AP1000

AP1000 Regulatory Overview

Andrea Sterdis

Westinghouse

AP1000 Licensing


The United States Nuclear Regulatory Commission
hereby certifies the

AP600 Standard Plant Design

as set forth in Appendix C of 10 CFR Part 52
Dated the 16th day of December, 1999

Director
Office of Nuclear Reactor Regulation

Chairman
U.S. Nuclear Regulatory Commission

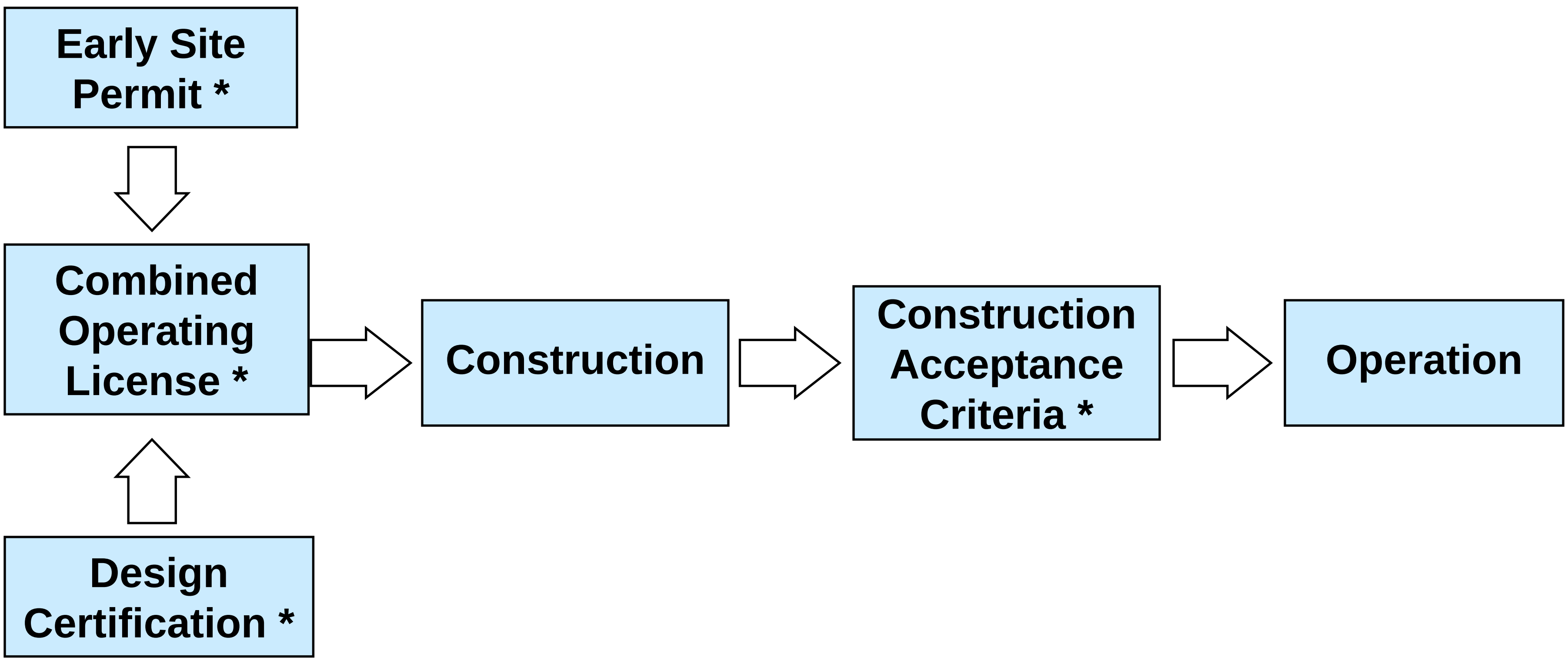
10 CFR 52

Revised Licensing Process

10 CFR 52 Process

- Revised Licensing Process from the Existing Part 50 2-Step Process
- Goals were to Provide Licensing Stability and Predictability
- Steps
  - Design Certification
  - Early Site Permit
  - Combined Operating License

Regulatory Process



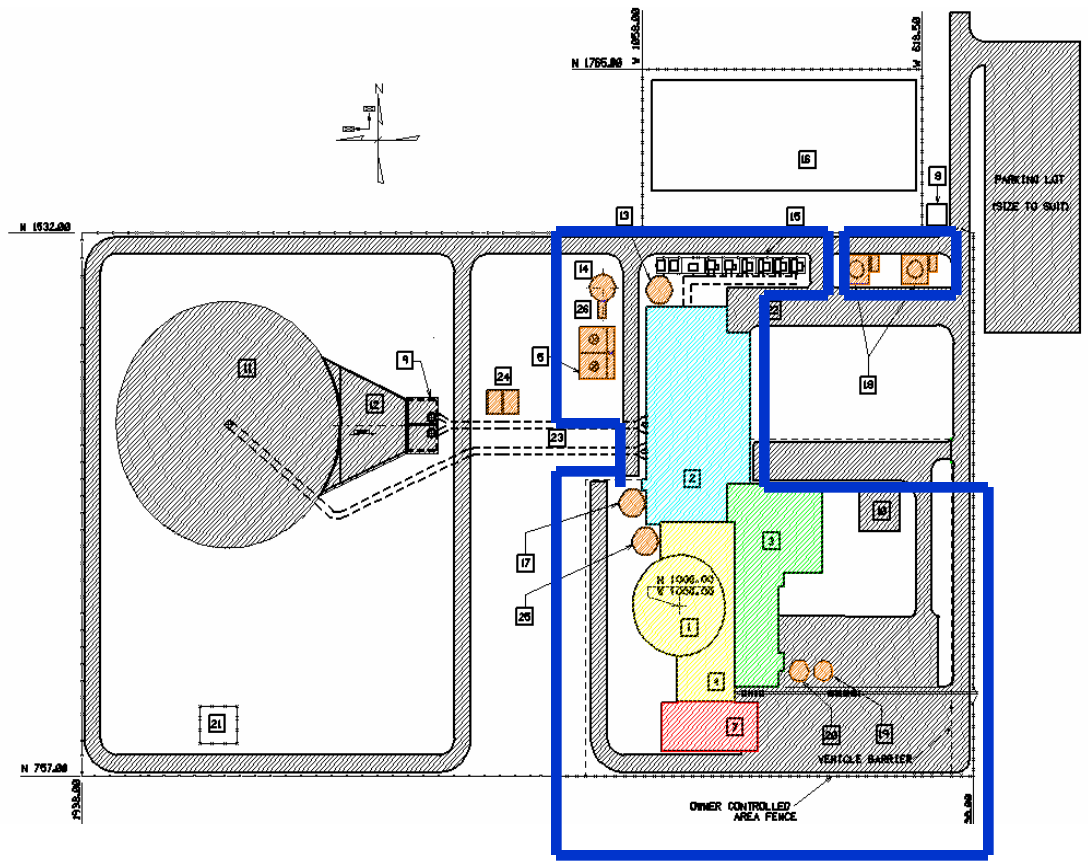
*** Public Comment Opportunity**

Design Certification

- Licensing Finality for Design Issues
- Results in Design Certification Rulemaking
- 4 Existing Certified Designs
  - ABWR
  - System 80+
  - AP600
  - AP1000

Design Certification

- Goal of Design Certification was to Achieve Licensing Basis Closure for Design Aspects
- Scope not limited to NSSS
- Licensing Issue Closure for Scope of Design Certification



Design Certification

Certified Design Documented in the Design Control Document

- Tier 1
  - Design-Related Information in the DCD approved and Certified by the NRC
  - Definitions and General Provisions
  - Design Descriptions
  - ITAAC
  - Significant Site Parameters
  - Significant Interface Requirements
  - Changes result in exemption to certified design rule

Design Certification

– **Tier 2**

- **Design-Related Information in the DCD approved and but not certified by the NRC**
- **Information required by 10 CFR 52.47**
- **FSAR as required by 10 CFR 50.34**
- **Supporting information for ITAAC**
- **COL Information Items**
- **Change mechanism similar to 50.59 process, documented in Section VIII of the rule**

AP600 Scrutinized By U.S. NRC for Over 7 Years

- June 1992 -Safety Analysis Report and PSA submitted.
- September 1998 - NRC issues the Final Design Approval.
- December 1999 - NRC issues Final Design Certification.
- Design Certification effective for 15 years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AP600/AP1000 Licensing Maturity

- Very thorough / complete NRC review of AP600
  - 110 man-year effort (NRC) over 7 years, $30 million, FDA in 9/98
  - Independent, confirmatory plant analysis and plant/systems testing
  - 7400+ questions answered, 380+ mtg with NRC, 43 mtg with ACRS
- NRC safety review of AP1000 is complete
  - Pre-licensing review established areas needing detailed safety review
  - Licensing information (DCD, PRA) submitted to NRC 3/02
  - NRC Final Design Approval issued on 9/13/04
  - Design Certification Rulemaking issued on 12/30/05

Phased Approach to AP1000 Licensing

- Phase 1
  - Establish goals and estimate for Prelicensing Review
  - Westinghouse prepare submittals to support goals
- Phase 2
  - NRC perform Prelicensing Review
  - NRC estimate Cost and Schedule for AP1000 Design Certification
  - Westinghouse develop Safety Analysis Report
- Phase 3
  - NRC perform Design Certification Review

AP1000 Design Certification Application

- Submitted DCD and PRA March 28, 2002
  - AP1000 Design Control Document (DCD) – 7000 pages
    - Tier 1 Information
      - Inspections, Tests, Analysis and Acceptance Criteria (ITAAC)
    - Tier 2 - Information
      - Standard Safety Analysis Report
      - Technical Specifications
      - PRA Insights
  - AP1000 PRA Report submitted – 4500 pages
    - Detailed Level 1, 2, 3 including shutdown, fires, floods
    - Addresses severe accident phenomenum

Most Thorough NRC Review

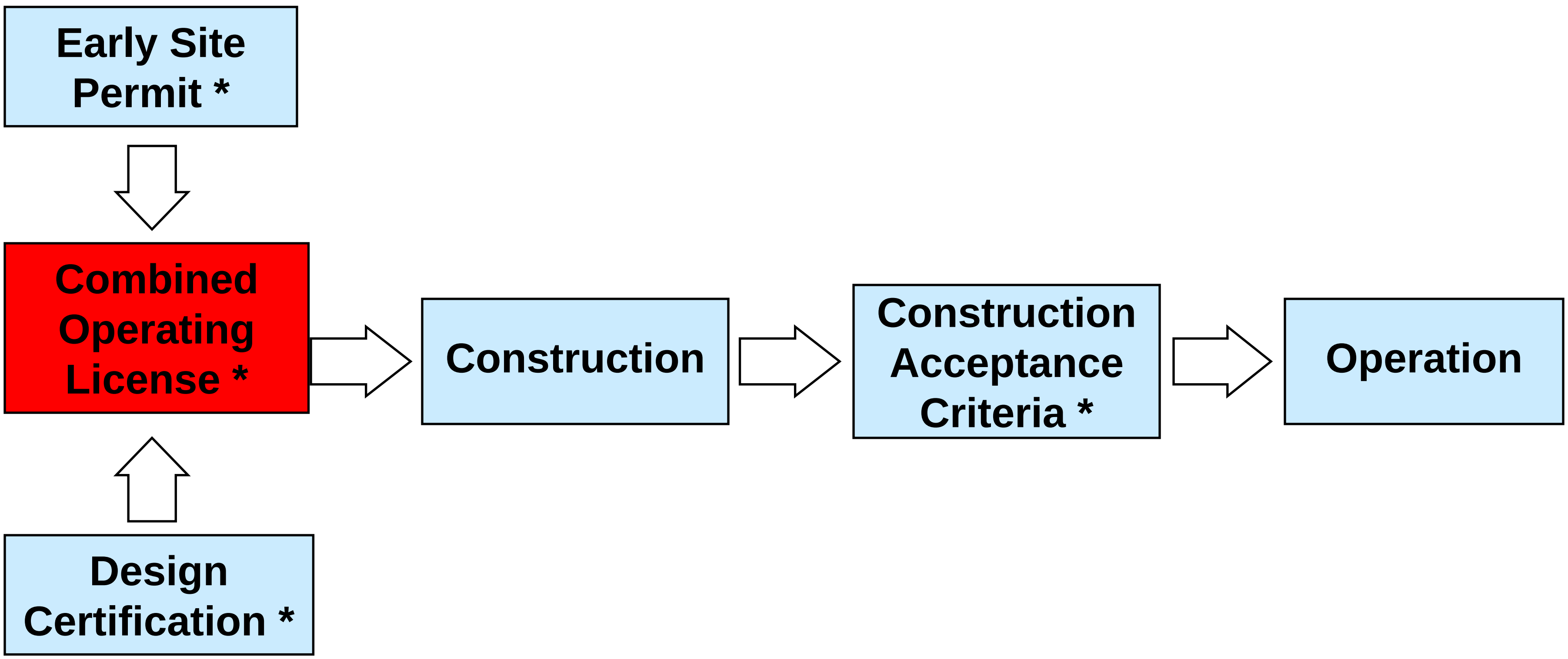
U.S. NRC Review of AP600 and AP1000		
	AP1000	**AP600**
Level of review	Final Design Approval	Final Design Approval
Material submitted for review[1] • Safety Analysis Report • Probabilistic Risk Assessment Report	 ~ 6500 pages[2] ~ 4500 pages	 ~ 6500 pages[2] ~ 4500 pages
Dates of review	2 1/2 years (3/02 – 9/04)	6+ years (6/92 – 9/98)
U.S. NRC review effort • Formal written questions • U.S. NRC meetings • ACRS meetings • U.S. NRC independent safety analysis • U.S. NRC independent tests	31 man-years 820 23 20 yes $1.2 million	110 man-years 7400 380 43 yes $5.4 million
U.S. NRC Safety Evaluation Report	NUREG-1793, 9/04 (~2400 pages)	NUREG-1512, 9/98 (~2700 pages)

Notes:

1. This only considers the information submitted initially for review. This does not include reports and answers to questions.
2. The SARs are consistent with U.S. NRC Regulatory Guide 1.70 plus a Chapter 18 on human factors and a Chapter 19, which summarizes the PRA.

AP1000 Design Certification Was Granted By NRC 12/30/05

Regulatory Process



* Public Comment Opportunity

COL Application Process

- Submittal of Application for COL referencing a Certified Design
- Address COL Information Items
- Address NRC FSER COL Action Items
- Environmental Report
- Emergency Plan
- Other License Requirements Per 10 CFR 50 and 52

NuStart Overview

- Established March 2004
- Cooperative Agreement with DOE under Nuclear Power 2010 Program
- Objectives
  - Demonstrate Part 52 Licensing Process
  - Complete first of a kind engineering for AP1000 and ESBWR
- NuStart Site Selection Decided
  - AP1000 Bellefonte (TVA)
  - ESBWR Grand Gulf (ENTERGY)

NuStart Milestones

• NuStart formed	March 2004
• Select sites	Sept 2005
• Submit COL applications	3Q07/1Q08
• Receive COLs	2010/2011
• Potential Construction	2011
• Plant Operation	2015

NuStart Activities

– NuStart is Developing a COL Application for 2 AP1000 units on the Bellefonte Site

– Target Date for Application Submittal is October 2007

– Intention is for Standard Sections to be Referenced by other AP1000 COL applicants

– Certified Design will be Referenced

– Pre-Application Activities Include Generation and Submittal of Technical Reports to Close/Address COL Information Items

Westinghouse Pre-Application Activities

- Technical Report generation
  - **Standard Design COL Information Items**
  - **Design ITAAC areas**
    - **Piping**
    - **I&C (PMS Design)**
    - **Main Control Room/Human Factors Engineering**
  - **Limited number of design changes**

COL Information Items

- Identified in DCD (Tier 2)
- 166 COL Information Items
- 75 that are Standard Design (Westinghouse Responsibility)
- 16 where Westinghouse Provides Technical Input to Others (Enercon or Applicants)
- 54 Number of Site-Specific/Applicant Specific (COL Application Preparer Responsibility)
  - 12 are merely confirming site within AP1000 interface boundaries
- 21 Number of Standard Programmatic/Administrative (Enercon Responsibility)

COL Application Preparation

- Standard Design Inputs (NuStart--Westinghouse)
  - Scheduled for Completion by July 2007*
- Standard Programmatic/Administrative Inputs (NuStart--Enercon)
  - Scheduled for Completion by July 2007*
- Site Specific Inputs (Remainder)
  - Bellefonte Scheduled for Completion by July 2007*
  - Established Format, Content, Level of Detail, Philosophy

*Final COL Application Review July-October 2007

Submittal of Bellefonte COLA October 2007

COL Preparation Schedule

- Site-Specific Activities
  - Site Work
  - Chapter 2 Site Specific Activities
  - Meteorological Data
  - Circulating Water System Design
  - Switchyard Design

Standard Design COL Information Items

- 59 Number of Technical Reports Planned/Scheduled to address Westinghouse COL Information Items
  - 51 number directly submitted to NRC
  - 8 number submitted to Enercon and other COL preparers for their use
  - Additional TRs could be developed
- Current Status
  - 32 TR Submitted addressing COL Information Items
  - 2 “white papers” submitted
    - Reactor Design
    - Seismic

Design ITAAC

- Limited to Three Areas for AP1000
  - Piping
  - Protection and Monitoring System I&C
  - Main Control Room / Human Factors Engineering
- Not Required to be Completed Before COL
- Risk Management is Driving Early Completion
- Substantial Efforts Planned, Scheduled and Funded to Complete a Significant Amount of this Detailed Design Implementation Work

More than a Mere Demonstration

Design ITAAC

- Piping
  - Leak-before-break—Complete
  - Piping Calculations to Complete DAC are planned and scheduled
  - Efforts intended to be Sufficient for NRC to make a Reasonable Assurance Conclusion and Close DAC

Design ITAAC

- Protection and Safety Monitoring I&C
  - Design Certification included trips, ESF actuations and minimum inventory for dedicated indication and control
  - Design Certification included the certification of the 5 phase design and implementation process
    - Conceptual (project definition) phase
    - System definition phase
    - Hardware and software design and implementation
    - System integration and test phase
    - Installation phase (including final V&V)

Design ITAAC

- Main Control Room / Human Factors Engineering
  - Design Certification included the certification of the 5 Phase design and implementation process
    - Planning (Complete, NRC review of TR 72 underway)
    - Analysis
    - Design
    - V&V
    - Operation

Design Changes

- A Limited Number of Design Changes Identified
  - Bar is Very High
  - Changes resulting from Detailed Design Implementation Activities
  - Number that impact Design Control Document is even smaller
    - 14 Total with DCD Impacts
    - 2 that Impact Tier 1
      - Pressurizer change impacts a wall height on a Tier 1 Drawing
      - Seismic change impacts the shear wave velocity
    - 12 Impact Tier 2
    - As DCPs are considered, DCD impacts are Identified
    - Section VIII Criteria (50.59-like review performed)

Design Changes
Technical Report Plan

- 14 Technical Reports Planned
  - 7 Complete and Submitted
  - Remainder being Scheduled
    - Budget and Resource Driven
    - Coordinating with Design Review Schedule
  - Possibility for Additional TRs Exists

Standardization Matrix Results

- 16 Chapters Reviewed (all but Chapters 2, 16, and 17)
- Excluding Chapters 18 (Human Factors) and 19 (PRA)
  - 536 x.y.z sections
  - More than 50% of the sections have no change from the DCD (merely a cross-reference to the DCD Section)
  - Remaining impacted sections many are COL Item Chapter List Sections and Reference Sections
  - Chapter 18 will be addressed in a “white paper” strategy document
  - Chapter 19 not expected to change due to forthcoming PRA revision

NRC Interaction Strategy

- Prepare/Submit Technical Reports including DCD markups
- Gain NRC Approval—Safety Evaluations
- Submit Design Certification Revision Application (May 2006)
- Gain Generic/Standard Issue Finality for the Standard Design Issues
- Working with NuStart to Include non-Westinghouse Standard Sections

NRC COLA Reviews

– NRC Established Design-Centered Review Approach

– One Issue, One Review, One Position

– Encourages Standardization

– Many COL Information Items can be Addressed in a Standardized Way

– NRC has Indicated that Deviations will cost Additional COL Review Time

Licensing Plan Going Forward

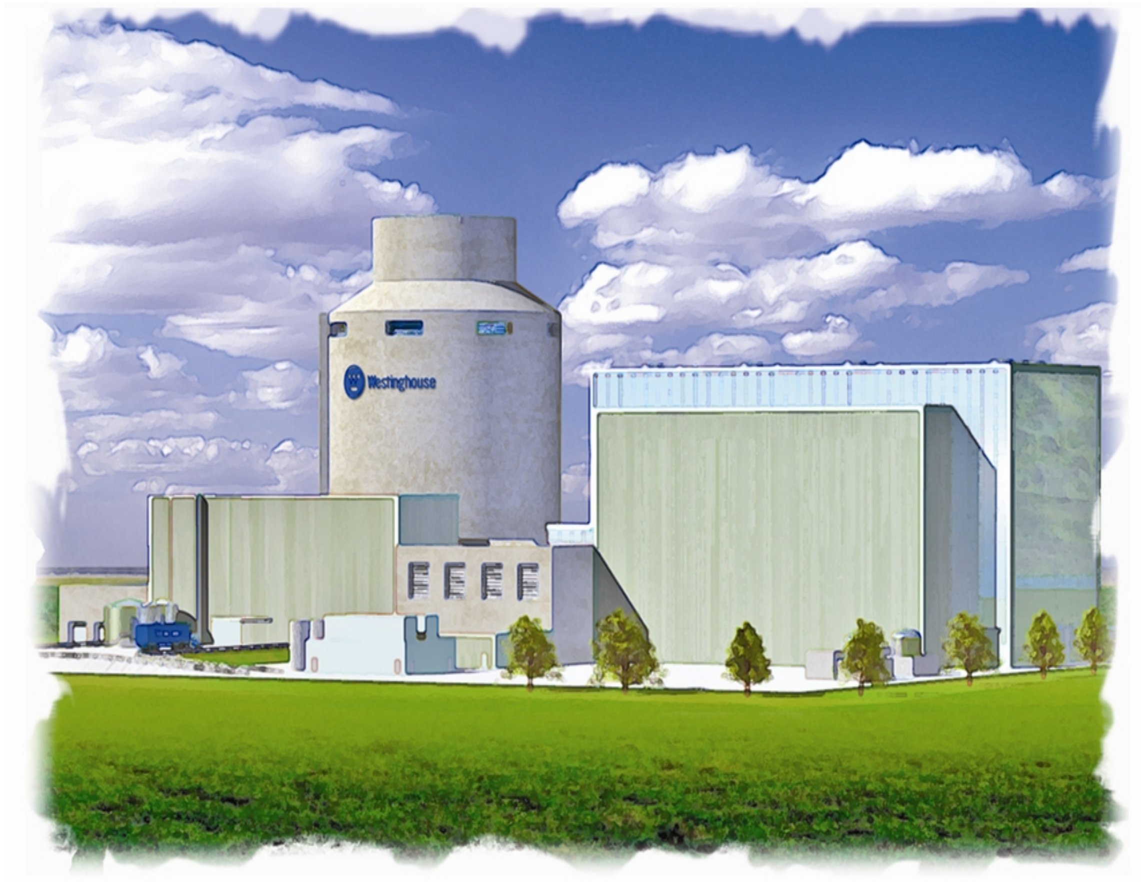
- Complete Planned Efforts
  - Most COL Items to be Addressed in TRs prior to May 2007
- Early NRC Interactions
  - Develop strategy papers to communicate plan to NRC
    - Seismic (complete)
    - Fuel (complete)
    - I&C (underway)
    - HFE (underway)
    - Technical Specifications (Planned with NuStart)
  - Drive frequent NRC interactions to gain closure
  - Establish agreement for sufficiency in DAC areas

