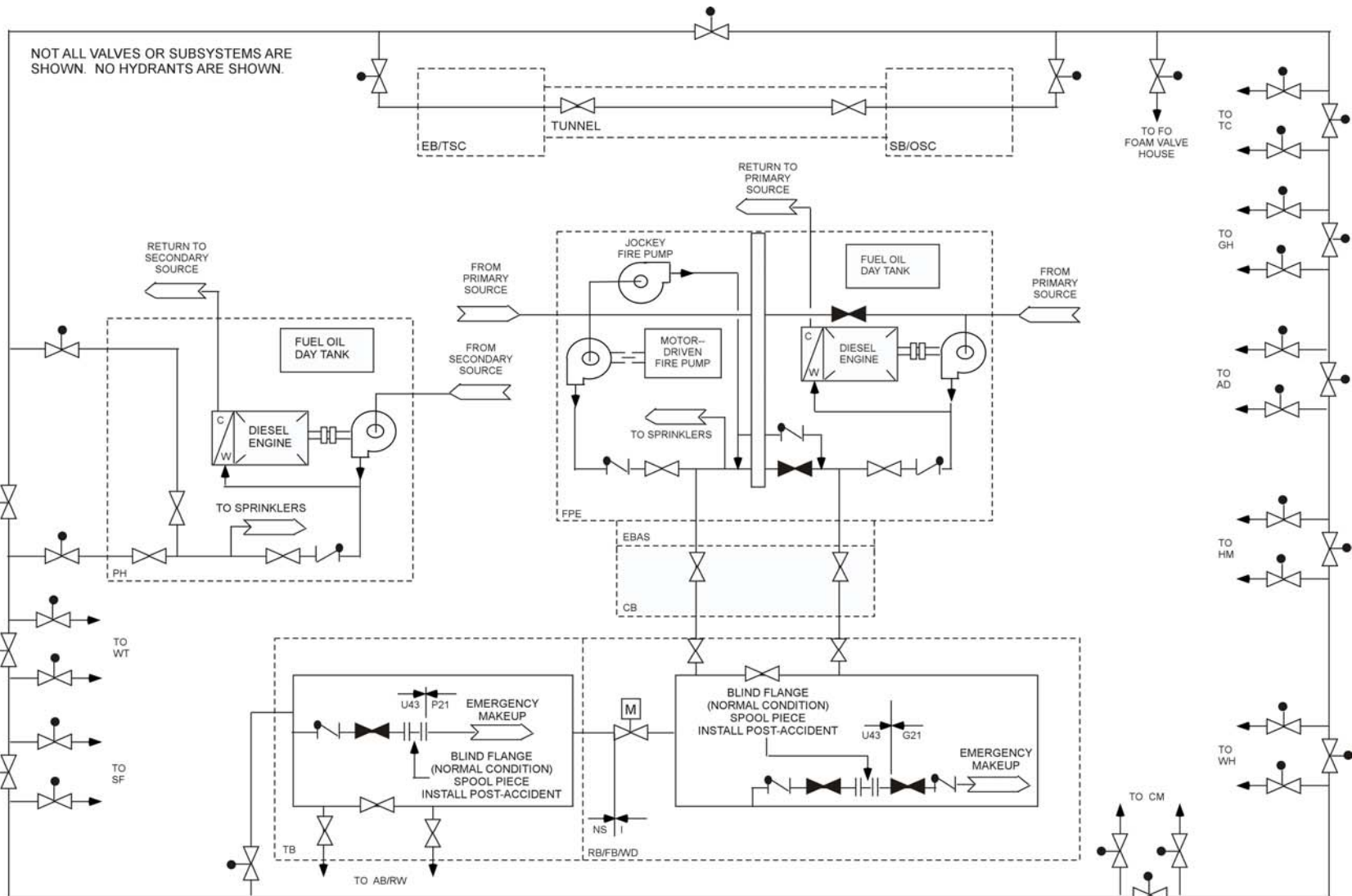
# Containment Inerting System (T31)

# Fire Protection System (U43)

- Fire Protection System is classified as a nonsafety-related system although it is subject to RTNSS requirements
- System is designed with defense in depth to achieve the required degree of reactor safety. System is designed to:
  - Control the spread and extinguish fires in all plant areas using fixed and/or portable fire fighting equipment,
  - Provide automatic fire detection and annunciation,
  - Provide maximum firewater demand assuming a single failure,
  - Preclude loss of function during a seismic event,
  - Preclude loss of fire water supply - two separate and independent fire water sources are connected to FPS
  - Ensure no single failure caused by an MELB can impair both the primary and backup fire suppression system
  - Provide a source of on site makeup water to FAPCS for the IC/PCC pools 72 hrs after a LOCA for 7 days.

# Fire Protection System (U43)

- Fixed automatic Fire suppression systems are installed in areas having a high fire hazard rating
- Building standpipes and hose stations are provided in major buildings
- Portable fire extinguishers are strategically located throughout the plant
- Comprehensive fire detection, alarm, supervisory control, and indication provided thru out the plant.
- Operation of system is automatic – can be locally controlled
- Main fire panel alarm panel is located in MCR
- Three 50% capacity firewater pumps provides 100% of demand assuming worst-case fire within NI.
  - Two NI fire pumps are located on top on a Seismic Cat I structure – lead pump is motor drive, backup pump is diesel driven
  - The second diesel driven fire pump is located remotely from the NI fire pumps and provides backup
  - Fuel oil tanks for diesel driven fire pumps has capacity for approximately 8 hrs.



# Fire Protection System (U43)