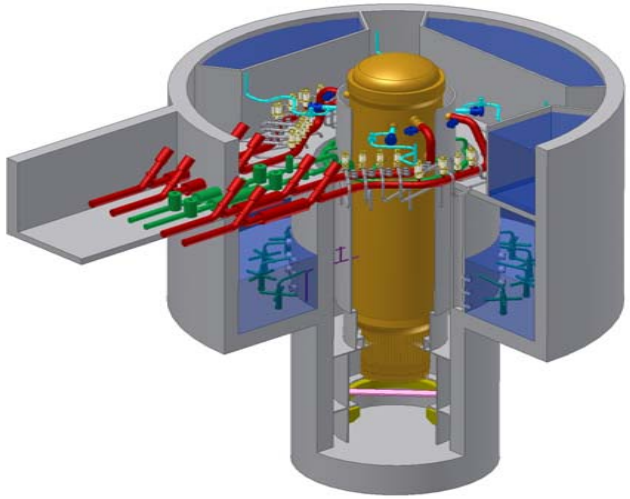


Presentation to
Nuclear Regulatory Commission

Summary
ESBWR Design Control Document, Tier 2
Chapter 5
Reactor Coolant System and Connected Systems

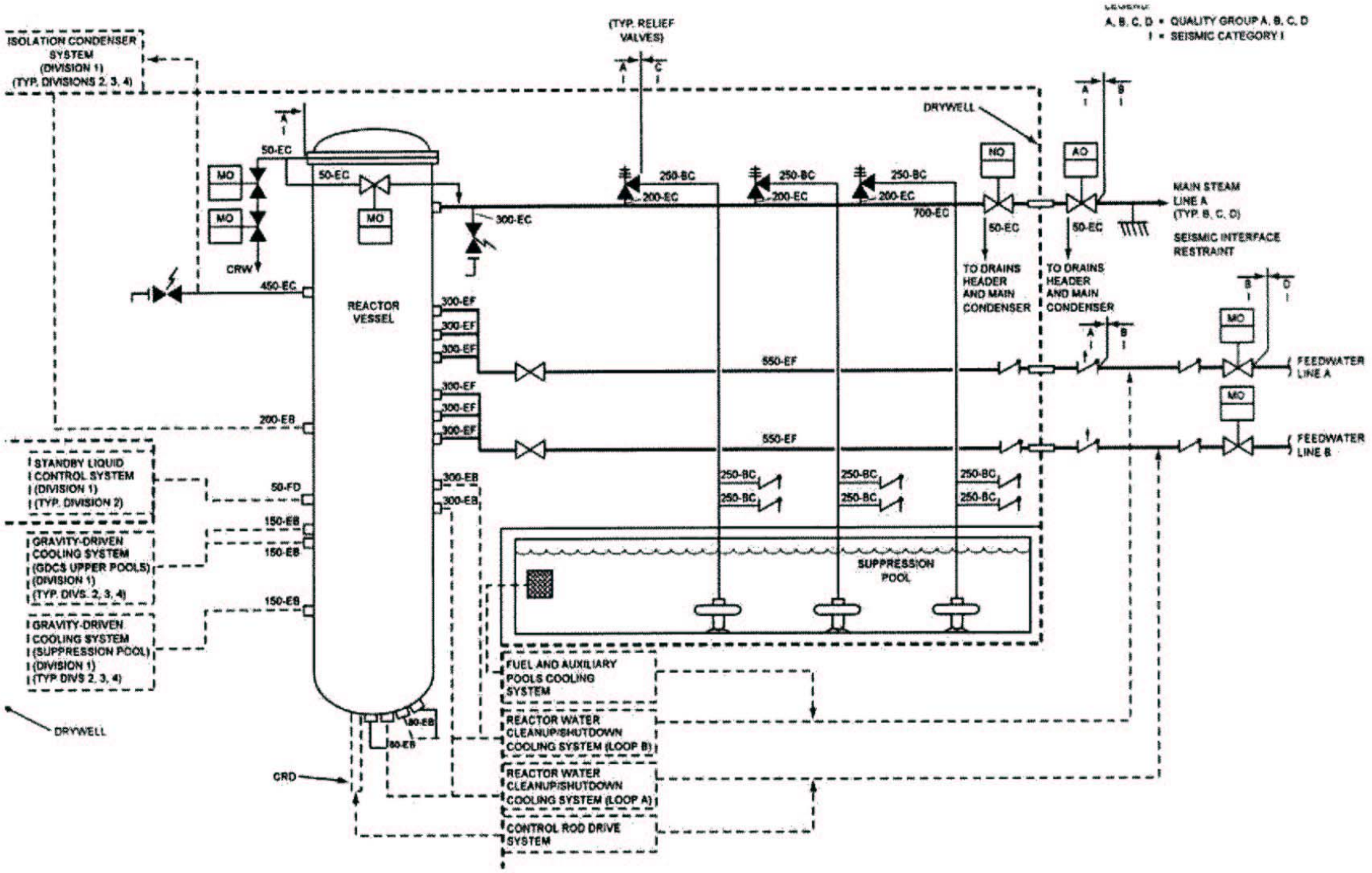
September 27, 2005

imagination at work

Reactor Coolant Systems

- Nuclear Boiler System
  - Main Steam
  - Feedwater
- Reactor Water Cleanup/shutdown Cooling System
- Isolation Condenser System