Licensing Success Path

- Standardized Approach
- NRC Recognition of Issue Closure/Finality Established during Design Certification
- Industry Understanding of NRC needs for establishing Reasonable Assurance Conclusion
- Early Interaction and Resolution of Issues
- Standardization, Standardization, Standardization

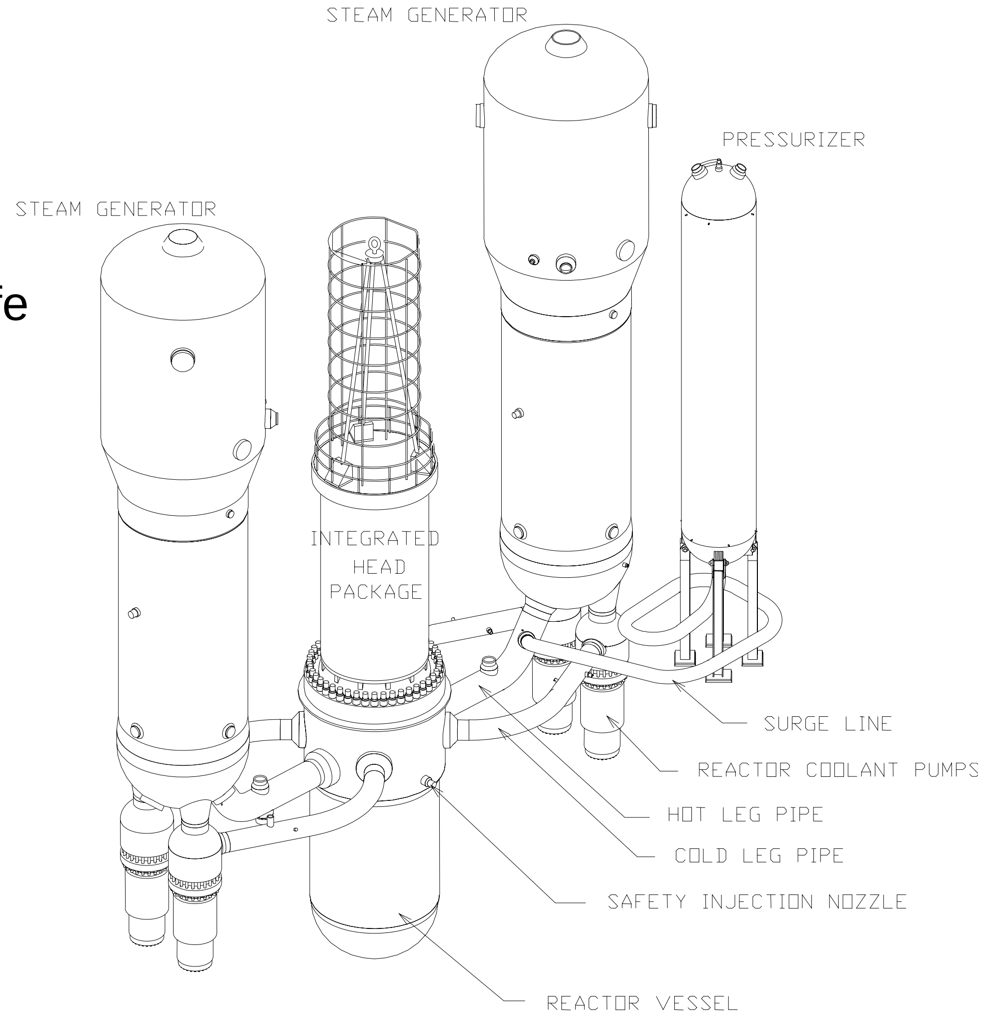
Passive Systems

Jim Winters



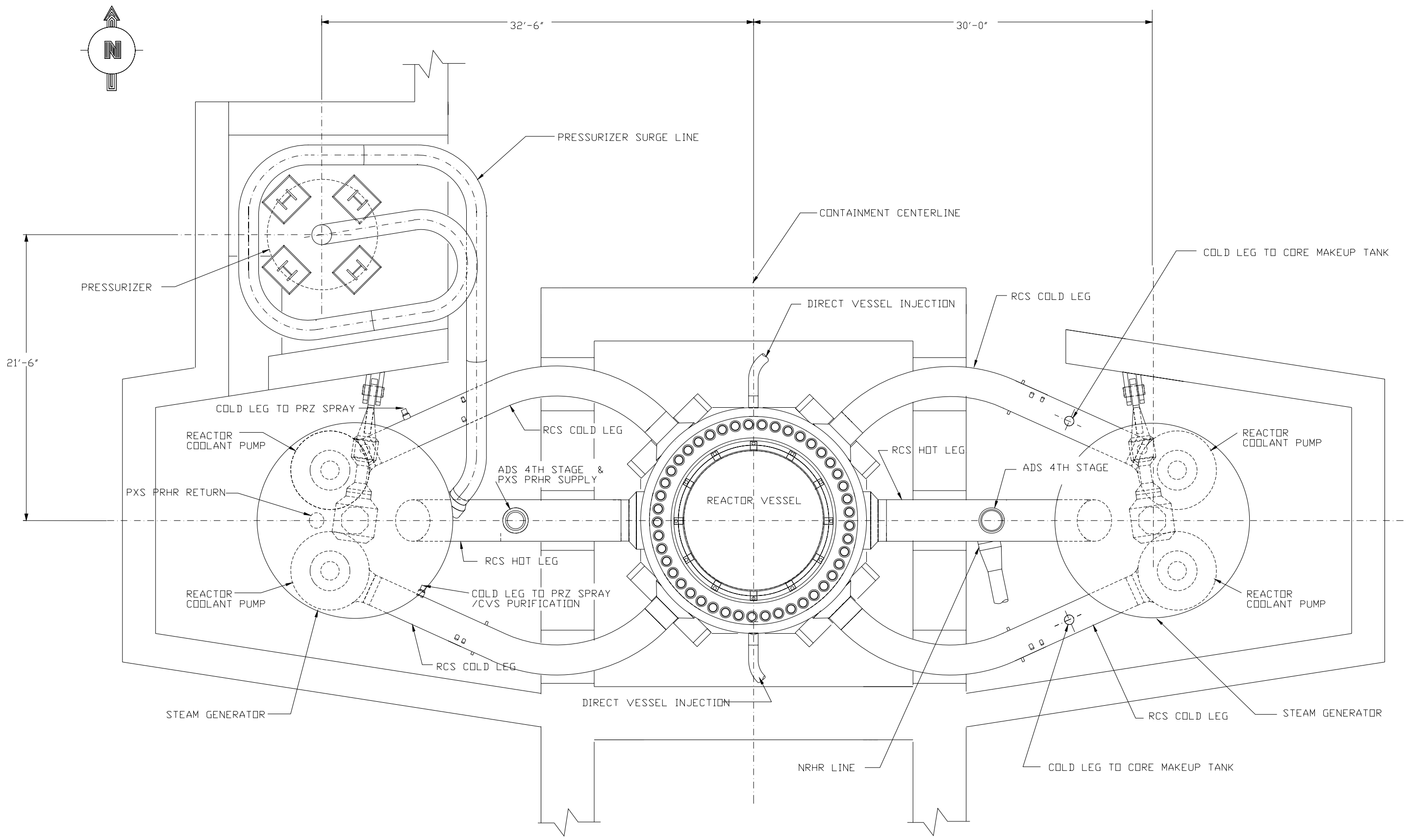
Reactor Coolant System

- **Reactor Vessel**
  - W 3XL Vessel
  - No bottom-mounted instrumentation
  - Improved materials - 60 yr life
- **Δ125 Steam Generators**
  - ANO RSG
- **Reactor Coolant Pump**
  - Canned motor pumps
    - Naval reactors; AP600; early commercial reactors
- **Simplified Main Loop**
  - Same as AP600
  - Reduced welds / supports



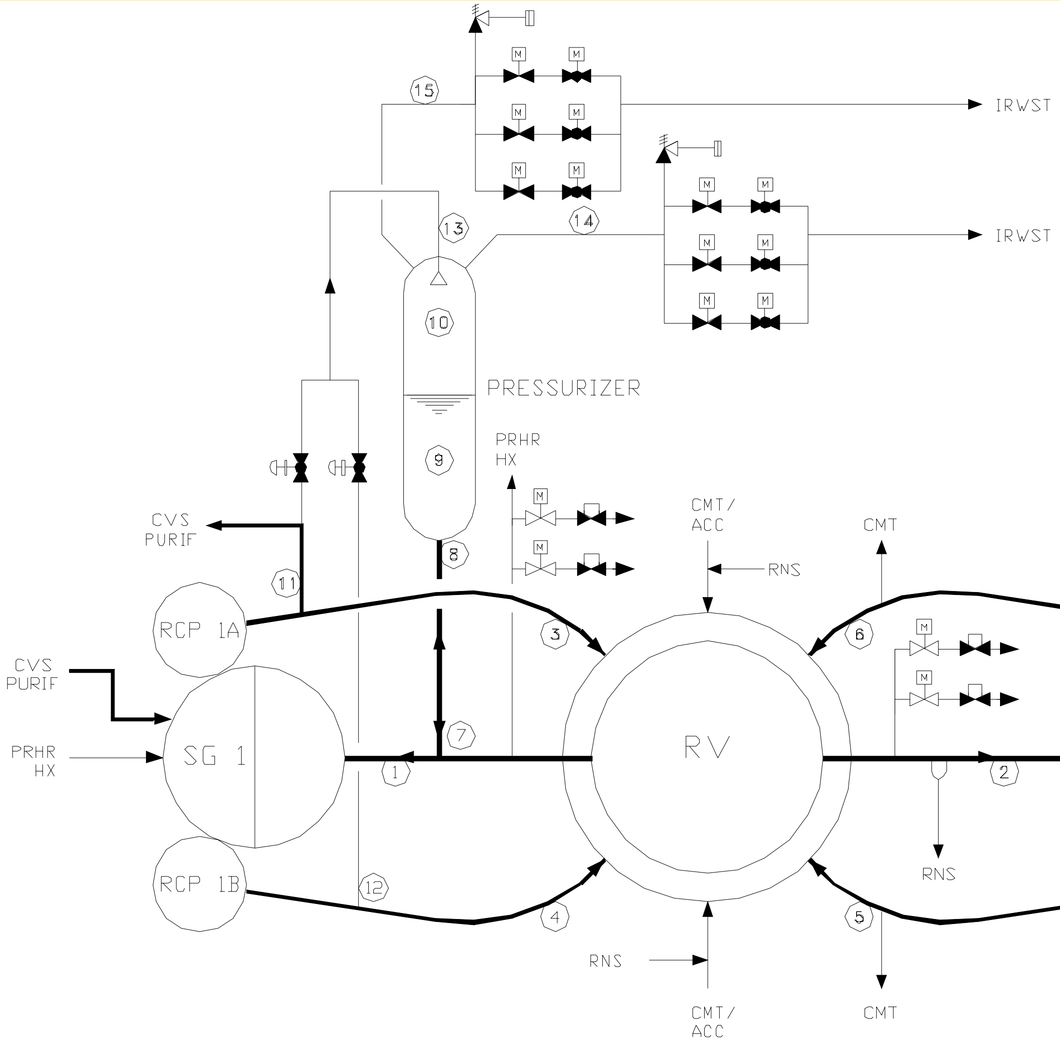
Reactor Coolant System Loop

Building Interface & Primary Shield Proven Based on Westinghouse 2-Loop Standard



• Hot Leg ID (31 in), Cold Leg ID (22 in), and Surge Line ID (18 in)

AP1000 Reactor Coolant System



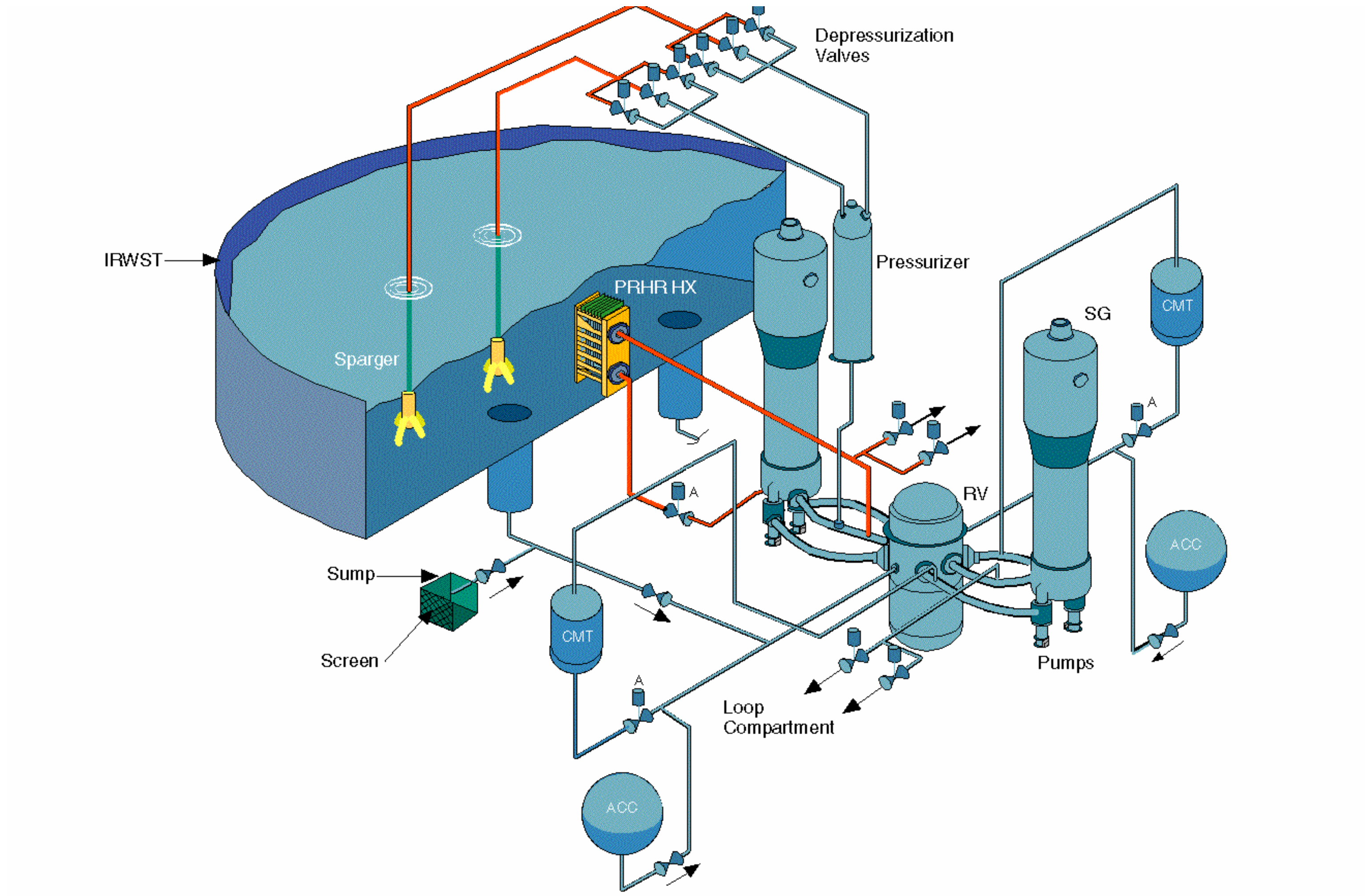
AP1000 Approach to Safety

- Passive Safety-Related Systems
  - Use "passive" process only, no active pumps, diesels, ….
    - One time alignment of valves
    - No support systems required after actuation
  - Reduced dependency on operator actions
  - Mitigate design basis accidents without nonsafety systems
  - Meet NRC safety goals without use of nonsafety systems
- Active Nonsafety-Related Systems
  - Reliably support normal operation
    - Redundant equipment powered by onsite diesels
  - Minimize challenges to passive safety systems
  - Not required to mitigate design basis accidents
  - Maintain low level of safety importance

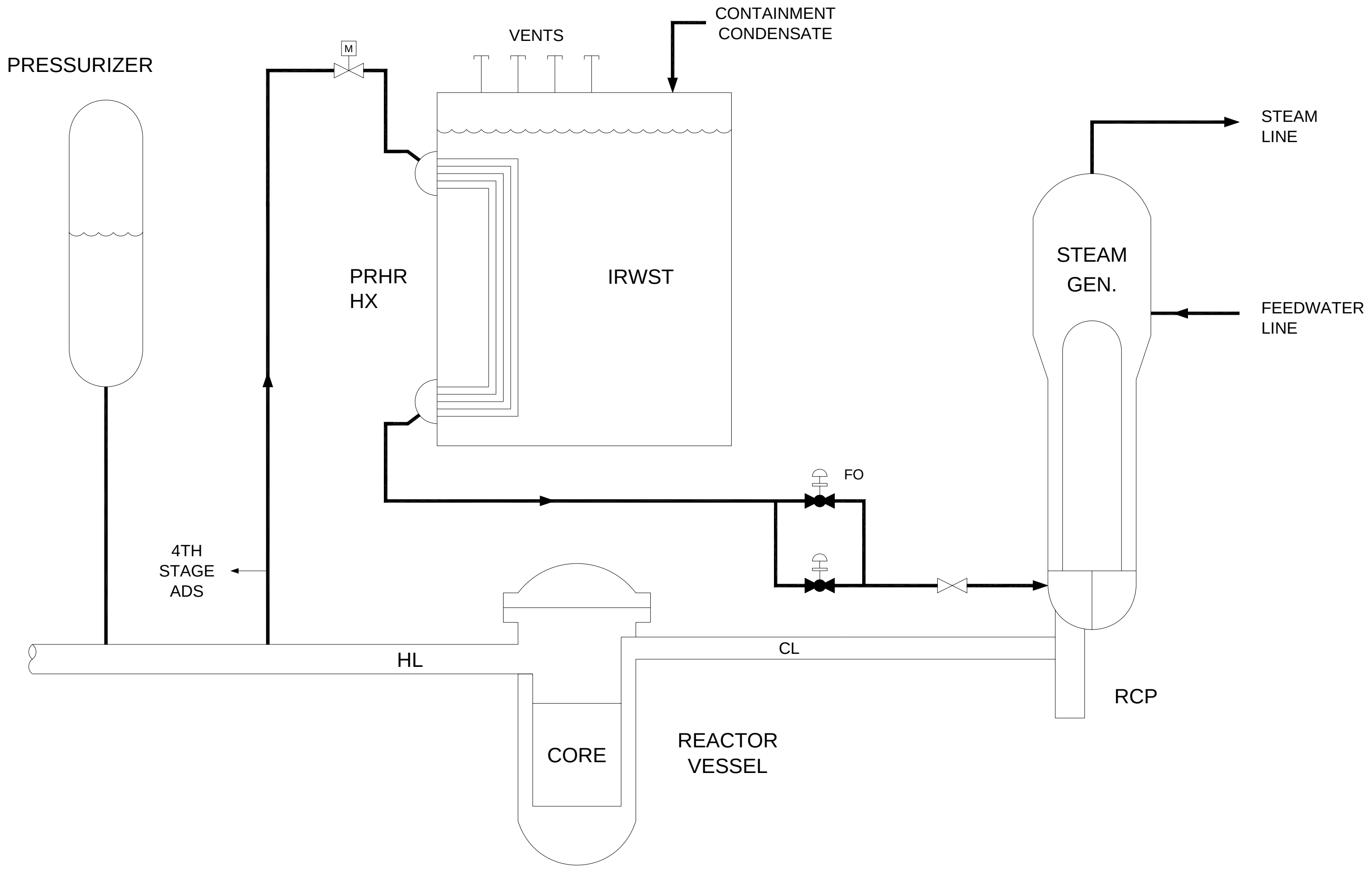
Passive Safety Features: Eliminate the Need for Safety AC Electric Power

- Passive Decay Heat Removal
  - Natural circulation heat exchanger connected to Reactor Coolant System (RCS)
- Passive Safety Injection
  - N_2 pressurized accumulators
  - Gravity drain core makeup tanks (RCS pressure)
  - Gravity drain refueling water storage tank (containment pressure)
  - Automatic RCS depressurization
- Passive Containment Cooling
  - Steel containment shell transfers heat to natural circulation of air and evaporation of water drained by gravity
- Passive Heating Ventilation Air Conditioning
  - Compressed air for habitability of main control room (MCR)
  - Concrete walls for heat sink (MCR and I&C rooms)