Nuclear Boiler System



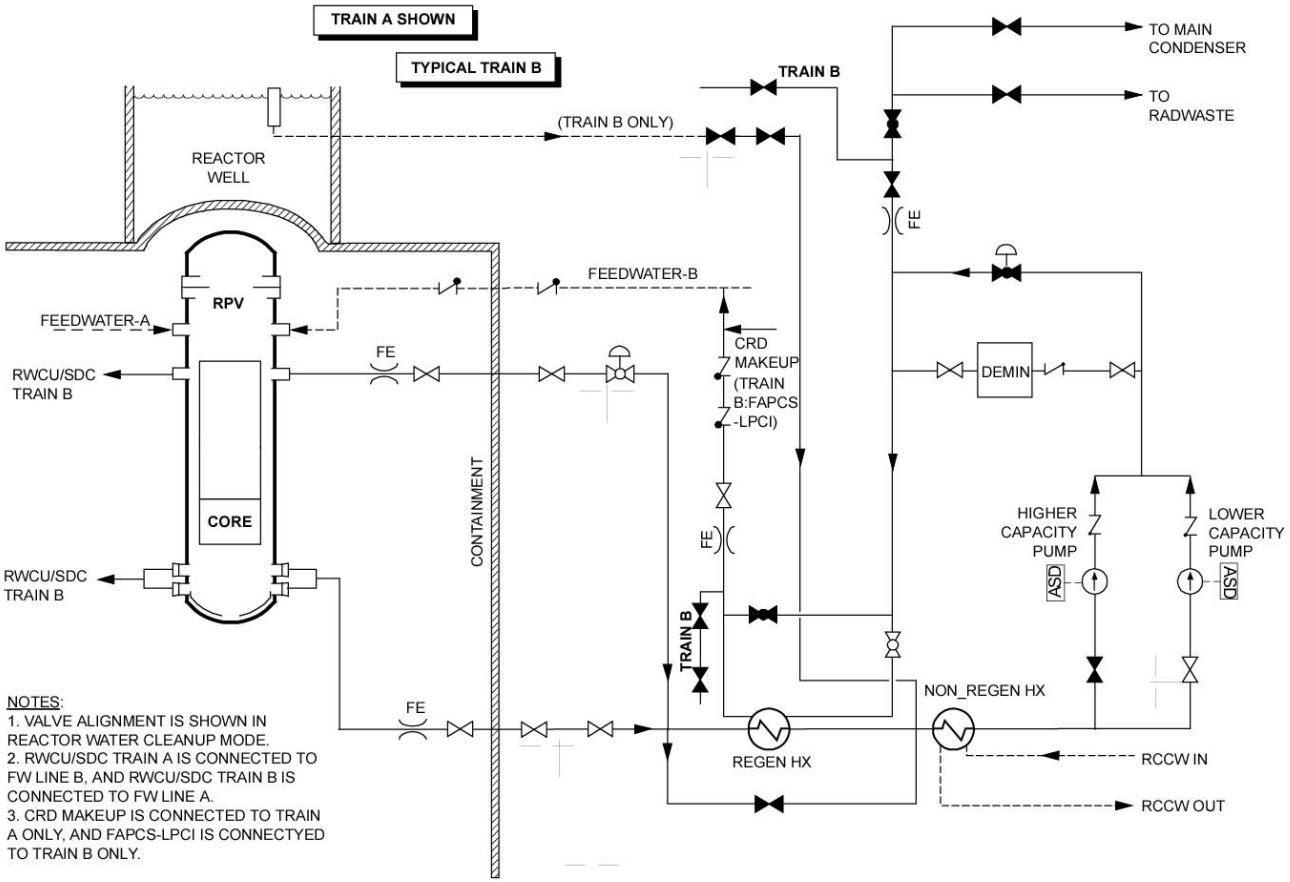
NBS Safety-Related Functions

- Provide containment Isolation of the main Steam Lines using MSIVs
- Prevent Backflow in Feedwater Lines and Containment Isolation
- Maintain Reactor Coolant Pressure Boundary
- Provide Overpressure Protection for RCPB with Failure of Scram Function
- Provide Capability to Depressurize RPV for a LOCA
- Provide Instrumentation for RPV Pressure, RPV Water Level, MSIV Position, SRV & DPV Position, etc

Major Equipment

- MSIVs
- ADS Valves
  - 10 Dual function Direct-Acting SR Valves
  - 8 Depressurization Valves
- 8 other SR Valves Direct-Acting Valves
- Feedwater isolation Valves

Reactor Water Cleanup (RWCU)



RWCU/SDC Functions

SAFETY-RELATED

- CONTAINMENT ISOLATION – BOTH TRAINS ARE ISOLATED BY CLOSURE OF CONTAINMENT ISOLATION VALVES ON RECEIVING AN ISOLATION SIGNAL FROM LD&IS
- DIVERSE MEANS OF DETECTION OF SYSTEM BREAK OUTSIDE DRYWELL ACCOMPLISHED BY:
  - (1) DIFFERENTIAL FLOW MEAUREMENT BY THE FLOW ELEMENTS & TRANSMITTERS INSIDE AND OUTSIDE DRYWELL