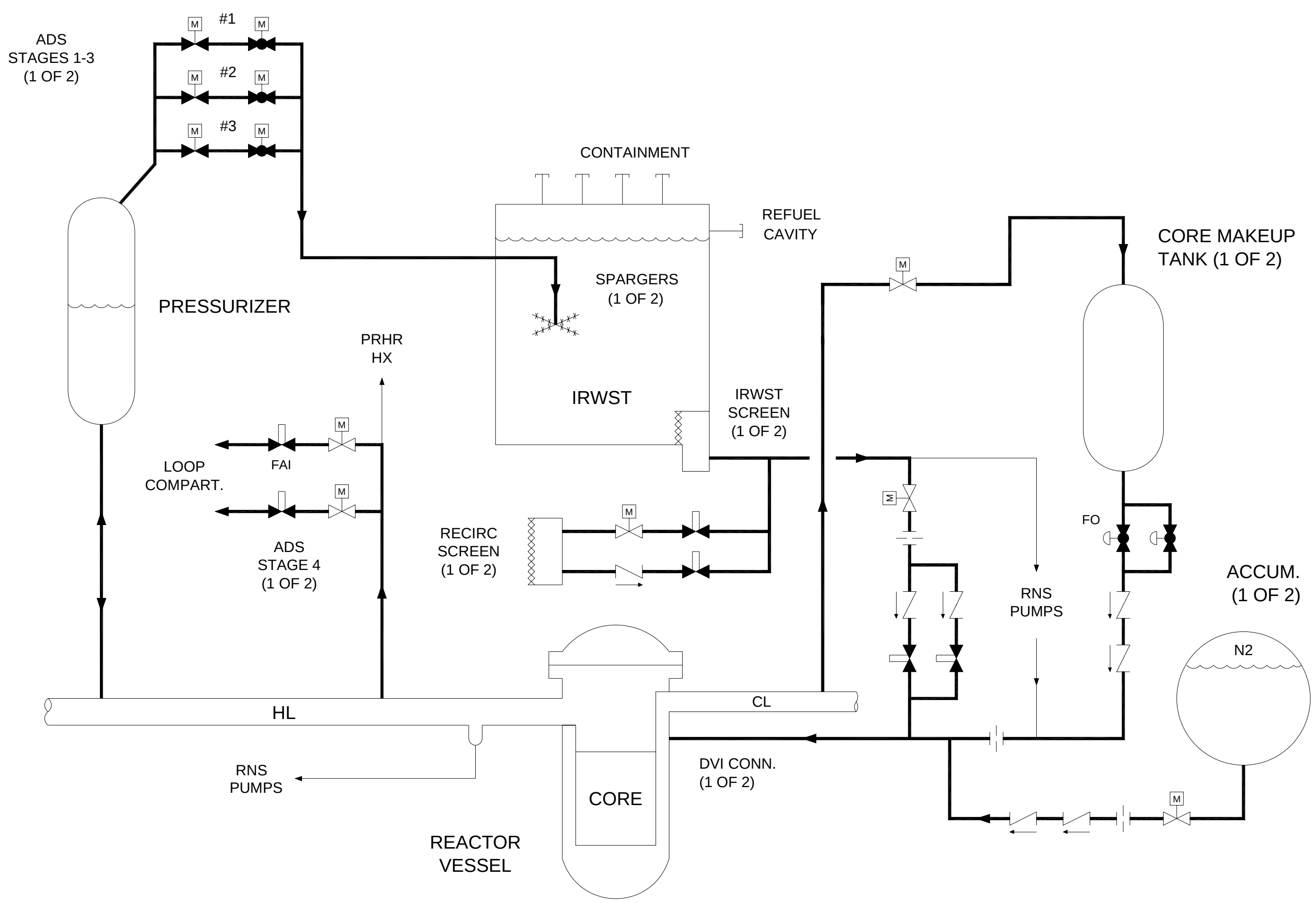
Passive Core Cooling



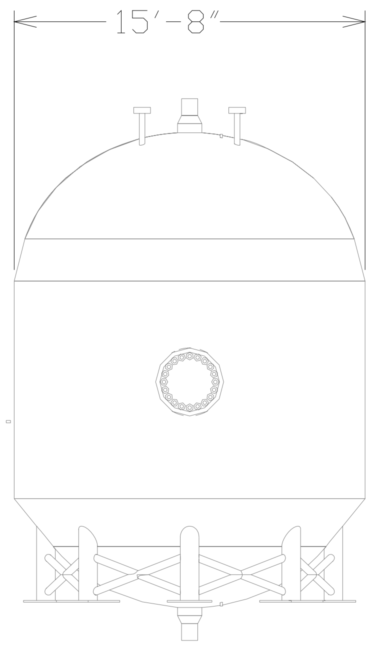
Passive Decay Heat Removal



Passive Safety Injection

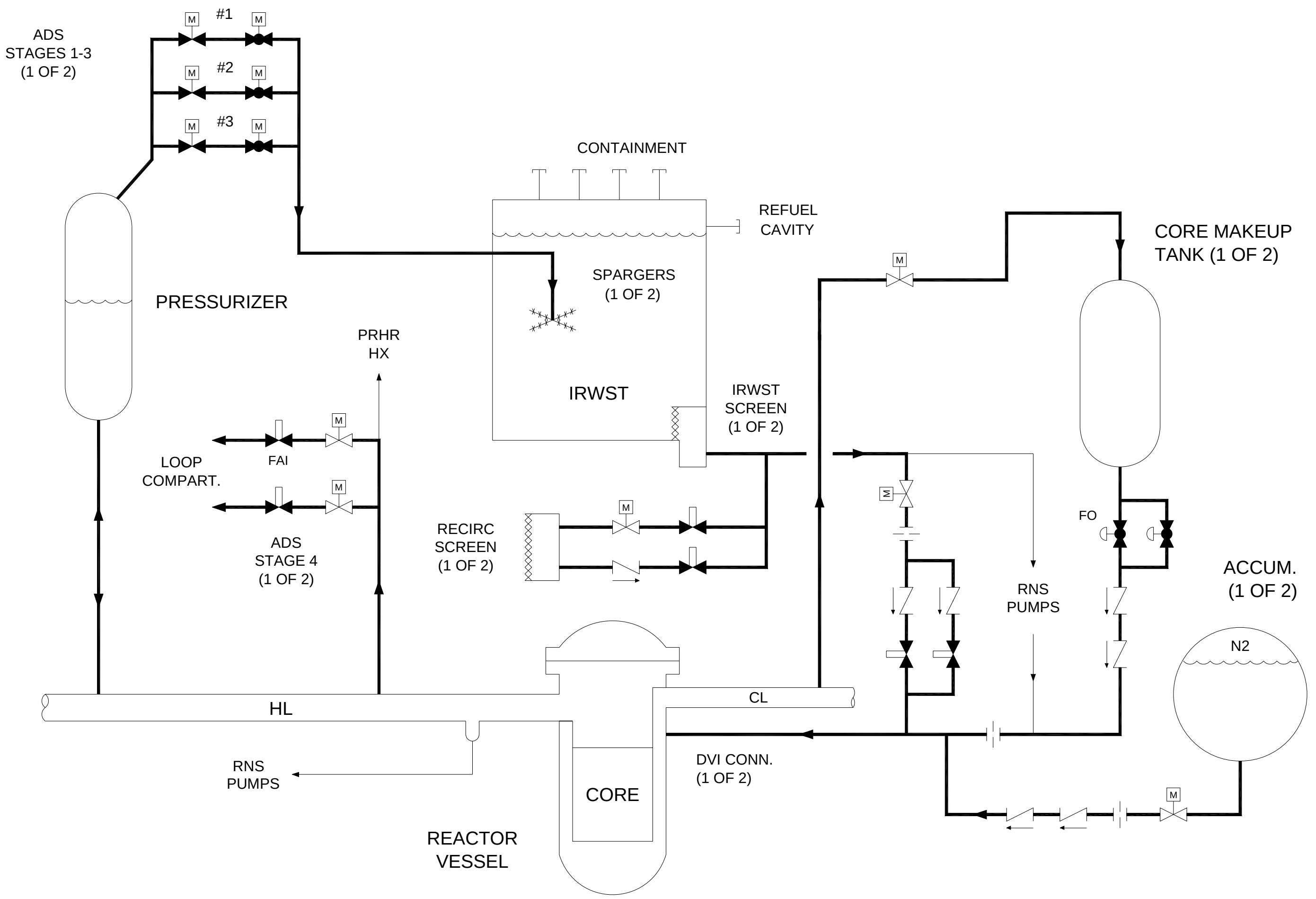


AP1000 Core Makeup Tanks

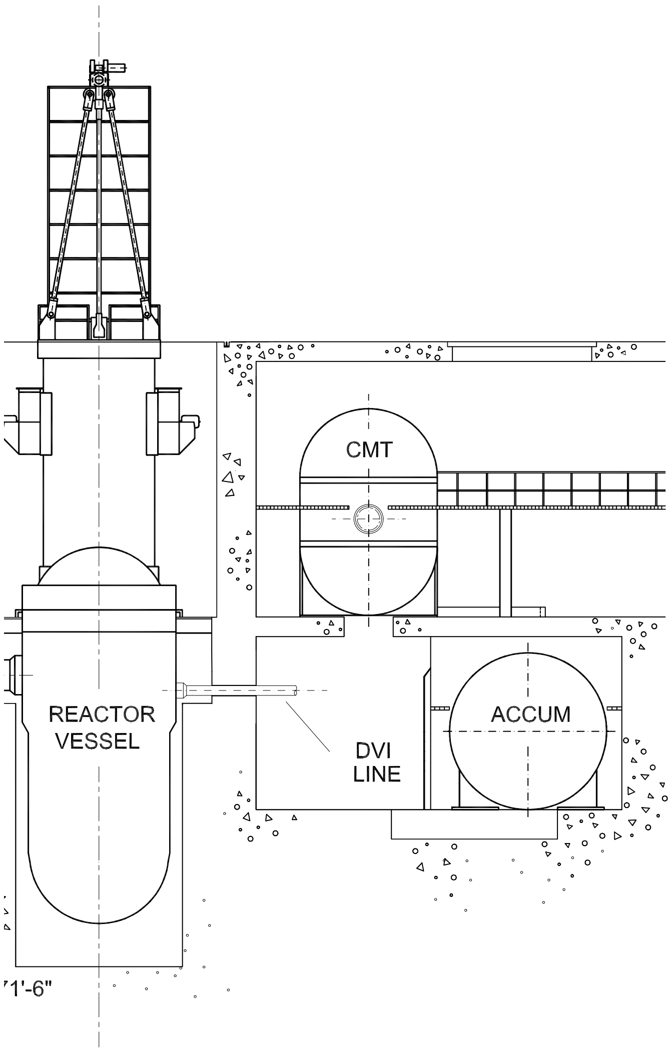


- Volume is 2500 ft3 (AP600 2000 ft3)
- Flow control orifice with same pipe size
    - Maintains duration of CMT injection same as AP600
    - Maintains time available for ADS to depressurize RCS to IRWST cut-in
- AP1000 CMT Has Sufficient Capability to Mitigate Small LOCA's
    – No core uncovery for DBA Sm LOCA
        - ≤ DVI LOCA
    – Required for PRA success criteria, multiple failure accidents w/o accum

Passive Safety Injection



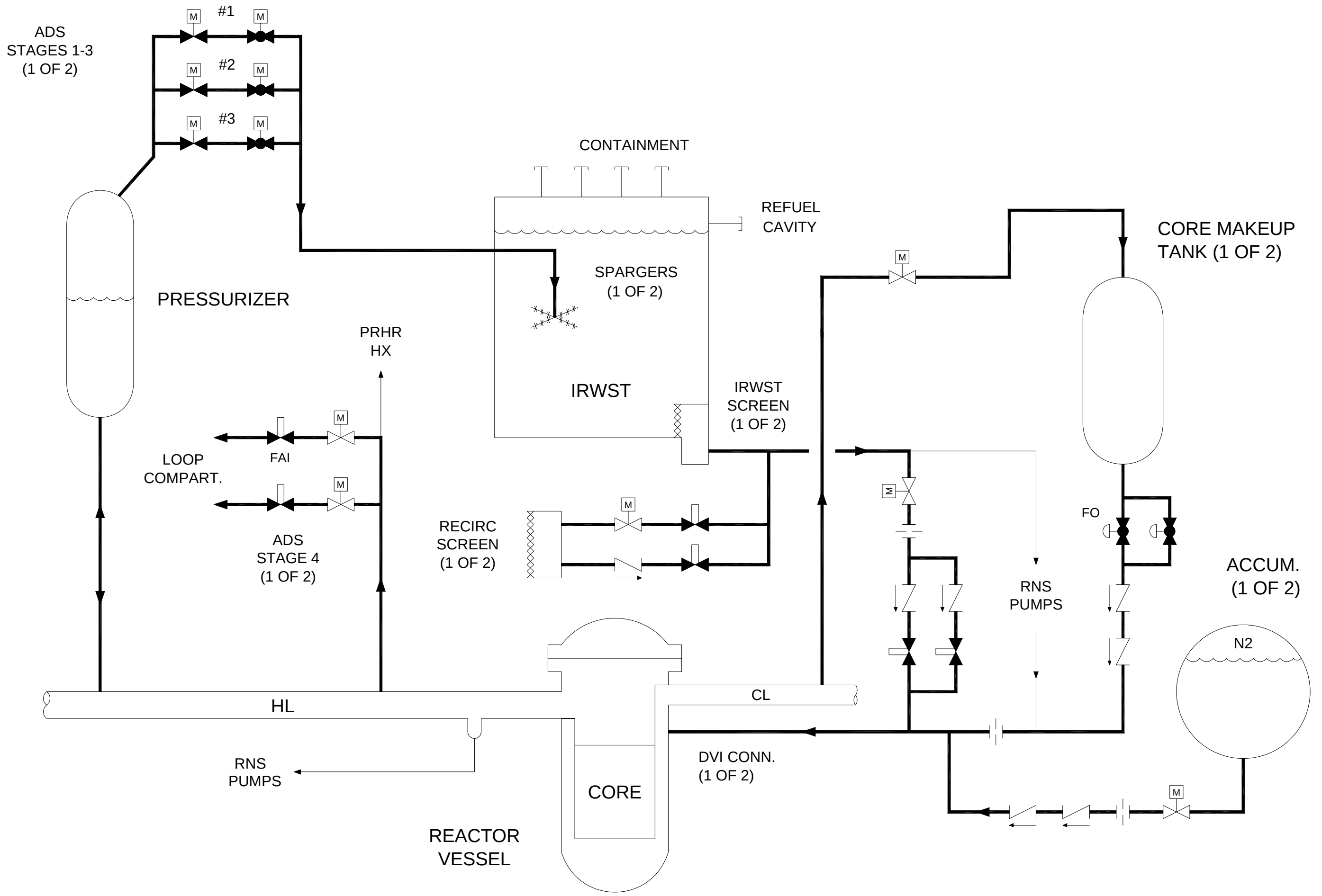
AP1000 Accumulator



Controlling accident is Large LOCA

- ~ 2120 F PCT for DBA Lg LOCA
- For PRA, success criteria requires 2 of 2 accum (same as DBA) for large RCS pipe breaks

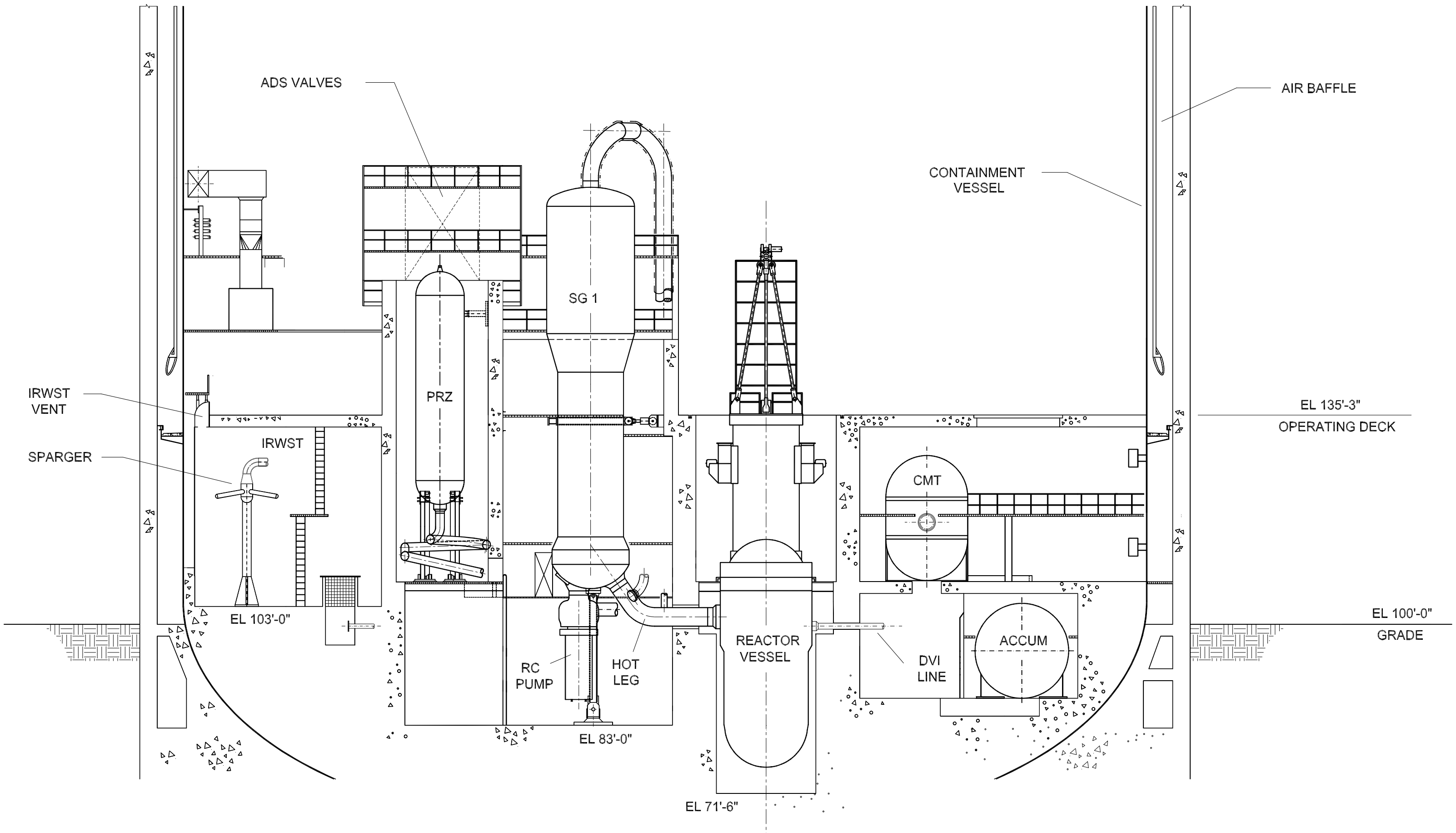
AP1000 Passive Safety Injection



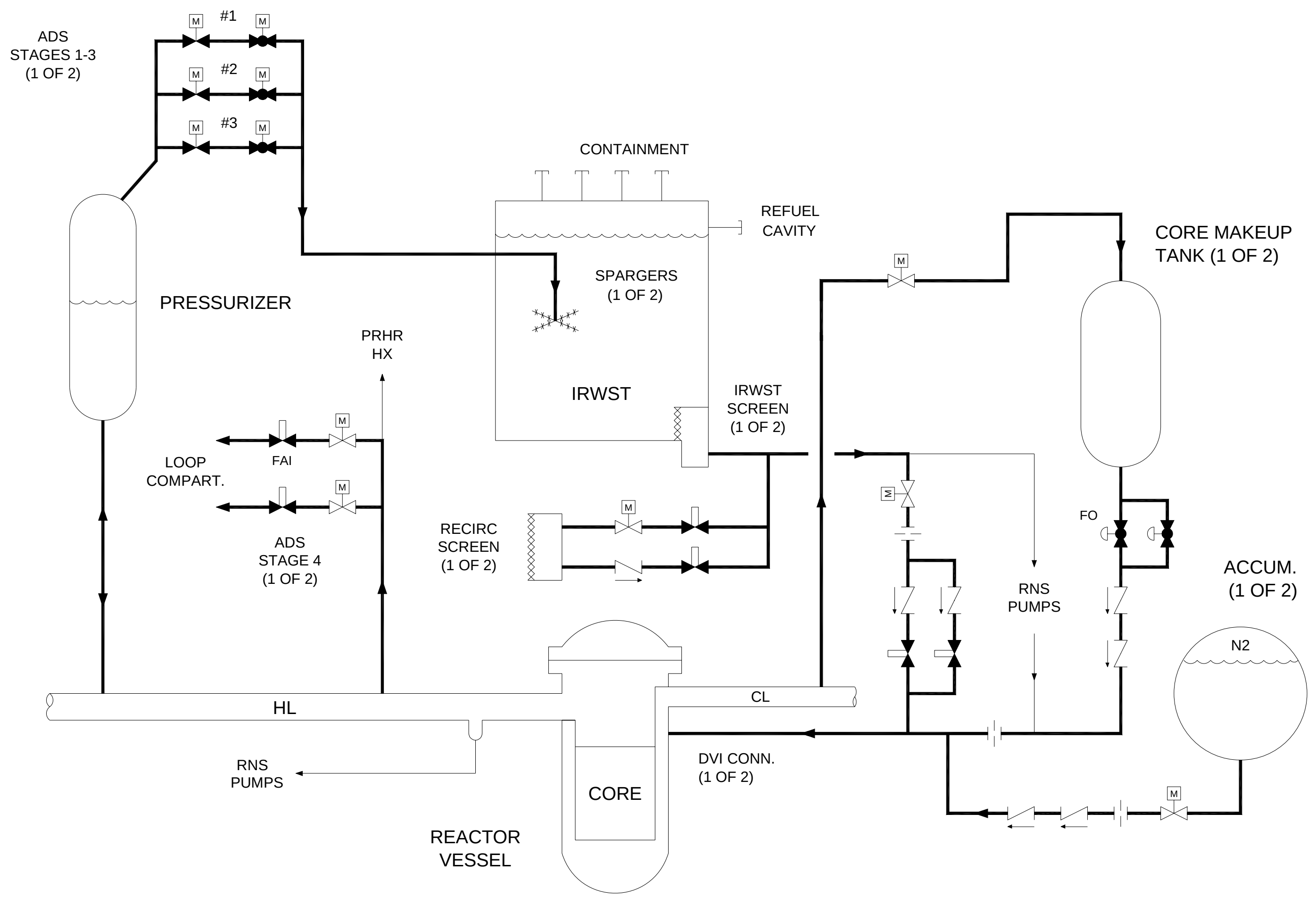
Automatic Depressurization System (ADS)

- ADS Stages 1,2,3 Not Changed
  - Not important for final RCS depressurization to IRWST Injection and Containment Recirc
  - Maintains ADS 1,2,3 piping layout / design, sparger design and IRWST T&H loads
- ADS Stage 4 Increased
  - Very important for final RCS depressurization to IRWST / Cont Recirc
  - ADS 4 valves / pipe increased to 14" (AP600 10")
    - Common pipe increased to 18" (AP600 12")
  - Critical flow area increases 76%
  - Subcritical flow increases 93%