  - (2) HIGH STEAM TUNNEL TEMPERATURE RESULTING FROM A BREAK IN AN RWCU/SDC SYSTEM COMPARTMENT

RWCU/SDC Functions

NON-SAFETY RELATED

- EXTERNAL HEATING OF THE REACTOR BEFORE HYDROSTATIC TEST AND STARTUP
- OVERBOARD EXCESS REACTOR WATER TO MAIN CONDENSER OR RADWASTE
- PROVIDE A CONNECTION TO REACTOR THAT CAN ACCEPT HIGH PRESSURE MAKEUP WATER FROM THE CRD SYSTEM (C12) TO CONTROL REACTOR WATER LEVEL (BY FW CONTROL SYSTEM)
- MAINTAIN THE TEMPERATURE DIFFERENCE BETWEEN THE REACTOR STEAM DOME AND THE BOTTOM HEAD DRAIN TO LESS THAN 80.6°C (145°F)
- MAINTAIN REACTOR WATER QUALITY WITHIN LIMITS
- TRANSFER REACTOR SENSIBLE HEAT AND CORE DECAY HEAT PRODUCED WHEN THE REACTOR IS IN THE SHUTDOWN CONDITION, TO THE RCCWS

RWCU/SDC Performance

PREVENT STRATIFICATION- PROVIDE SUFFICIENT FLOW, THROUGH THE BOTTOM DRAIN LINES DURING STARTUP OPERATION TO PREVENT THERMAL STRATIFICATION, BY MAINTAINING THE TEMPERATURE DIFFERENCE BETWEEN THE RPV STEAM DOME AND THE BOTTOM DRAIN LINE TO LESS THAN OR EQUAL TO 80.6°C (145°F).