Equipment Layout



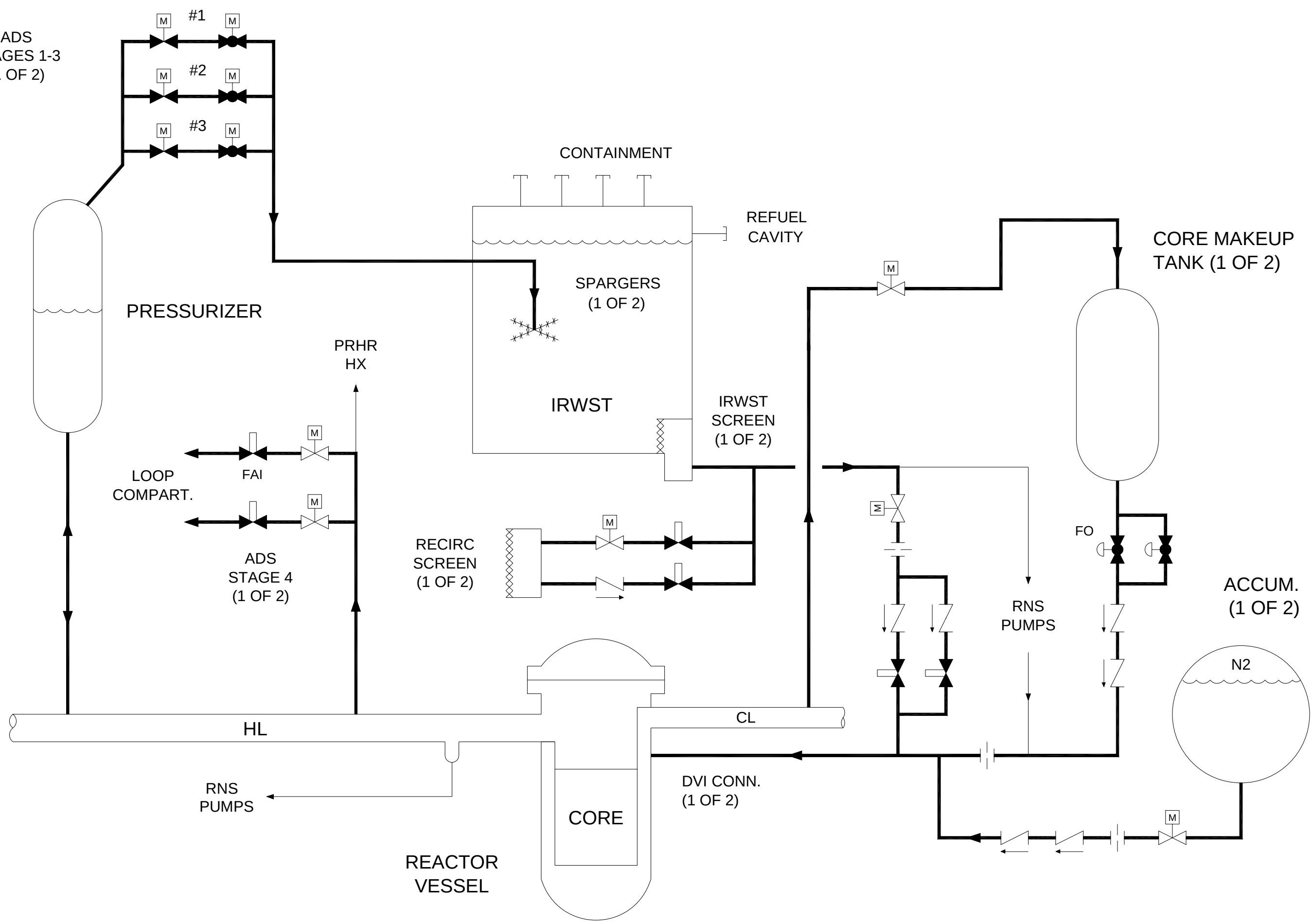
Passive Safety Injection



AP1000 IRWST Injection

- AP1000 IRWST Injection Capacity Increased
  - Pipe and valves increased to 8/10” (AP600 6/8”)
    - Eliminated flow tuning balancing orifices
      - Simplifies piping, helps apply larger piping size
      - System can tolerate flow variation without orifice
  - Initial water level increased
    - Added narrow range level sensors to reduce error
  - Flow capacity increased 89%

Passive Safety Injection

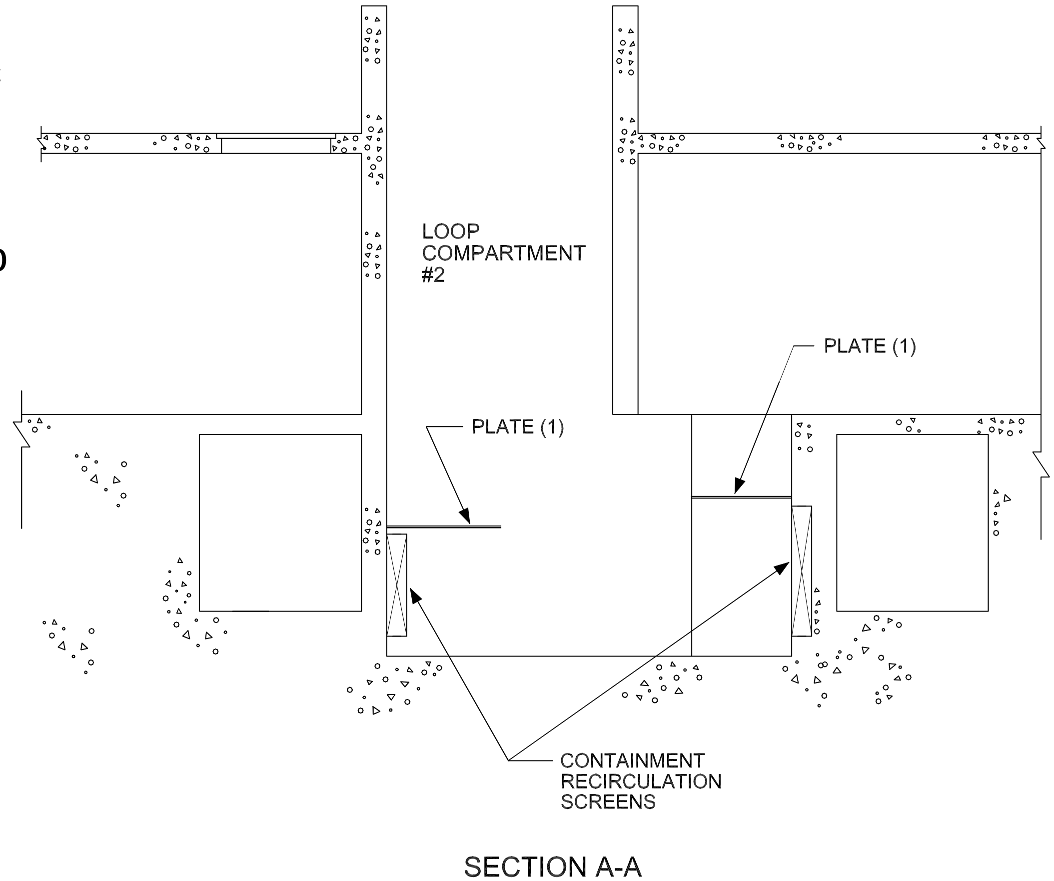


AP1000 Containment Recirculation

- AP1000 Cont. Recirc. Capacity Increased
  - Pipe and valves increased to 8” (AP600 6/8”)
  - Containment post ADS water elevation increased
    - DVI LOCA min flood elevation is 108.05’ (AP600 106.2’)
      - PXS curbs raised to 110.17’ (AP600 108.17’)
    - Initial IRWST level increased
    - Initial flooding of refueling cavity prevented
      - Check valves added to drain line
    - RNS suction from outside containment
      - Injection suction from Spent Fuel cask loading pit
      - Prevents RNS operation from reducing time for recirc start
        - By pumping down IRWST during DVI LOCA
  - Flow capacity increased 139%

Plates Protect Recirc Screens

- Horizontal Plates
  - Located just above both recirc screens
  - Prevents debris from
    - Getting into water close to screens
    - Being transported to screens
  - Debris of concern is failed coatings
    - Relatively heavy
    - Reasonable settling rates
  - Settling is helped by
    - Low recirc flows
    - Deep flood levels
    - Long delays to start recirc



NOTE 1 - MINIMUM PLATE SIZE AND ELEVATION LIMITS ARE DEFINED IN SUBSECTION 6.3.2.2.7.1.

Containment Recirculation Screens

- **No Fibrous Debris Generated by LOCA**
  - Fibrous debris could create safety challenge
    - Transported to screens, forms mat and filters out smaller particles (crud, dirt)
    - Increases differential pressure, could challenge core cooling
  - Avoided in AP1000; all insulation in LOCA jet zone is reflective metal
- **Enhanced Debris Settling**
  - Deep floodup levels with low flows / velocities
  - Long delay to initiation of recirculation
- **Protective Plates Above Screens**
  - Prevents particles (coating debris) from being transported to screens
- **Coatings Inside Containment**
  - Non-safety related - if detach, will settle before reaching screens
  - Reduced use of coatings inside containment (stairs, cabinets, etc)

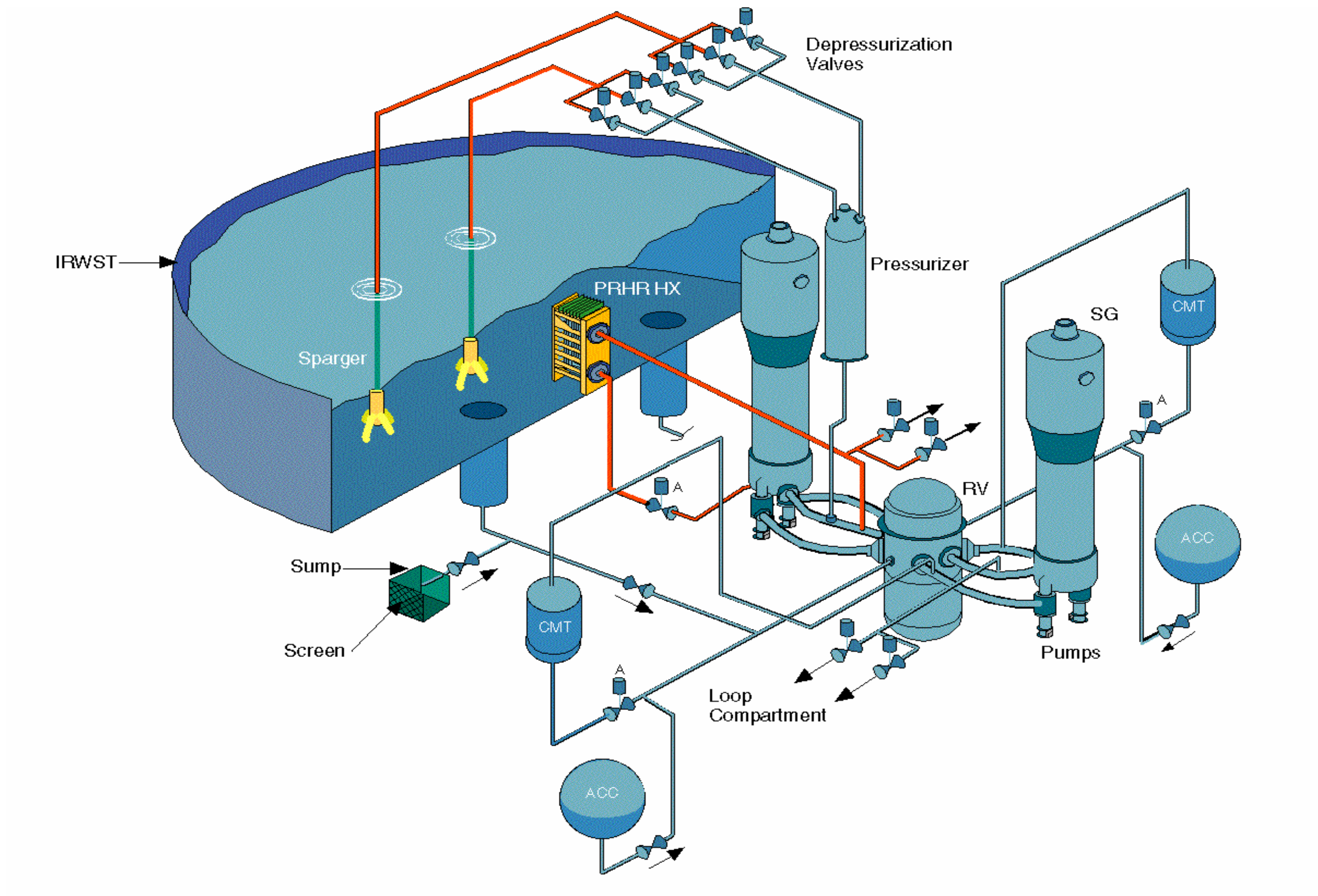
AP1000 Containment Recirc

- PRA Based Changes
  - Recirc MOVs made normally open
    - Improves opening reliability
      - Fewer valves need to open
      - Squibs more reliable than MOVs
  - Containment Recirc squib diversity
    - AP1000 applies diversity between Cont Recirc paths
      - Recirc paths with MOVs use low pres squib (150 psig)
      - Recirc paths with check valves use high pres squib (2500 psig)
        - Same squib valve used in IRWST injection lines
      - Improves reliability of Cont. Recirc. and drain for IVR support

AP1000 Post Accident pH

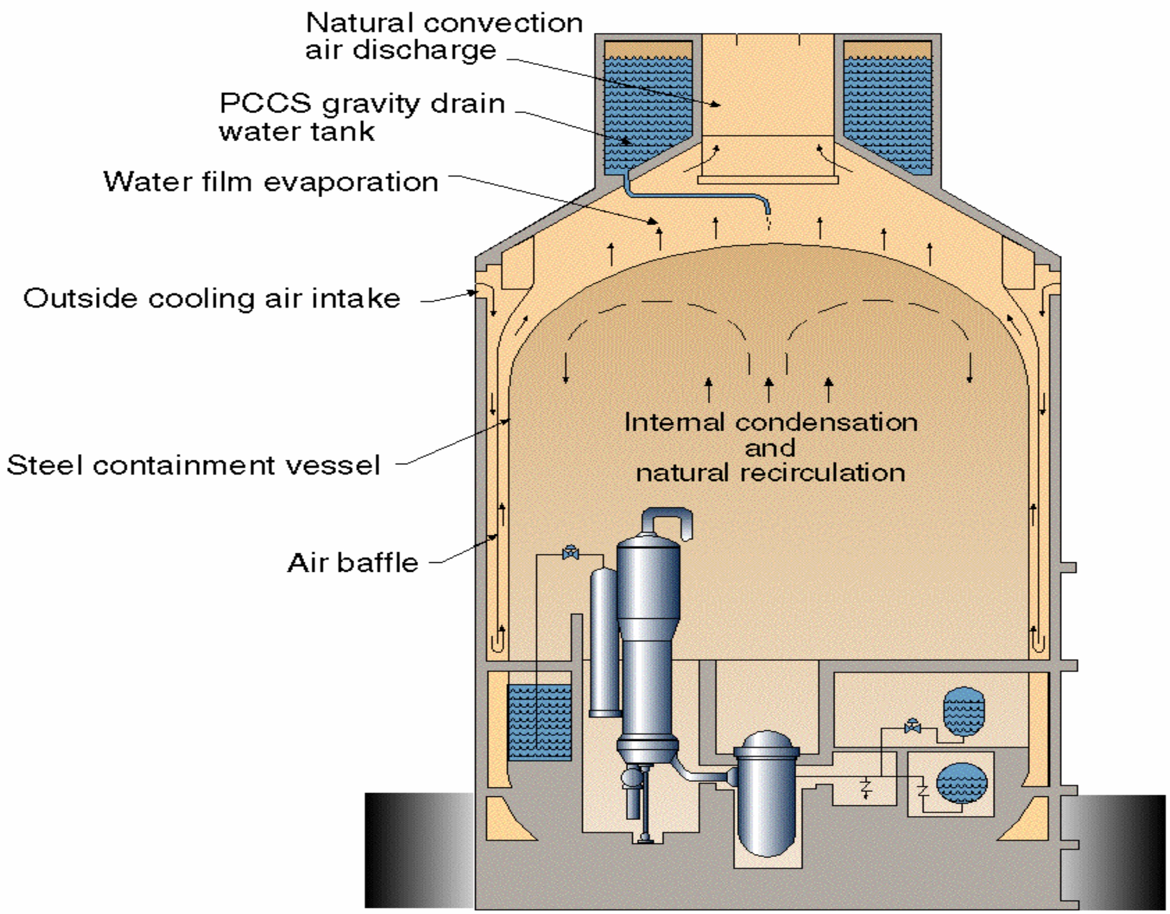
- Passive pH Adjustment
  - Uses baskets of Trisodium Phosphate
    - Located below post accident flood level
    - Located so that small leaks or spills will not reach baskets
    - No valves or instruments used
  - Capable of raising pH to >7.0
    - Includes margin for long term acid sources
    - Includes margin for inservice inspection

Passive Core Cooling System

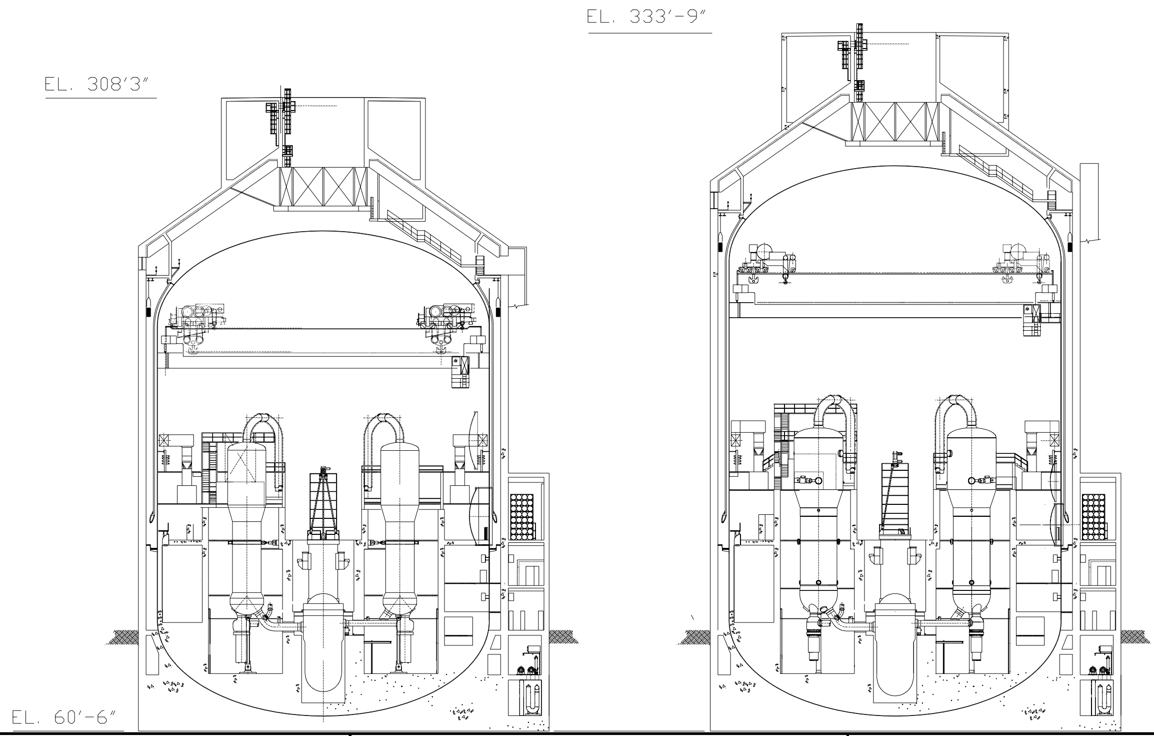


Westinghouse

Passive Containment Cooling System

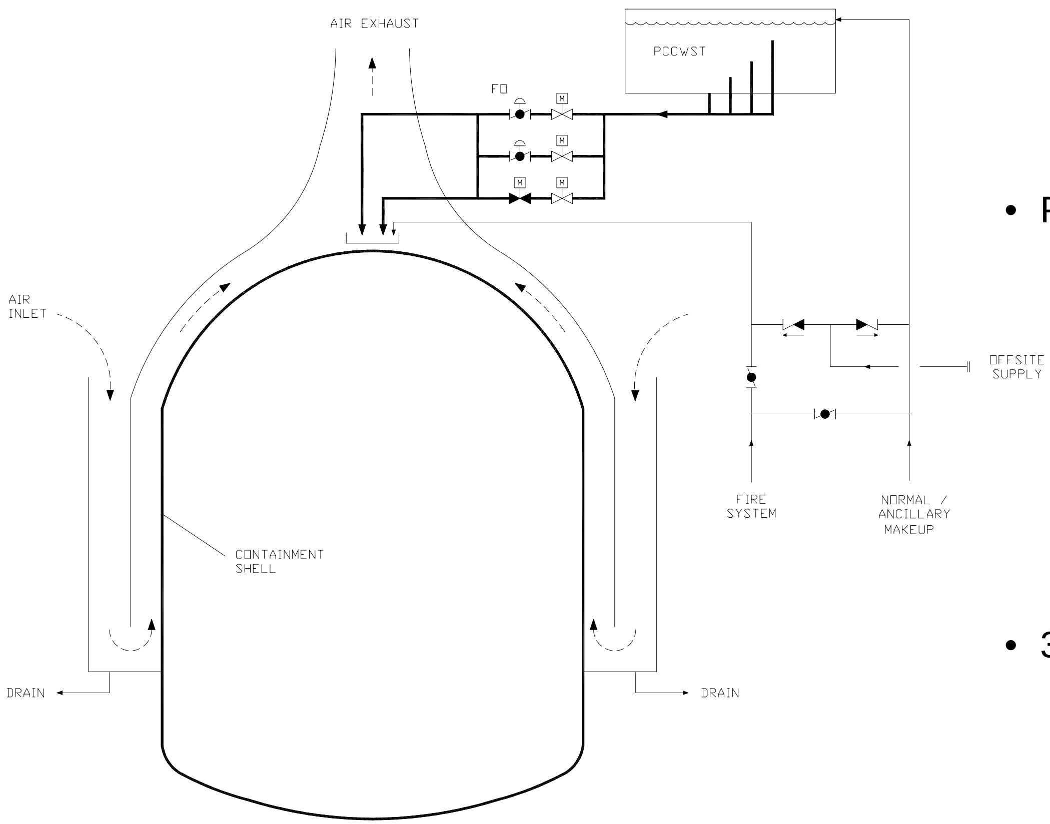


AP1000 Containment Comparison



	AP600	AP1000
Total Free Volume	100%	122%
Design Pressure, psig	45	59
Shell Thickness	1 5/8"	1 3/4" +
Material	A537 Class 2	SA738 Grade B

Passive Containment Cooling System



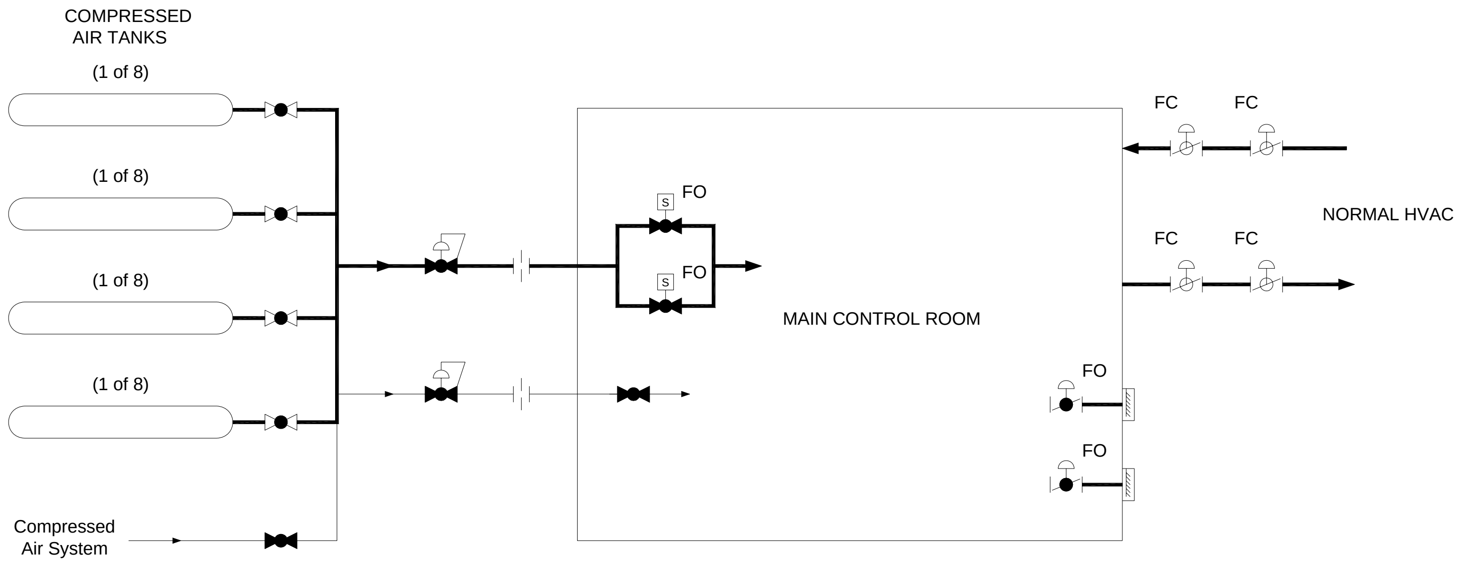
- PCS Water Storage Tank
  - 755,100 ft3
  - Provides 72 hr drain
  - Better fit of flow to heat removal
    - Uses 4 standpipes in 72 hr
- PCS Flow Rates
  - Initial flow 469 gpm (6%)
  - Rapidly forms water film
    - Effectively reduces Cont pres
  - 72 hr flow 100.7 gpm
    - Better fit of flow - heat removal
- 3rd Diverse Drain Path
  - Adds PRA margin
    - T&H uncertainty of cont cooling without water drain

AP1000 Hydrogen Mitigation

- **Design Basis Accidents**
  - Slow long term buildup of H2
  - Uses 2 full size Passive Autocatilyic Recombiners (nonsafety)
    - No power or actuation required
  - Equipment is non-safety based on NRC / industry activities on risk-informed changes to 10 CFR 50.44 (Combustible Gas Control)
- **Severe Accidents**
  - Rapid buildup of H2
  - Uses 64 non-safety igniters distributed in pairs around containment
    - Location based on severe accident analysis of AP1000
  - Plant layout design places release paths from RCS and potential standing H2 flames well away from containment walls
    - IRWST uses two different vent designs
      - Vents located close to containment are spring loaded to prevent them from venting H2
      - Vents located away from containment open easily to vent H2

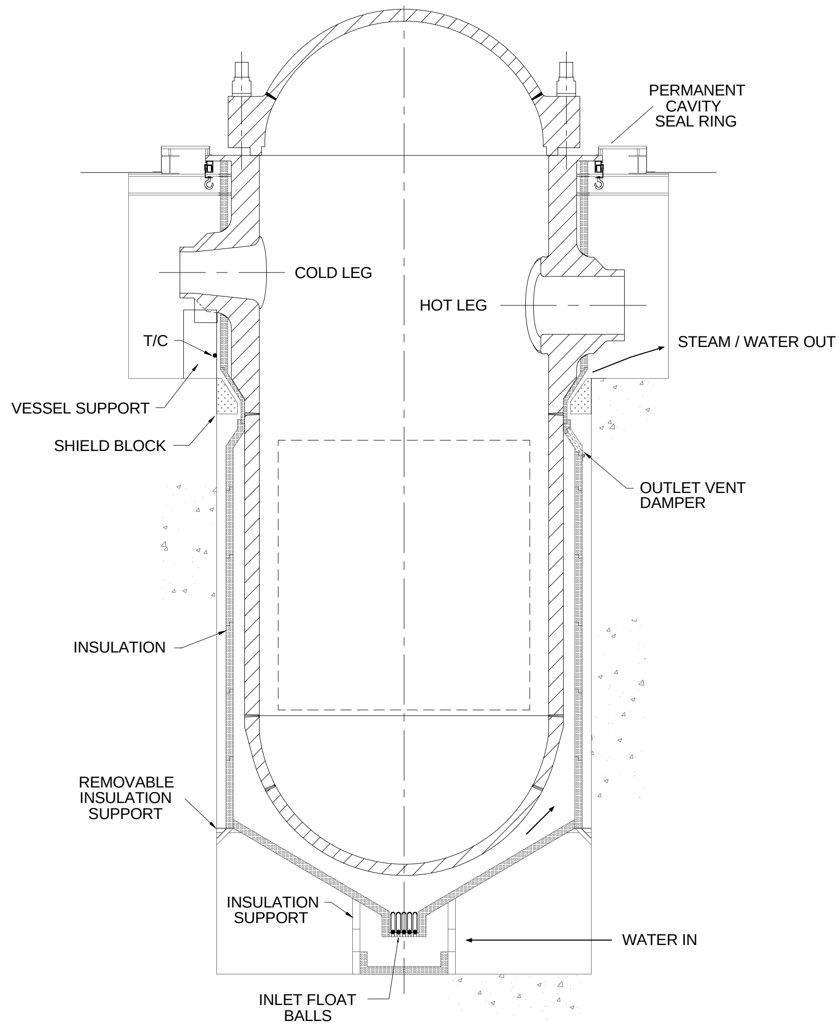
AP1000 MCR Emergency HVAC

- In Case of Failure of Normal, Non-Safety MCR HVAC
  - Compressed air provides breathable air for operators
    - 65 SCFM air flow pressurizes MCF 1/8 inch water
  - MCR air temperature remains < 85F for 72 hours



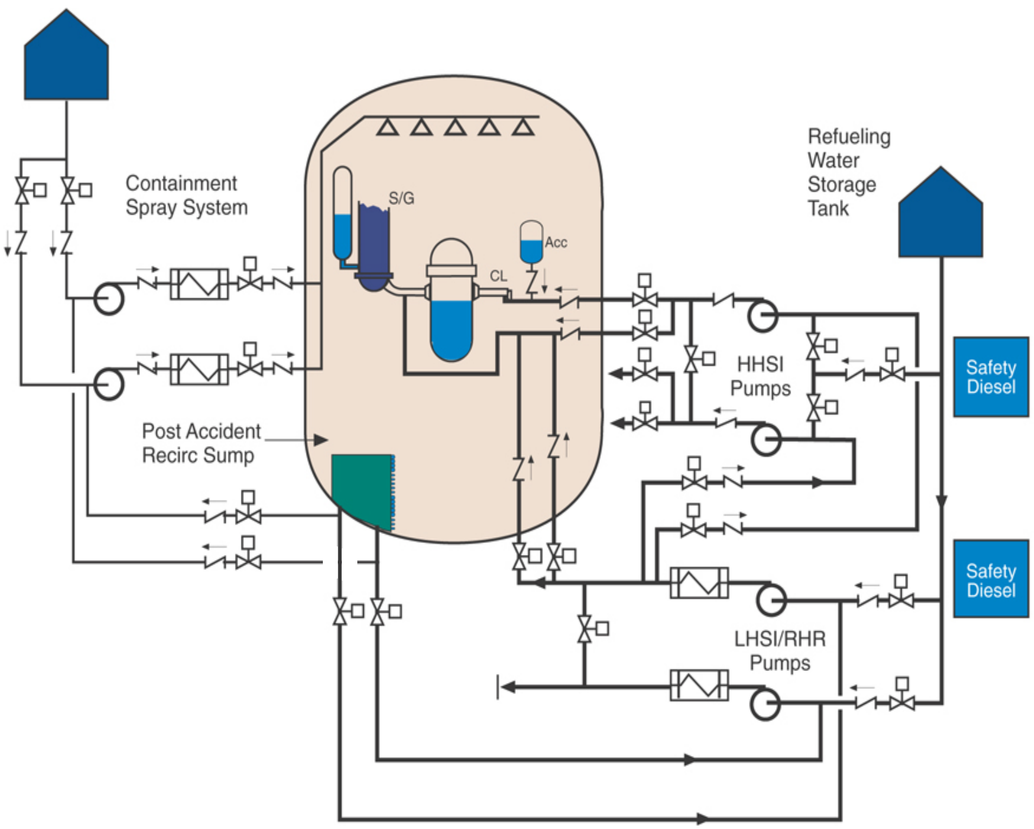
Severe Accidents Addressed

- Invessel Retention
  - Ex-vessel cooling
  - Provides reliable means of cooling damaged core
  - AP600 tests and analysis of IVR reviewed by U.S. NRC
  - Prevents core-concrete interaction
- High Pressure Core Melt
  - Eliminated with ADS
- Hydrogen Detonation
  - Prevented by igniters and passive autocatalytic recombiners
- Steam Explosions
  - ADS eliminates high pressure
  - IVR eliminates low pressure

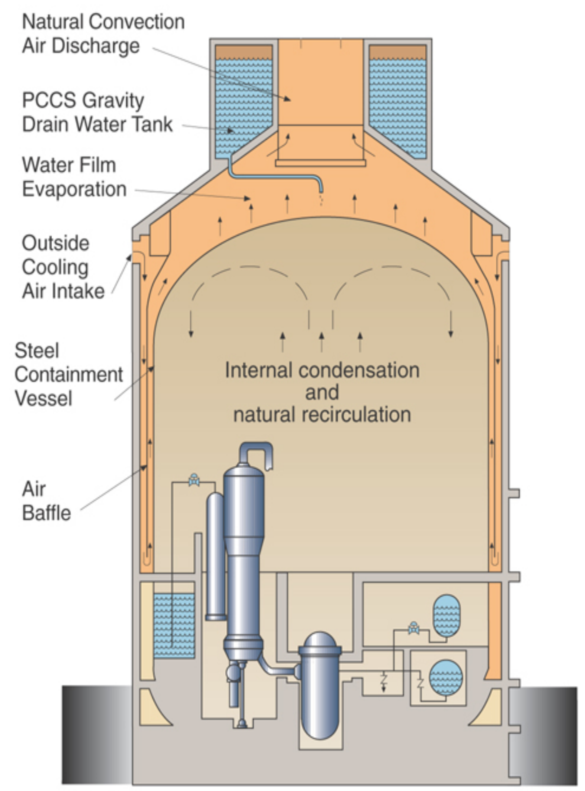


Simplification of Safety Systems Dramatically Reduces Building Volumes

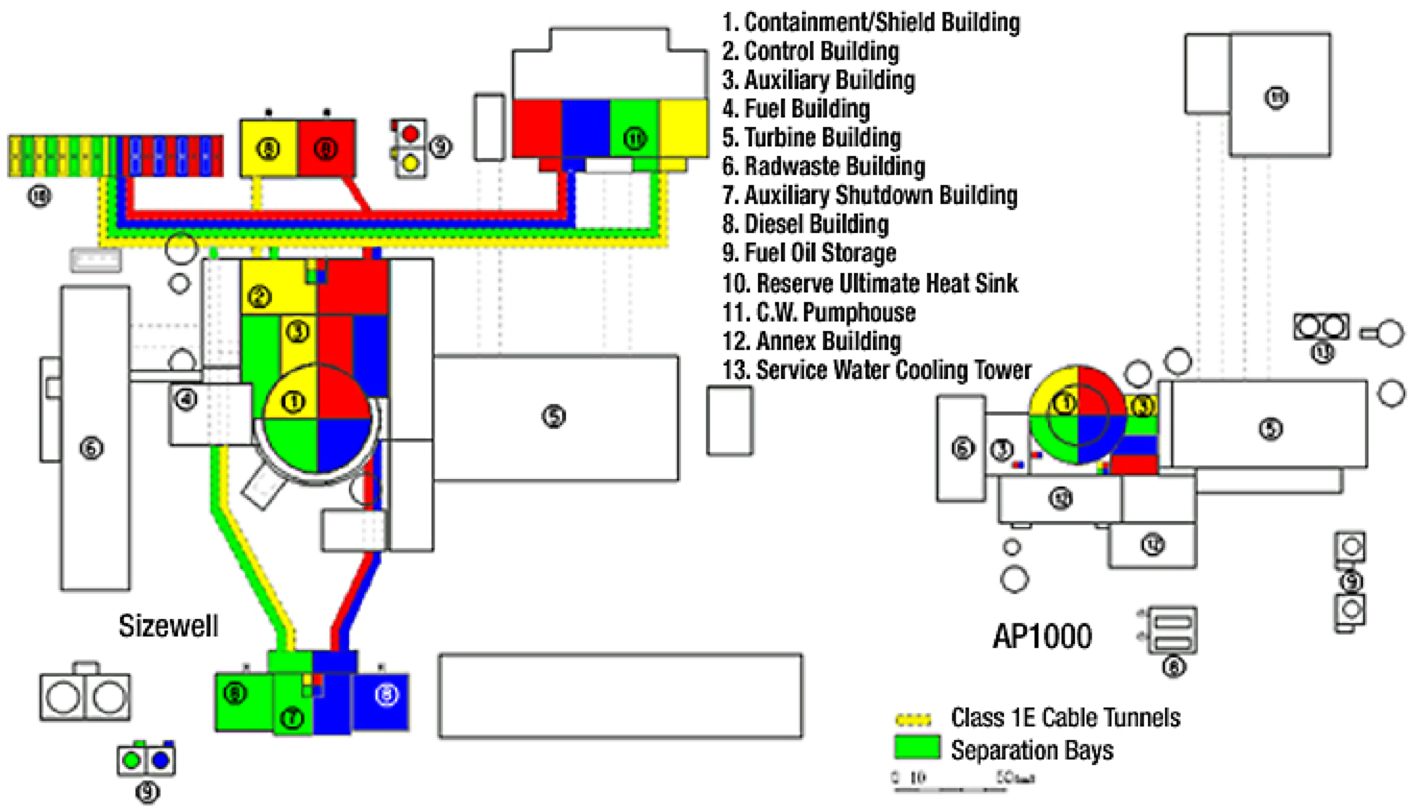
Standard PWR



AP1000



The AP1000 is Smaller and Dramatically Simpler than Evolutionary Plants



Sizewell B **AP1000**

74147A

Safety Analysis Examples

Jim Winters

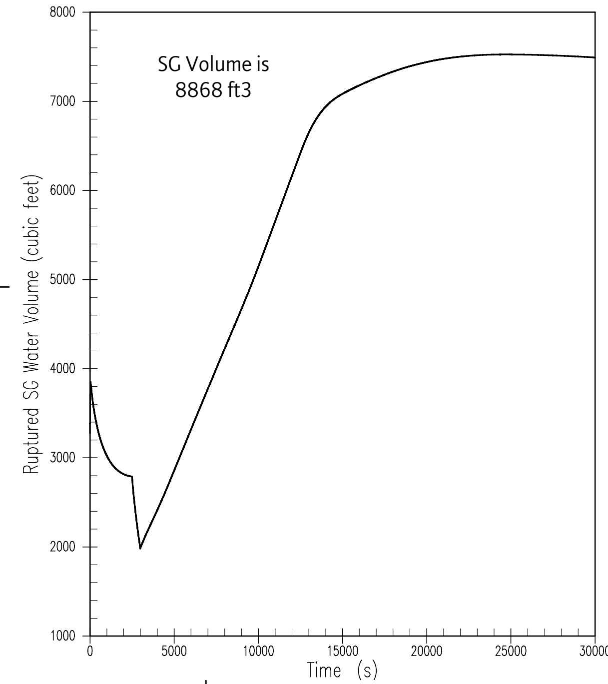
AP1000 Safety Margins

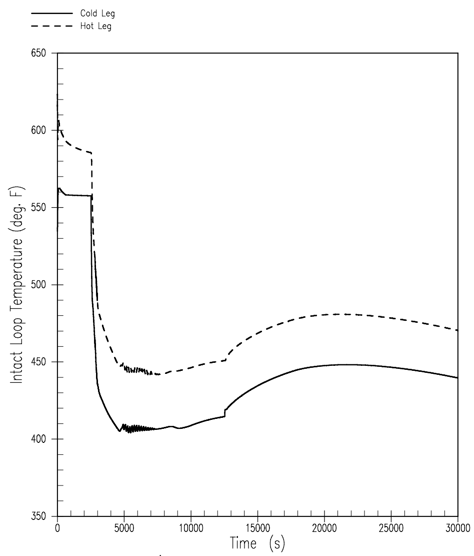
	Typical Plant	AP600	AP1000
• Loss Flow Margin to DNBR Limit	~ 1 - 5%	~16%	~16%
• Feedline Break (^oF) Subcooling Margin	>0^oF	~170^oF	~140^oF
• SG Tube Rupture	Operator actions required in 10 min	Operator actions **NOT** required	Operator actions **NOT** required
• Small LOCA	3" LOCA core uncovers PCT ~1500^oF	< 8" LOCA **NO** core uncovery	< 8" LOCA **NO** core uncovery
• Large LOCA PCT (^oF) with uncertainty	2000 - 2200^oF	1676^oF	<1600^oF (1)
• ATWS, Pres (psig) (% core life)	3200 psig 90%	3200 psig 90%	2800 psig 100%

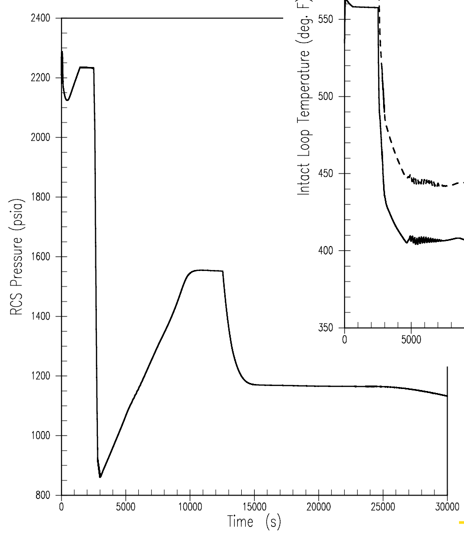
Note (1) Based on ASTRUM analysis of AP1000 which is more realistic then the "bounding" Lg LOCA analysis performed for AP600.

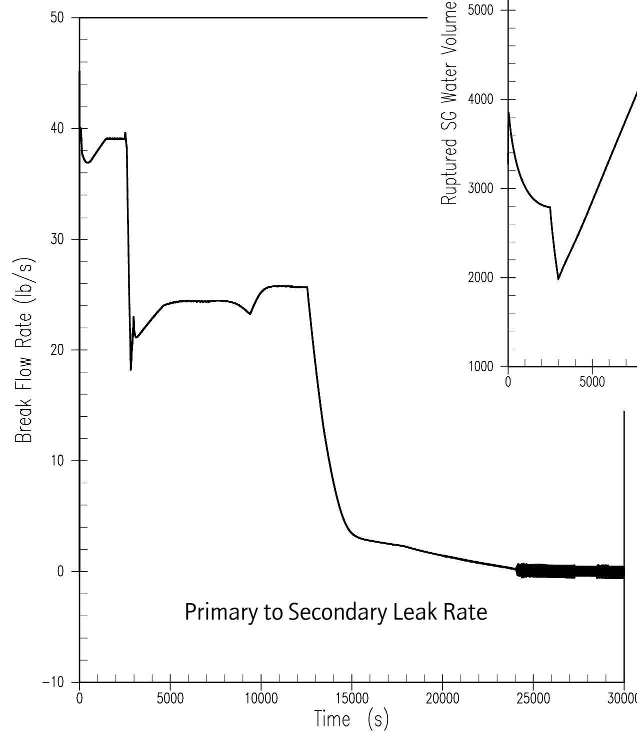
SGTR Analysis

- PXS Automatically Terminates SG Tube Rupture Leak
  - PRHR HX operation cools RCS to less than SG temperature
  - CMTs provide RCS makeup
  - Protection I&C isolates CVS makeup & SFWS on high SG level
  - SG overfill is automatically prevented