EXTERNAL HEATING- MEET HEATUP FLOW REQUIREMENTS ASSUMING THE REACTOR TEMPERATURE RANGE IS FROM 15.6°C (60°F) TO 80°C (176°F) AND PRESSURE RANGE IS FROM ATMOSPHERIC DOWN TO 380 MM HGA (7.5 PSIA) WITHOUT CAVITATION IN ANY SECTION OF THE BOTTOM DRAIN PIPING LEADING TO THE RWCU/SDC PUMPS SUCTION.

CLEANUP- REDUNDANT CLEANUP CAPACITY SUCH THAT EACH TRAIN OF PUMP AND DEMINERALIZER PROCESSES 1% OF THE RATED FEEDWATER FLOW RATE TO ACHIEVE AND MAINTAIN THE REQUIRED REACTOR WATER QUALITY. WITH BOTH TRAINS IN OPERATION THE SYSTEM SHALL PROCESS 2% OF THE RATED REACTOR FEEDWATER FLOW.

RWCU/SDC Performance (continued)

NORMAL SHUTDOWN COOLING- IN CONJUNCTION WITH MAIN CONDENSER AND/OR THE ISOLATION CONDENSERS SHALL PROVIDE SUFFICIENT COOLING CAPACITY TO COOL THE REACTOR FROM RATED PRESSURE AND TEMPERATURE

- (A) TO 60°C (140°F) OR LESS IN 24 HOURS FROM CRD INSERTION
- (B) TO 54°C (130°F) OR LESS IN 40 HOURS FROM CRD INSERTION
- (C) TO 49°C (120°F) OR LESS IN 96 HOURS FROM CRD INSERTION

ABNORMAL SDC- IN CONJUNCTION WITH ICS SHALL COOL THE REACTOR FROM RATED PRESSURE AND TEMPERATURE TO COLD SHUTDOWN CONDITIONS (100°C (212°F)) OR LESS IN 36 HOURS ASSUMING SINGLE ACTIVE FAILURE & A LOPP WHEN THE SYSTEM ELECTRICAL COMPONENTS ARE AUTOMATICALLY CONNECTED TO THE STANDBY NON-CLASS 1E AC POWER SOURCE.

OVERBOARDING- PROVIDE THE CAPABILITY OF OVERBOARDING REACTOR WATER AND ACCEPT HIGH PRESSURE MAKEUP WATER FROM THE CRD SYSTEM (C12) TO CONTROL REACTOR WATER LEVEL (BY FWCS).

RWCU/SDC Modes of Operation

MODE 1- REACTOR EXTERNAL HEATING

- 1-1 INITIAL EXTERNAL HEATING
- 1-2 FINAL EXTERNAL HEATING
- 1-3 DEAERATION

MODE 2- REACTOR STARTUP

2-1 LOW PRESSURE STARTUP
2-2 INTERMEDIATE PRESSURE STARTUP
2-3 HIGH PRESSURE STARTUP

MODE 3- REACTOR WATER CLEANUP

3-1 CLEANUP- ONE TRAIN OPERATION – 1% FW FLOW
3-2 CLEANUP-TWO TRAIN OPERATION – 2% FW FLOW

MODE 4- SHUTDOWN COOLING

4-1 HIGH PRESSURE SDC- @ 0.5 HRS FROM CRD INSERTION
4-2 LOW PRESSURE SDC- @ 8 HRS FROM CRD INSERTION
4-3 LOW PRESSURE SDC- @ 24 HRS FROM CRD INSERTION
4-4 LOW PRESSURE SDC- @ 40 HRS FROM CRD INSERTION
4-5 INITIAL REFUELING SDC- @ 96 HRS FROM CRD INSERTION
4-6 END OF REFUELING SDC - @ 6 DAYS FROM CRD INSERTION
4-7 REACTOR WELL COOLING
4-8 REACTOR BOLTUP

Component Materials

- MSIVs – Carbon Steel
- SRVs & DPVs
  - SRV body; Carbon Steel
  - DPV Body; Stainless Steel
  - Disk; Nickel Alloy Stainless Steel
  - Spring; Low Alloy Steel
- Main steam Piping – Carbon Steel
- Reactor Vessel – Low Alloy Steel
- Isolation Condenser Piping – Steam Lines; Carbon Steel
  - Condensate Lines; Stainless Steel
- Feedwater Piping – Low Alloy Steel