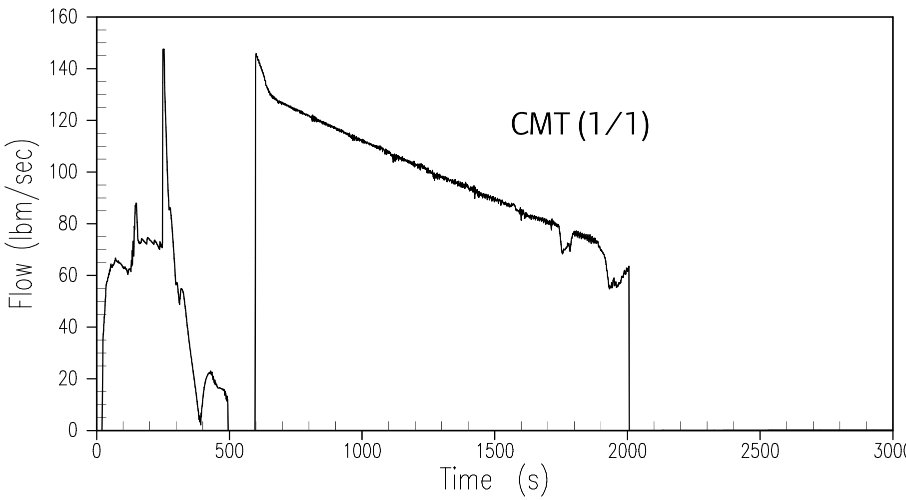


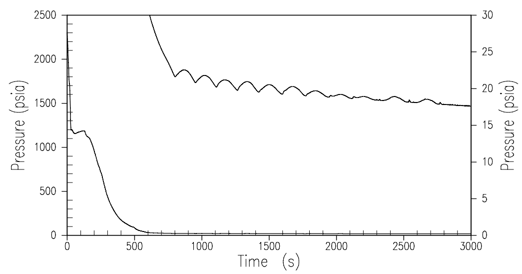


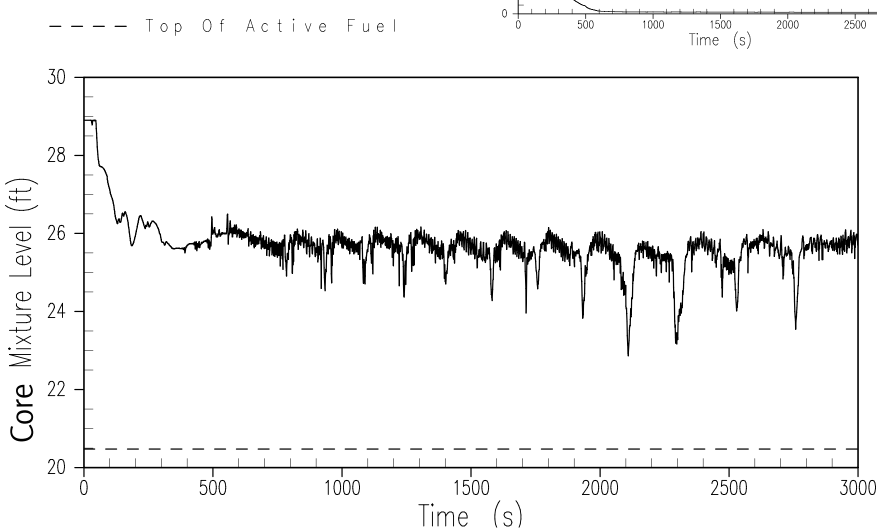


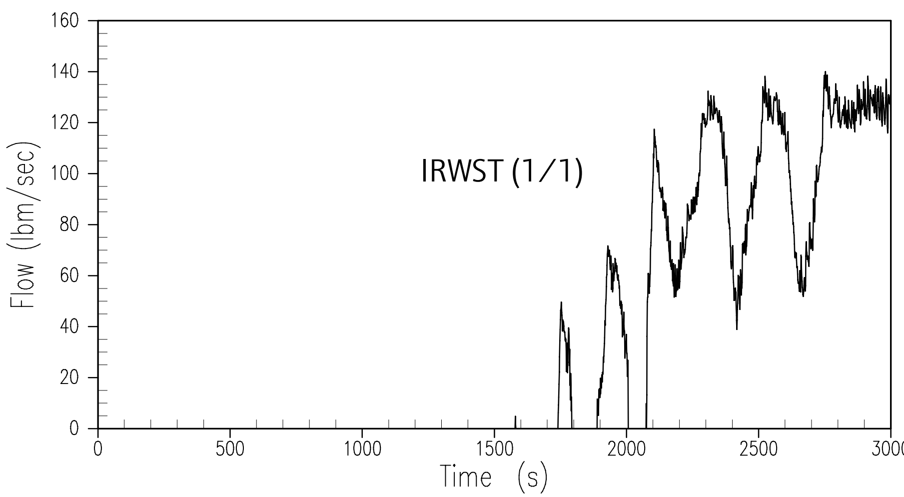
DVI LOCA Analysis

- PXS Provides Effective Core Cooling
  - CMTs, accum and IRWST provide injection
    - 1/2 CMT, Accum, IRWST line spill to contain.
  - ADS effectively reduces the RCS pressure
  - Core remains covered with significant margin



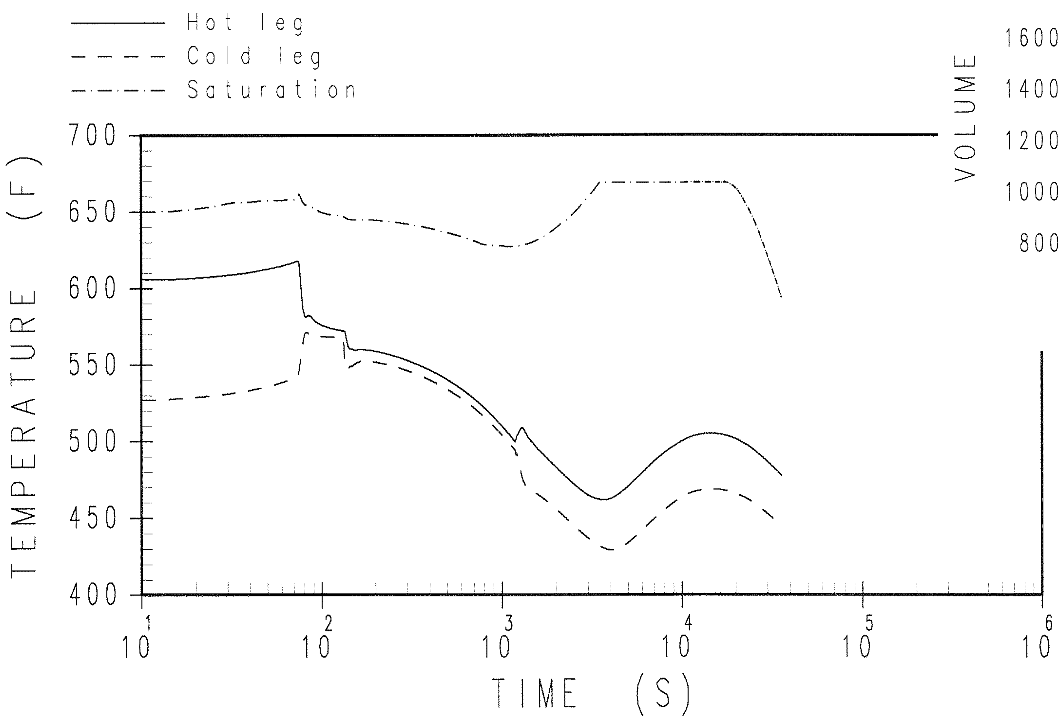


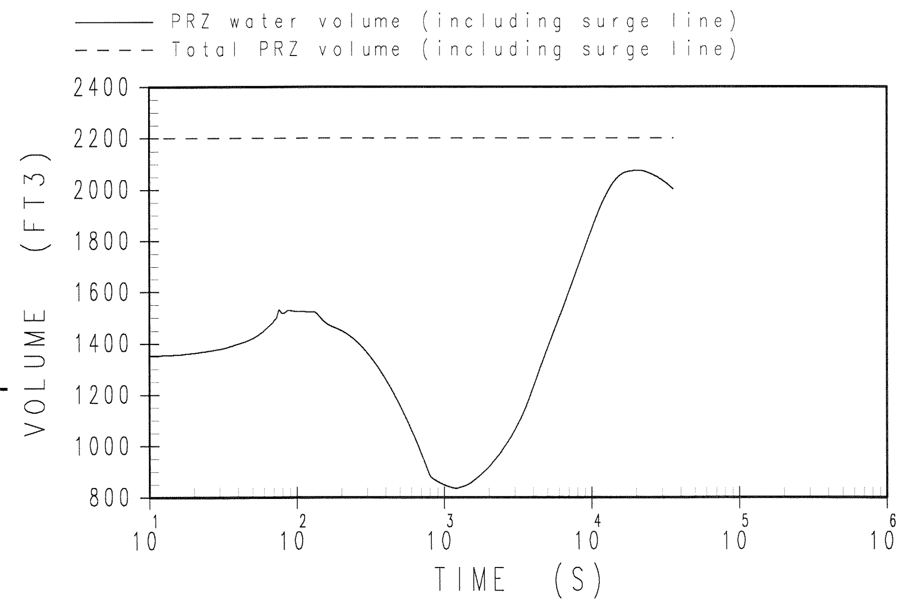




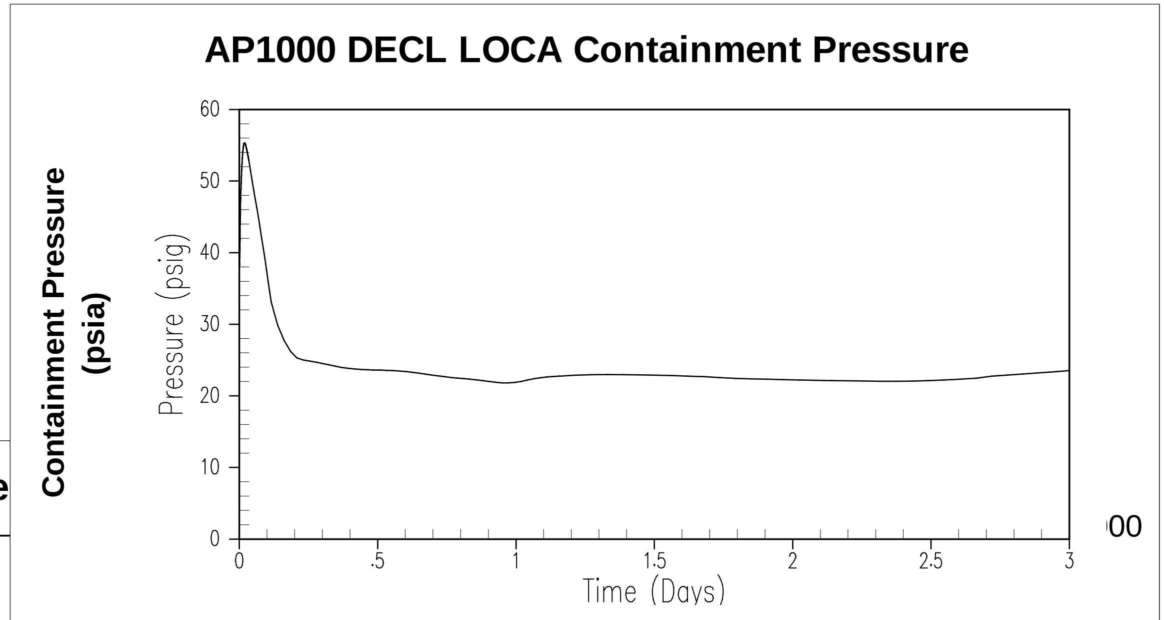
Loss Main Feedwater Analysis

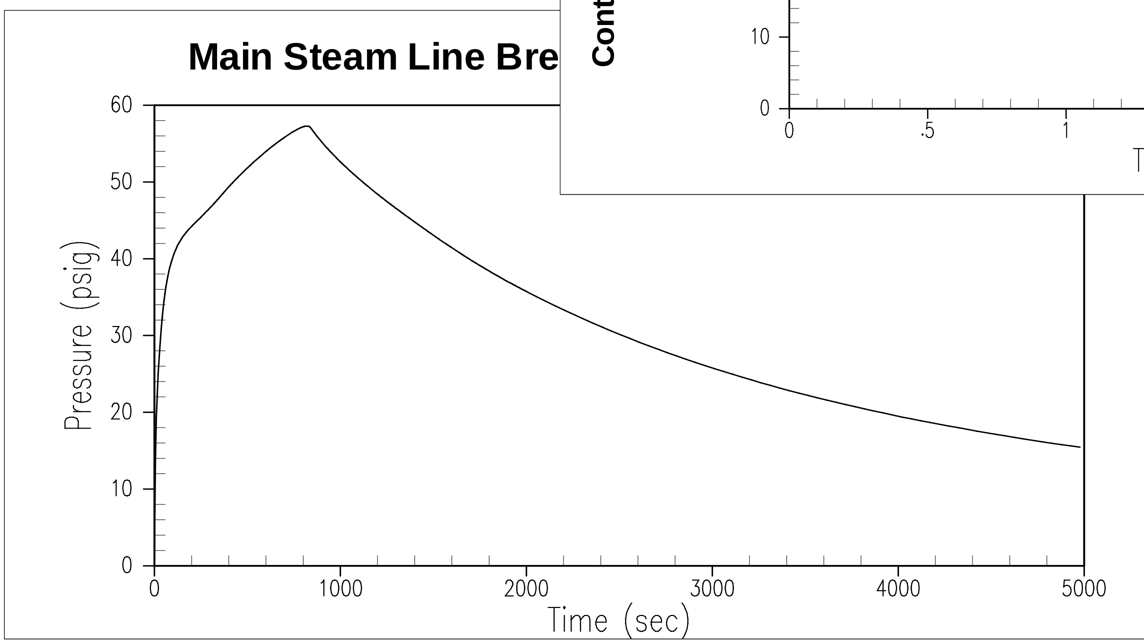
- PRHR Provides Effective Core Cooling
  - RC pumps operate until trip on low Tc (~1167 sec)
  - PRHR HX operates with forced then natural circ.
  - Large subcooling & Pzr level margin provided





AP1000 Containment Analysis Results





- **Main Steam Line Break is Limiting**
  - Not sensitive to passive containment cooling performance

AP1000 Nuclear Design

- Peaking Factors
  - Peaking Factor Limits unchanged from AP600
    - Fq = 2.60
    - F-delta-h = 1.65
- Reactivity Coefficients
  - Reactivity Coefficients are comparable to those in conventional core designs
  - Doppler power coefficients more negative than AP600
  - Moderator temperature coefficients more negative than AP600
  - Boron coefficients less negative than AP600

AP1000 Nuclear Design

- Control Rod Worths
  - Control Rod Bank Worths similar to those in AP600
  - N-1 Control Rod Worths are increased relative to those in AP600
- Shutdown Margins
  - Control requirements have increased relative to AP600 due to increased doppler and moderator feedback
  - Shutdown margins have increased relative to AP600
    - Increase in N-1 Control Rod Worth outweighs increases in control requirements
  - Shutdown margins substantially greater relative to those in conventional designs

AP1000 Thermal Hydraulic Design

- DNBR Margin Summary for AP1000

Core and Axial Offset Limits		All Other RTDP Transients	
Typical Cell	Thimble Cell	Typical Cell	Thimble Cell
16.7%	16.7%	18.7%	19.3%

  – These margins are much greater than those associated with currently operating Westinghouse plants

Thermal Hydraulic Design Parameters

- Flow, Flow velocity, Mass velocity has increased relative to AP600
- Coolant temperatures have increased relative to AP600 but are lower than uprated 3-Loop + typical XL Plant coolant temperatures
- DNBR Margins have increased

Plant	AP600	AP1000	2900 MWt 17X17 3-Loop	3800 MWt Typical XL
Thermal Design Flow (10^6 lbm/hr)	72.9	113.5	104.0	145.0
Coolant Average Velocity (ft/sec)	10.6	15.9	13.7	15.6
Mass Velocity (10^6 lbm/hr-ft^2)	1.72	2.41	2.15	2.59
Nominal Inlet Temperature (deg-F)	532.8	535.0	552.9	549.8 - 561.2
Core Average Temperature (deg-F)	572.6	578.1	592.8	586.9 - 597.8
Vessel Average Temperature (deg-F)	567.6	573.6	587.4	582.3 - 593.8

Reactor Vessel

Pressure/Temperature Curves

- Developed in Accordance with 10CFR50, Appendix G with Exception that Flange Requirement is Not Considered per WCAP 15315, “Reactor Vessel Closure Head/Vessel Flange Requirements Evaluation for Operating PWR and BWR Plants”
  - Results in Improvement in RCS Operating Window
    - Larger Margin for RNS Cut-In
    - Reduces Likelihood of Opening RNS Low-Temperature Overpressure Relief Valve

Defense-In–Depth Systems

Jim Winters

Approach to Safety: Defense-in-Depth

- Simple Passive Safety Systems
  - Dedicated safety systems - not required for normal operation
  - Use "natural" driving forces
  - One-time alignment of active valves
  - No support systems after actuation
  - Reduced operator dependency

- Simple Active Non-Safety Systems
  - Reliable active equipment for normal operation
  - Redundant active equipment powered by nonsafety diesels
  - Minimize unnecessary use of passive safety systems
  - Reduce risk to utility & public

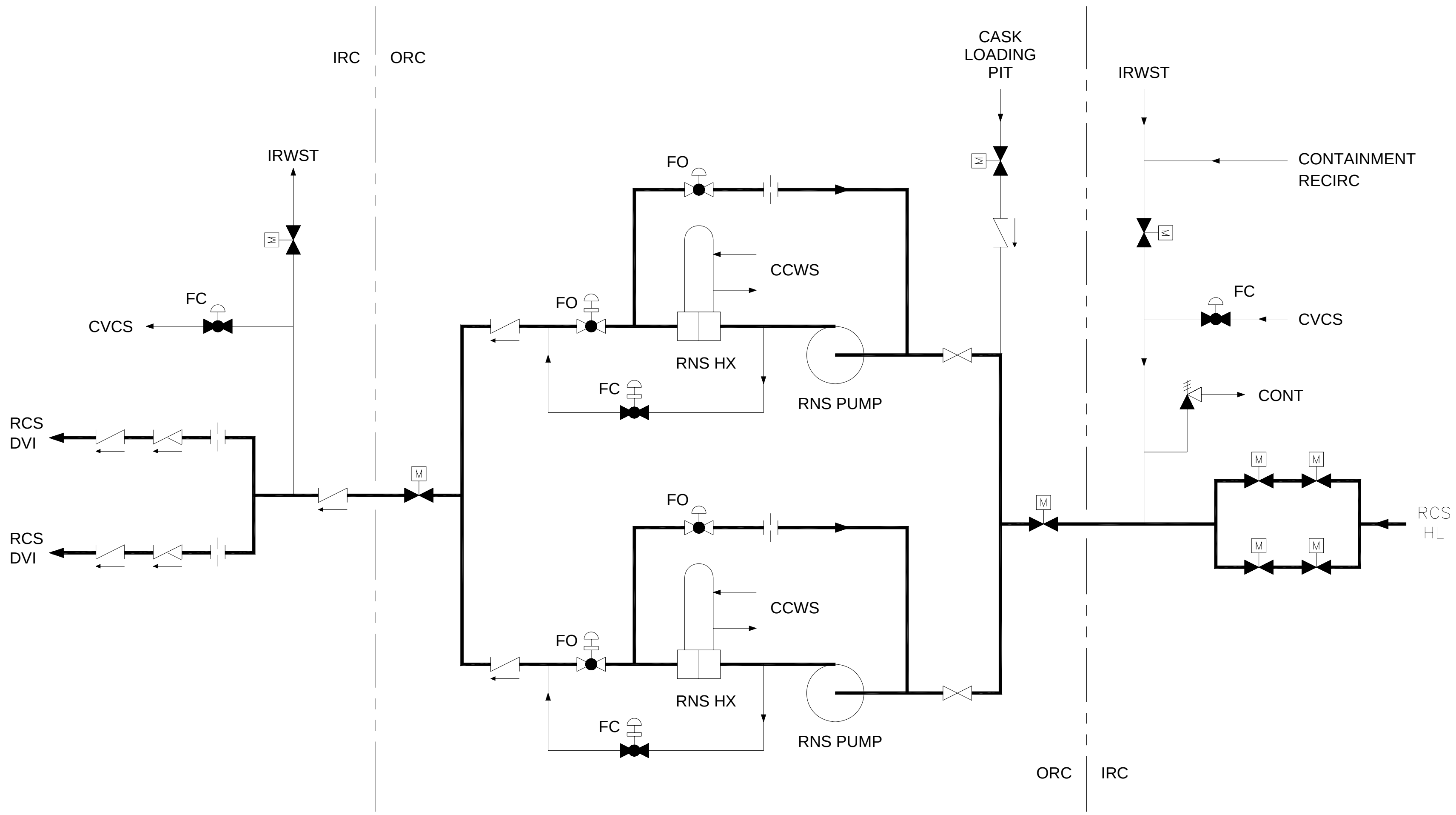
System Defense In Depth

- AP1000 Provides Multiple Levels of Defense
  - First feature is usually nonsafety active feature
    - High quality industrial grade equipment
  - Other feature is safety passive feature
    - Provides safety case for SSAR
    - Highest quality nuclear grade equipment
  - Other passive features provide additional levels of defense
    - Example; passive feed/bleed backs up PRHR HX
  - Available for all shutdown conditions as well as at power
  - More likely events have more levels of defense

Active Nonsafety Systems

- Active Nonsafety System Functions
  - Reliably support normal operation
  - Minimize challenge to passive safety systems
  - Not required to mitigate design basis accidents
  - Not required to meet NRC safety goals
- Active Nonsafety System Design Features
  - Greatly simplified designs
  - Redundancy for more probable failures
  - Automatic actuation with power from onsite diesels
- Active Nonsafety System Equipment Design
  - Reliable, experienced based, industrial grade equipment
  - Non-ASME, non-seismic, limited fire / flood / wind protection
  - Availability controlled by procedures, no shutdown requirements
  - Reliability controlled by maintenance program

Primary Support Systems
Normal Residual Heat Removal System



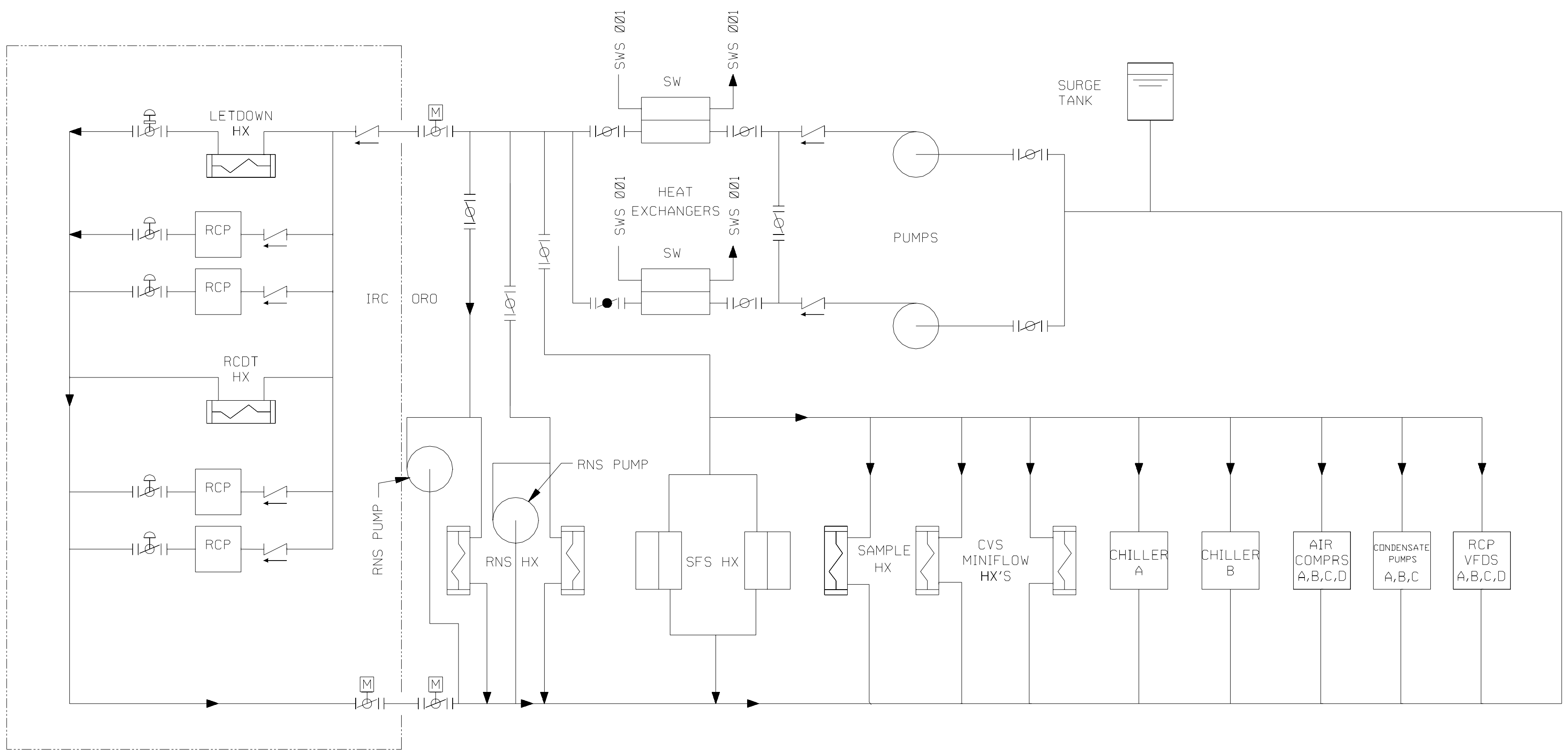
Primary Support Systems
Normal Residual Heat Removal System

- Cask Loading Pit (AP600 = IRWST) Source for Low Pressure Injection to RCS During LOCA
  - Provides Additional Water Into Containment to Increase Margin for Core Cooling
  - Maintains Water in IRWST, Results in Higher Driving Head at Initiation of IRWST Injection After ADS Stage 4 Actuation
  - Curb Height Adjusted to Accommodate Additional Water During Post-Accident Containment Floodup [Chapter 3]
- Relief Valve for Low Temperature Overpressure Protection
  - Same Valve as AP600
  - AP1000 P/T Curves Allow Higher Set Pressure (818 psig) Than AP600 (563 psig), Results in Higher Relieving Capacity

Primary Support Systems
Normal Residual Heat Removal System

- Same Equipment as AP600
- Valves Added in Pump Miniflow Line to Increase RCS Cooldown Capability
  - When Closed, Increases RCS Flow Through Each Heat Exchanger to 1500 gpm (AP600 = 1300 gpm)
- RCS Cooldown Performance - 350 F to 125 F in 96 Hrs (AP600 = 350 F to 120 F in 96 Hrs)

Primary Support Systems
Component Cooling Water System

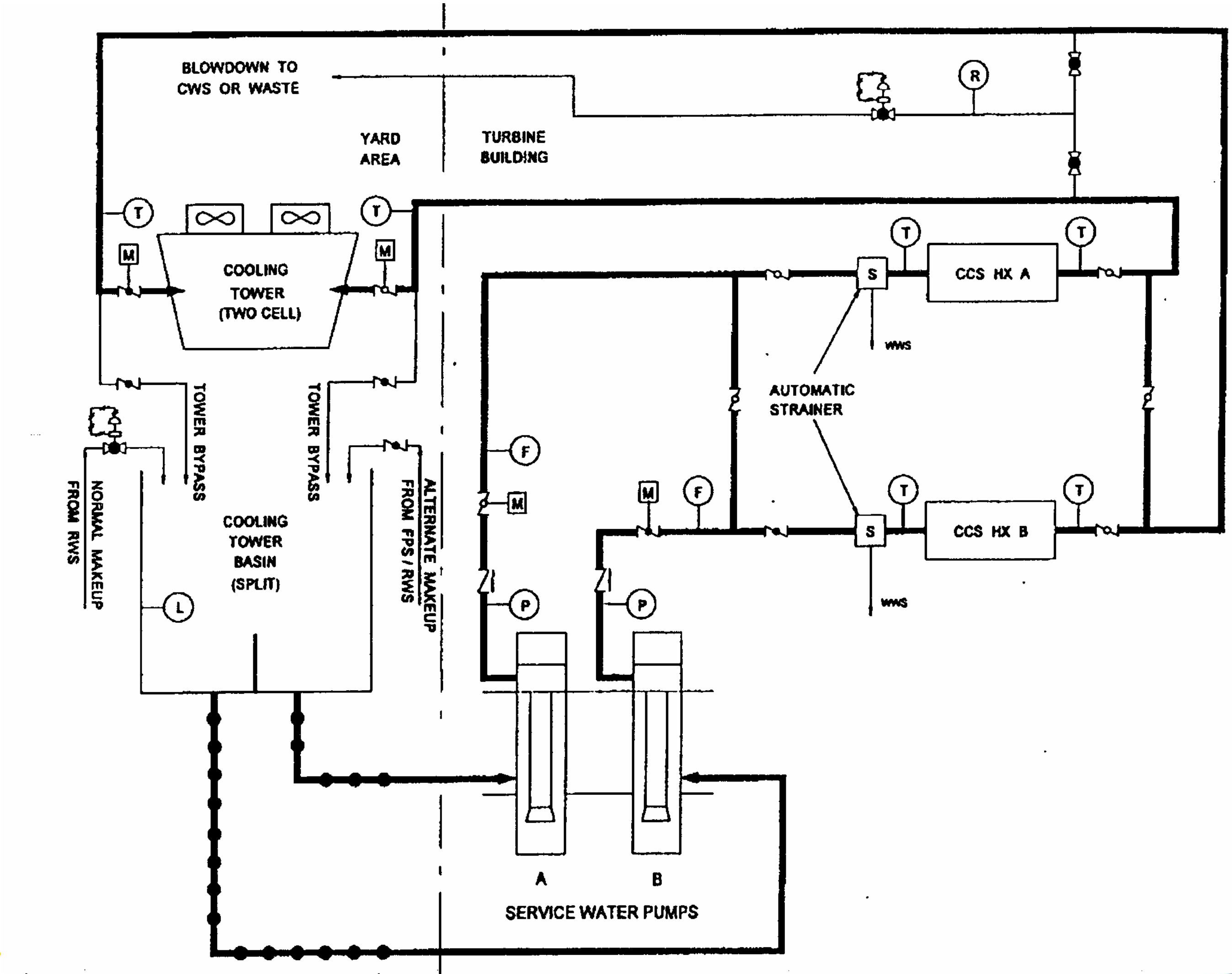


Primary Support Systems

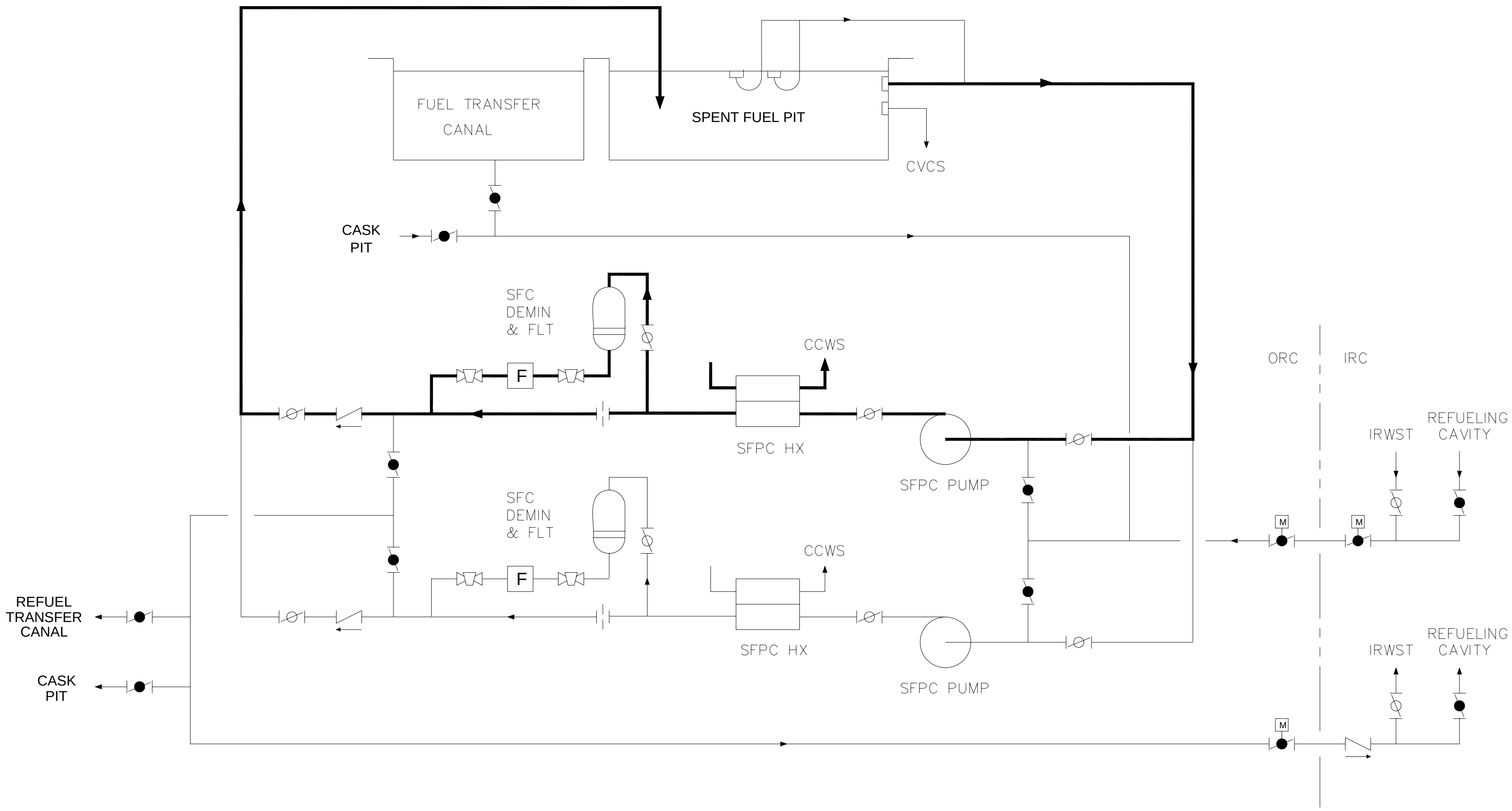
Component Cooling Water and Service Water

- Configurations of Both Systems Same as AP600
  - Added CCS Cooling of RCP Variable Frequency Drives
- Increased Capacity of Pumps and Heat Transfer Equipment Consistent With Heat Load Changes
  - AP1000 CCS Flow Per Pump 8000 gpm (AP600 = 6000 gpm)
  - AP1000 CCS Heat Exchanger UA 14.0 Btu/Hr-F (AP600 = 10.4 Btu/Hr-F)
  - AP1000 SWS Flow Per Pump 8000 gpm (AP600 = 6200 gpm)
  - AP1000 SWS Cooling Tower Heat Removal 296 X 106 Btu/Hr (AP600 = 173 X 106 Btu/Hr)

Primary Support Systems
Service Water System



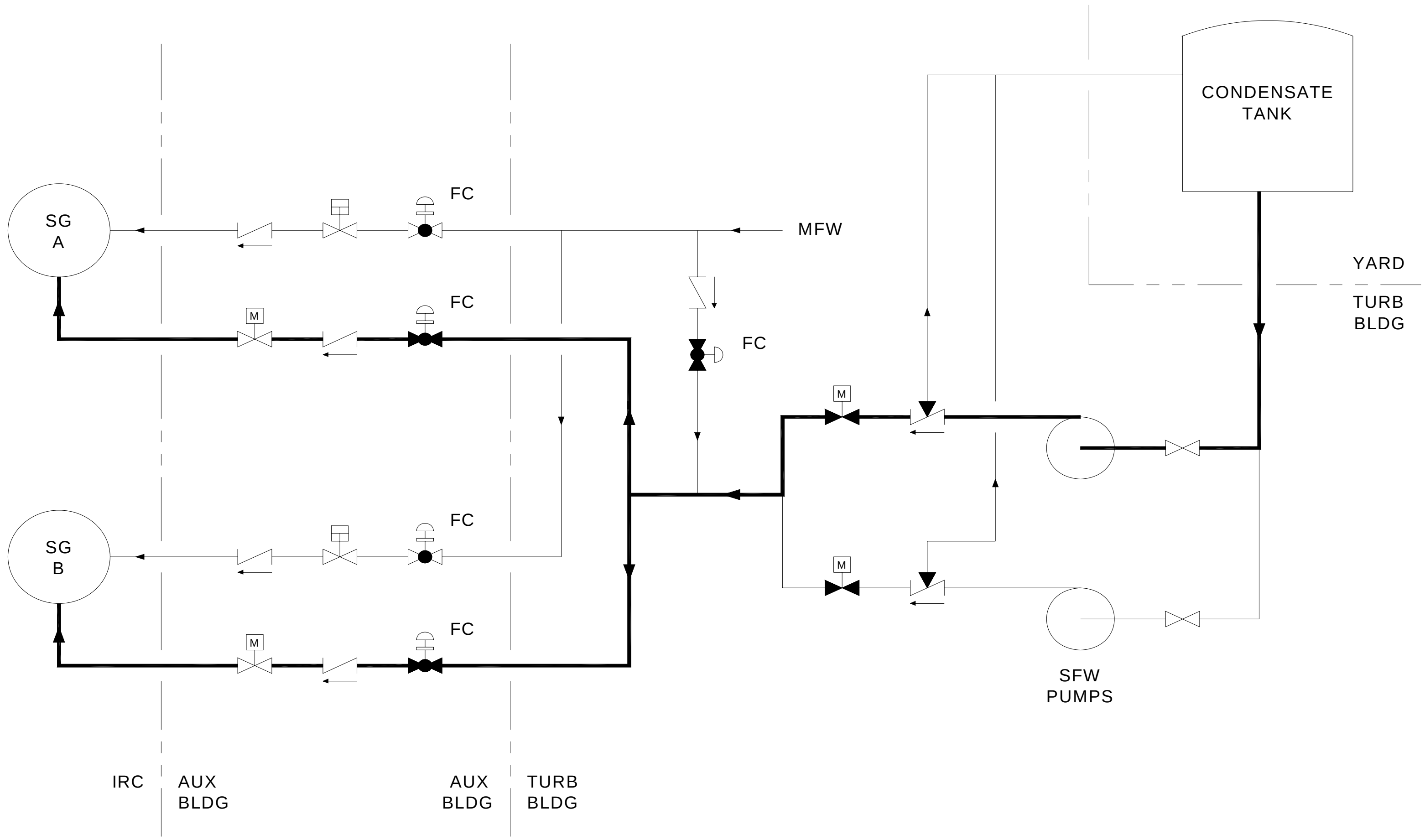
Spent Fuel Cooling



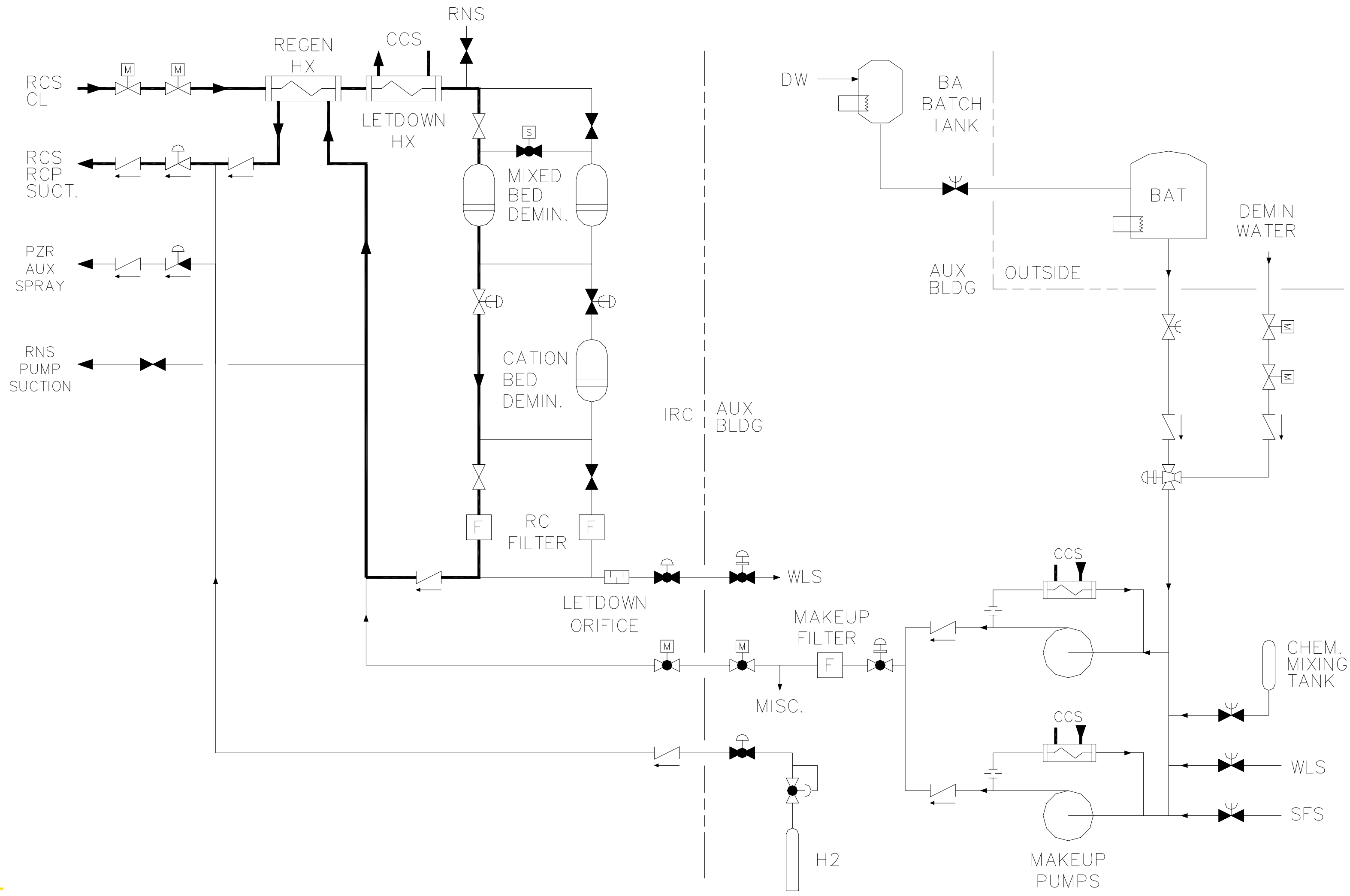
Primary Support Systems
Loss of Normal Spent Fuel Pool Cooling

AP1000 Station Blackout/Seismic Event Times (AP600 Times/Height)			
Event	**Time to Saturation (Hrs)**	**Height of Water Above Fuel at 72 Hours (ft)**	**Height of Water Above Fuel at 7 Days (ft)**
Seismic Event – Power Operation Following Refueling	8.8 (20.1)	4.6 (13.8)	4.6 (6.7)
Seismic Event – Refueling Immediately Following 44% Offload	6.4 (14.6)	8.3 (12.0)	8.3 (0.5)
Seismic Event – Refueling – Full Core Following 44% Offload	2.5 (4.6)	8.3 (8.3)	8.3 (8.3)

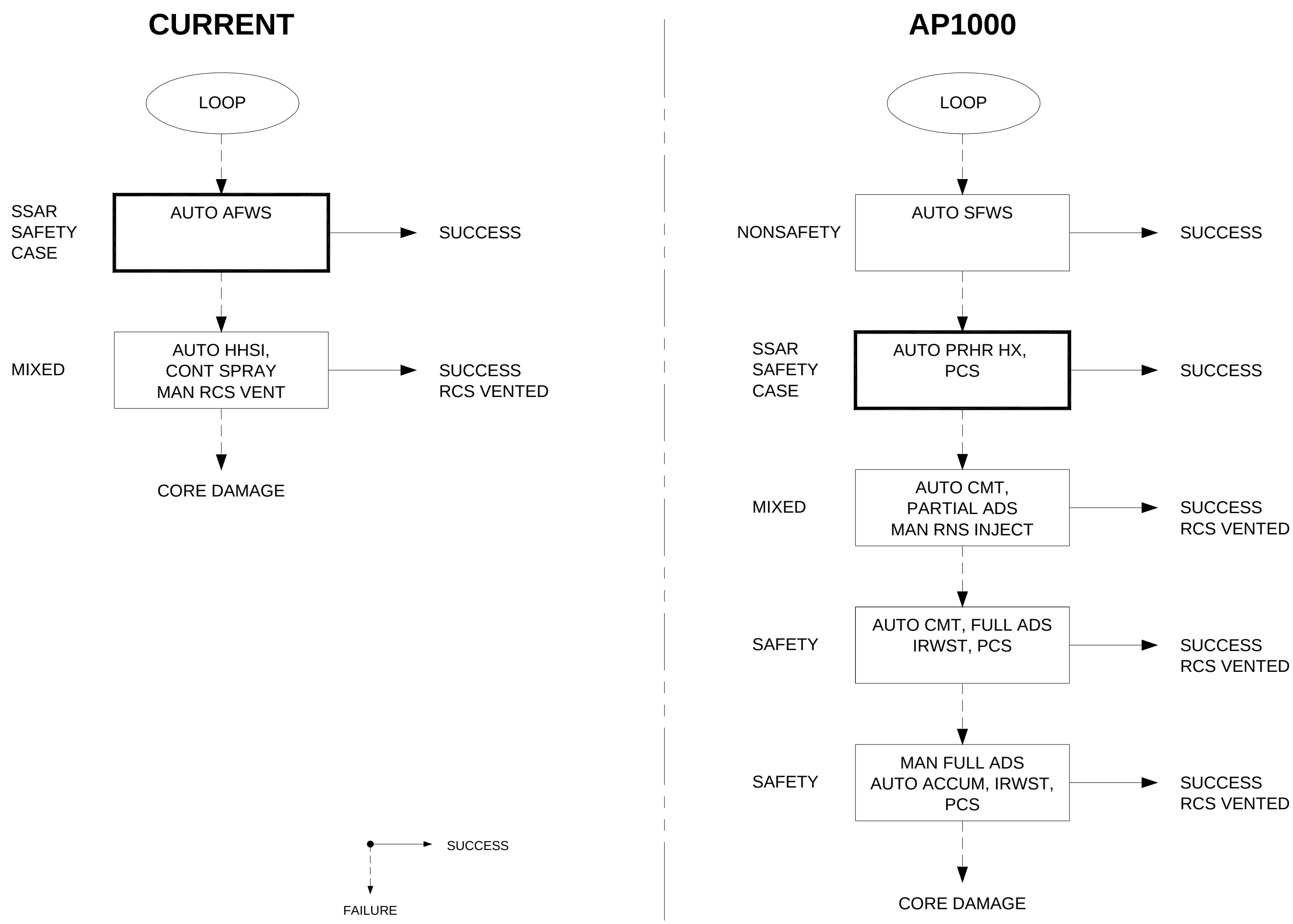
Startup Feedwater System



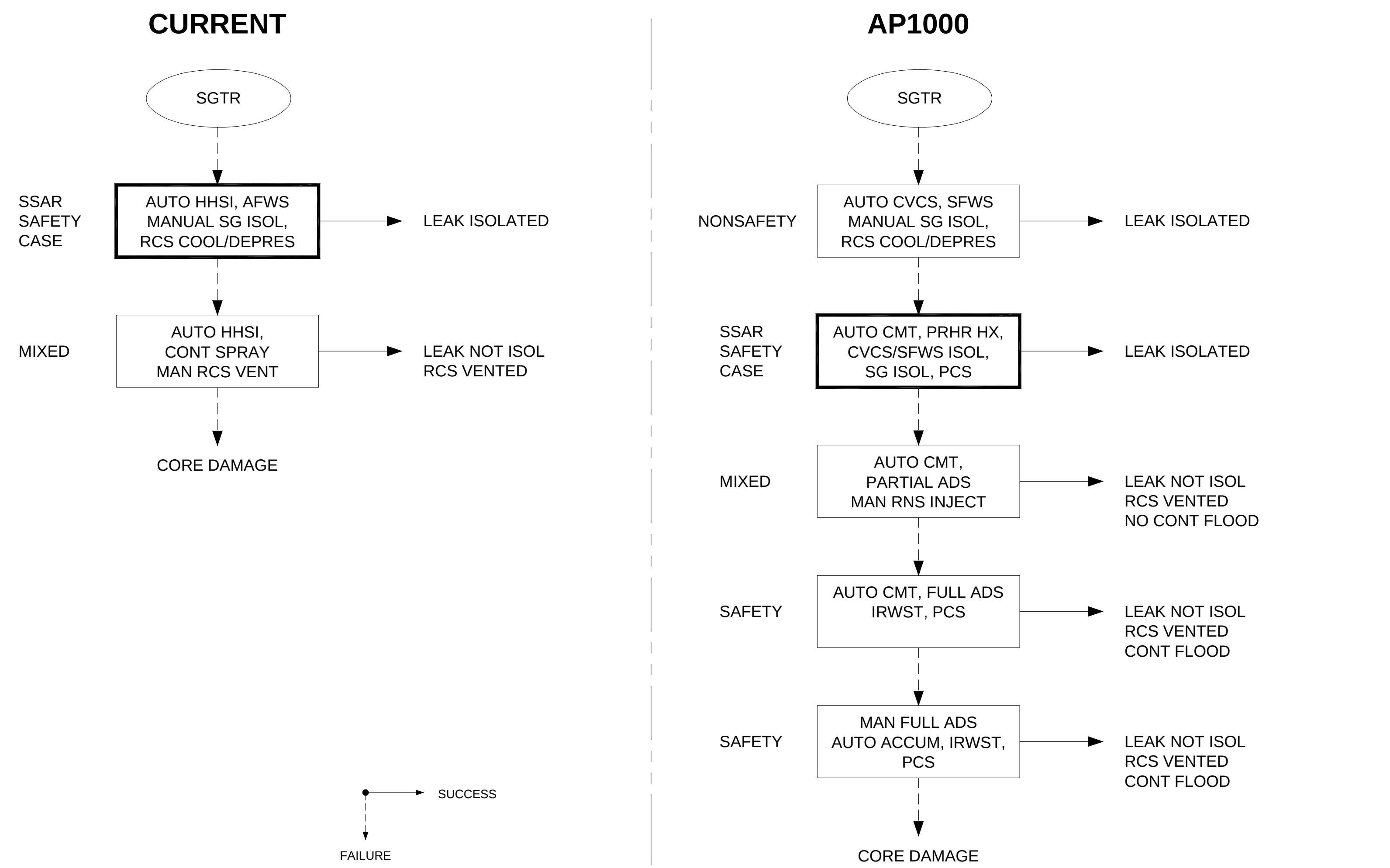
Chemical and Volume Control System



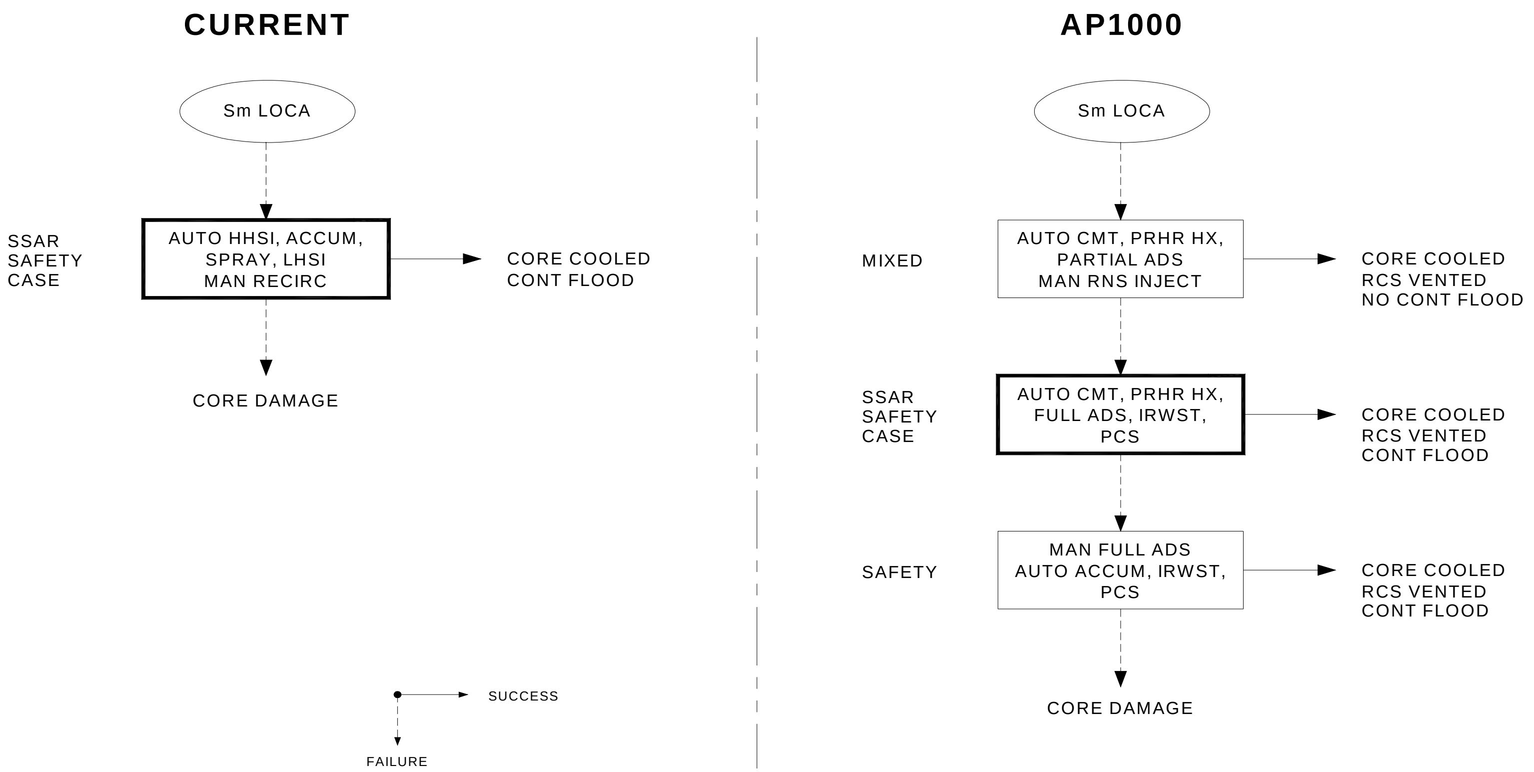
Loss of Offsite Power



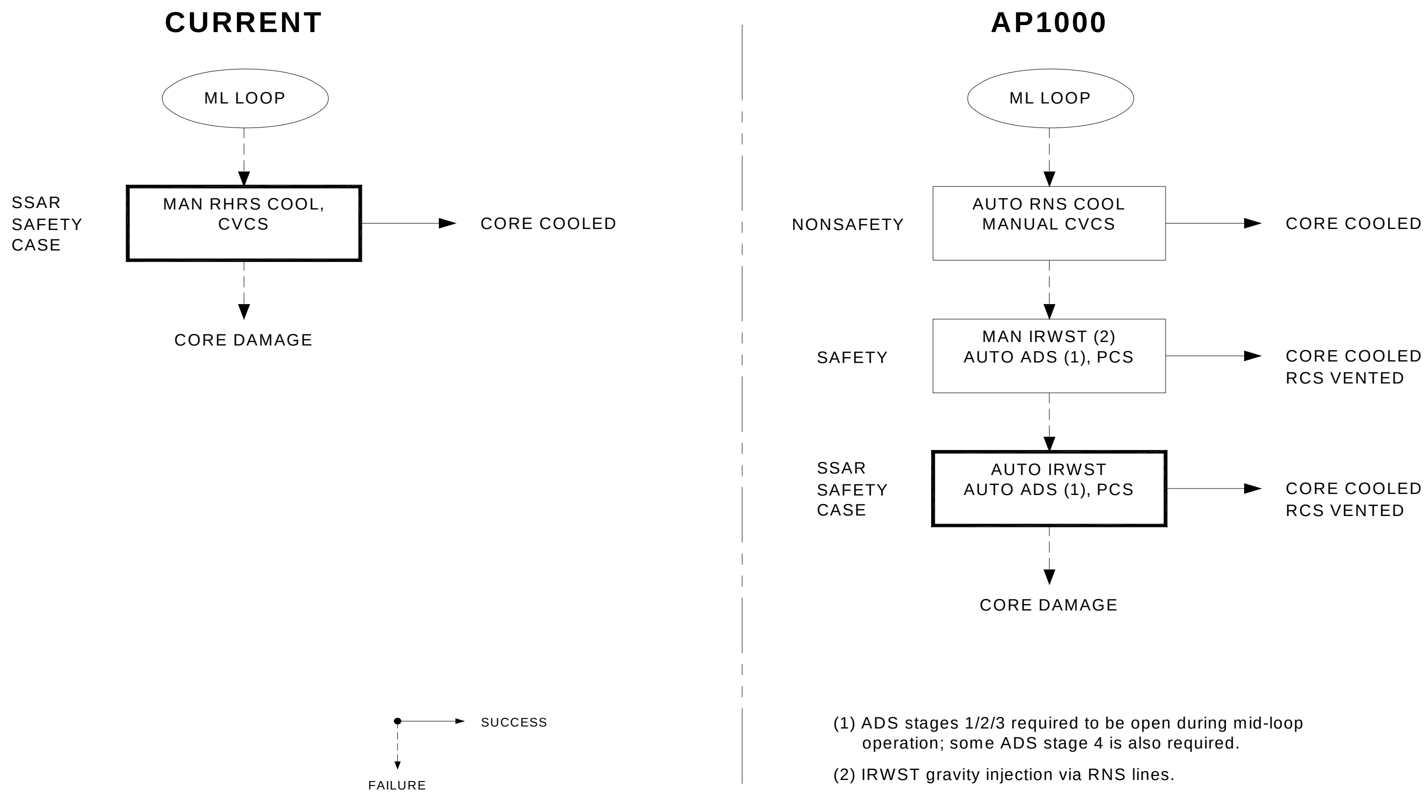
SG Tube Rupture



Small LOCA


CURRENT
Sm LOCA
SSAR SAFETY CASE
AUTO HHSI, ACCUM, SPRAY, LHSI MAN RECIRC
CORE COOLED CONT FLOOD
CORE DAMAGE
SUCCESS
FAILURE
AP1000
Sm LOCA
MIXED
AUTO CMT, PRHR HX, PARTIAL ADS MAN RNS INJECT
CORE COOLED RCS VENTED NO CONT FLOOD
SSAR SAFETY CASE
AUTO CMT, PRHR HX, FULL ADS, IRWST, PCS
CORE COOLED RCS VENTED CONT FLOOD
SAFETY
MAN FULL ADS AUTO ACCUM, IRWST, PCS
CORE COOLED RCS VENTED CONT FLOOD
CORE DAMAGE

Mid-Loop Loss Power



(1) ADS stages 1/2/3 required to be open during mid-loop operation; some ADS stage 4 is also required.

(2) IRWST gravity injection via RNS lines.

PRA Overview

Jim Winters

AP1000 PRA Development

- Westinghouse Uses PRA as Design & Licensing Tool
  - 7 PRA major quantifications performed on AP600
    - First in 1987, final in 1997
    - Extensive interaction with plant designers
    - Extensive NRC review / comment
  - AP1000 PRA quantified in 2001
    - Started with AP600 models / analysis
    - Benefited from AP600 development and NRC review
    - Modified models to account for few changes between AP600 & AP1000
    - Have revised PRA 4 times in response to NRC questions

AP1000 PRA

- Each PRA Quantification Included
  - Plant design input and PRA model development
  - Quantification and sensitivity studies
    - Importance of nonsafety features, operator actions, etc.
  - Review / understanding of results
  - Improvement of PRA and plant
    - PRA event / fault trees, success criteria T/H analysis
    - Plant operating procedures
    - Plant design
  - Subsequent PRAs became very detailed
    - I&C system modeled
    - Internal/fire/flood events from at power & shutdown conditions

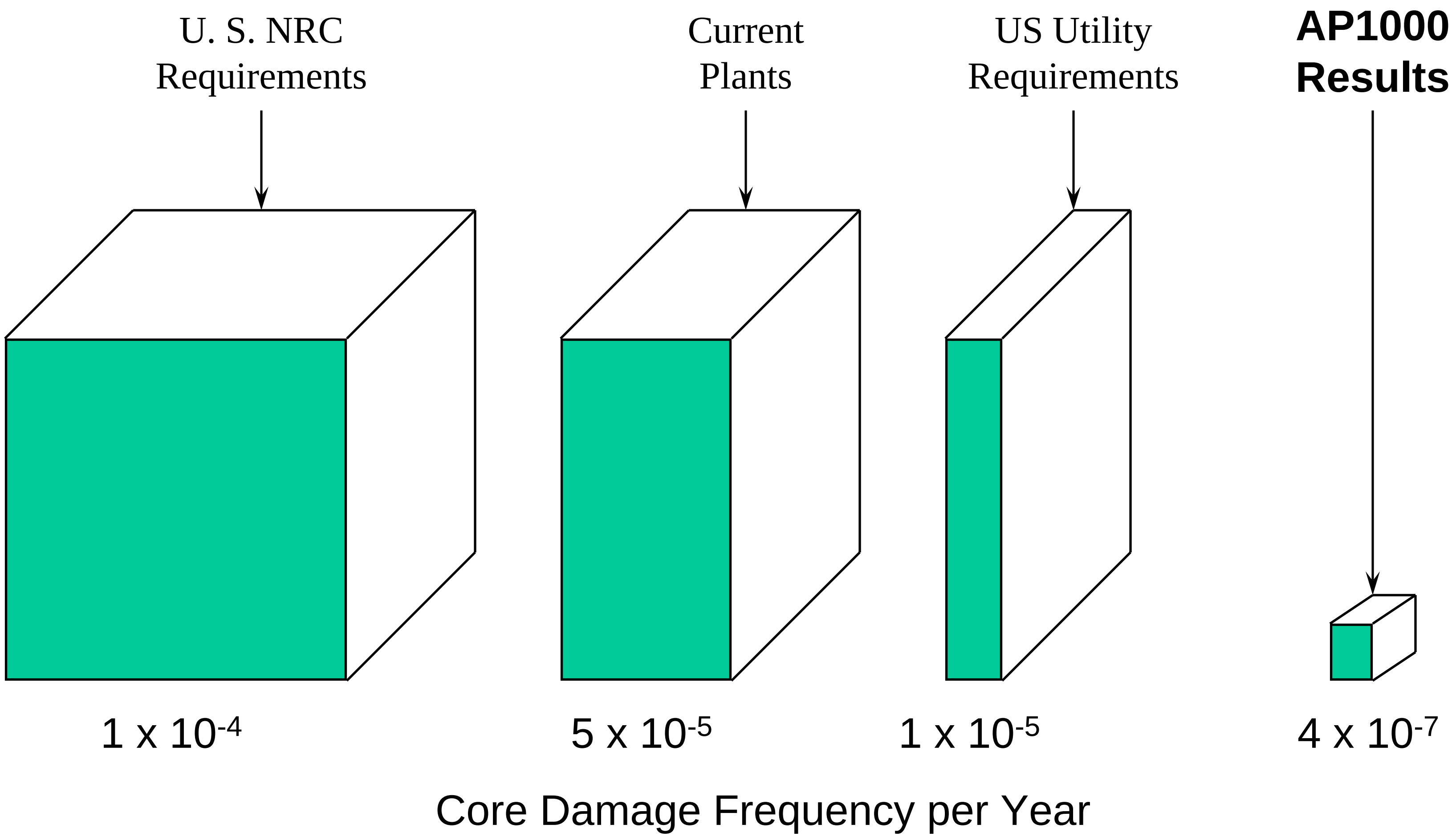
PRA Influence on Initial AP600

- Initial Design Utilized Westinghouse PRA Experience
  - Insights from analysis of existing Westinghouse PWRs
  - Insights from use of PRA in design of later plants
    - Sizewell, PUN, SP/90 (APWR)
  - PRA impact on initial AP600 included
    - Fail-safe valves for PRHR HX & passive cont cooling
    - Automatic SGTR protection via ADS
    - Redundant active equipment in NNS systems
      - Powered by on-site AC source (one diesel-generator)
      - SFWS with redundant pumps
      - Improvements to RNS
        - Separate from SFS, Mid-loop, RCS isolation

Full Level 3 PRA

- Level 1, Core Damage Frequency
  - Linked event / fault trees
  - 26 initiating events, some unique to AP600 / AP1000
  - Fault trees included common cause modeling
  - Operator actions explicitly modeled
- Level 2, Containment Response
  - Containment event trees
  - Severe accident phenonium addressed
    - Hydrogen burns, high pressure core ejection, steam explosions, invessel retention / core-concrete interaction
- Level 3, Offsite Releases
  - Mechanistic release, transport of activity

AP1000 Provides Safety and Investment Protection



AP1000 PRA Results

At Power, Internal Events	2 Loop	AP600	AP1000
Medium LOCA	5.0E-06	8.0E-08	1.1E-07
Large LOCA	8.0E-07	5.0E-08	7.5E-08
ATWT	2.2E-06	1.0E-08	4.4E-09
Vessel Rupture	3.0E-07	1.0E-08	1.0E-08
SG Tube Rupture	1.7E-06	6.1E-09	6.8E-09
Small LOCA	8.0E-06	4.7E-09	1.9E-08
Transients	1.3E-05	4.4E-09	7.3E-09
RCS Leak	--	2.3E-09	1.7E-09
Loss Offsite Power	6.6E-06	1.0E-09	9.6E-10
Steam Line / Feed Line Breaks	--	6.1E-10	7.5E-10
Loss Support Sys (CCW/SW, ...)	--	2.9E-10	1.0E-09
Inter-System LOCA	1.0E-06	5.0E-11	5.0E-11
Total at Power, CMF/yr	**3.9E-05**	**1.7E-07**	**2.4E-07**
w/o Operator Action, CMF/yr	**~ 2 E-03**	**1.8E-05**	**1.4E-05**
w/o Nonsafety Sys, CMF/yr	**~ 2 E-03**	**7.7E-06**	**7.4E-06**

AP1000 Core Damage Frequency

At Power, Internal Events	Current US	AP600	AP1000	Ratio (Current vs AP600	AP1000)
Transients	1.3E-05 /yr	4.4E-09 /yr	7.3E-09 /yr	2959	1772
Loss Offsite Power	6.6E-06 /yr	1.0E-09 /yr	9.6E-10 /yr	6600	6889
Steam Line / Feed Line Breaks	-- /yr	6.1E-10 /yr	7.5E-10 /yr	na	na
SG Tube Rupture	1.7E-06 /yr	6.1E-09 /yr	6.8E-09 /yr	279	250
RCS Leak	-- /yr	2.3E-09 /yr	1.7E-09 /yr	na	na
Small LOCA	8.0E-06 /yr	4.7E-09 /yr	1.9E-08 /yr	1717	430
Medium LOCA	5.0E-06 /yr	8.0E-08 /yr	1.1E-07 /yr	63	44
Large LOCA	8.0E-07 /yr	5.0E-08 /yr	7.5E-08 /yr	16	11
ATWS	2.2E-06 /yr	1.0E-08 /yr	4.4E-09 /yr	218	496
Loss Support Sys (CCW/SW, ...)	-- /yr	2.9E-10 /yr	1.0E-09 /yr	na	na
Inter-System LOCA	1.0E-06 /yr	5.0E-11 /yr	5.0E-11 /yr	20000	20000
Vessel Rupture	3.0E-07 /yr	1.0E-08 /yr	1.0E-08 /yr	30	30
Total	**3.9E-05** /yr	**1.7E-07** /yr	**2.4E-07** /yr	228	160
Total without Operator Actions	**~ 2 E-03** /yr	**1.8E-05** /yr	**1.4E-05** /yr	111	146
Total without Nonsafety Systems	**~ 2 E-03** /yr	**7.7E-06** /yr	**7.4E-06** /yr	260	270

AP1000 Reduces Risk

	Core Melt Frequency		Large Release Frequency	
	At-Power	Shutdown	At-Power	Shutdown
Internal Events	2.41E-07 /yr	1.23E-07 /yr	1.95E-08 /yr	2.05E-08 /yr
Internal Floods	8.82E-10 /yr	3.22E-09 /yr	7.10E-11 /yr	5.37E-10 /yr
Internal Fires	5.61E-08 /yr	8.52E-08 /yr	4.54E-09 /yr	1.43E-08 /yr
Sub-Totals	2.98E-07 /yr	2.11E-07 /yr	2.41E-08 /yr	3.53E-08 /yr
Grand-Totals	5.09E-07 /yr		5.94E-08 /yr	
NRC Safety Goals	1.00E-04 /yr		1.00E-06 /yr	

- Meets US NRC Safety Goals with High Margin & Low Uncertainty
  - Demonstrates effectiveness of passive safety features
    - Reduced dependency on operator actions and nonsafety features
    - Low safety risk from floods and fires
  - Severe accidents addressed by design
    - Invessel retention is very effective and reliable

AP1000 CDF / LRF Summary

	AP600	AP1000	NRC Goal	
Core Damage Frequency				
Internal Events at Power	1.7E-07	2.4E-07		
Internal Events at Shutdown	9.1E-08	1.2E-07		
Total	**2.6E-07**	**3.6E-07**	**1.0E-04**	/yr
Large Release Frequency				
Internal Events at Power	1.8E-08	2.0E-08		
Internal Events at Shutdown	1.5E-08	2.0E-08		
Total	**3.3E-08**	**4.0E-08**	**1.0E-06**	/yr

AP1000 Importance of Non-Safety Systems

- Determined Safety Importance of Non-Safety Systems
  - Part of the resolution of Regulatory Treatment of Non-Safety Systems (RTNSS) Policy Issue
  - Included PRA sensitivity studies / evaluations
    - Initiating event frequency evaluations
    - Mitigation importance evaluations using system importances
      - Shows CDF less than NRC safety goals
  - Also included deterministic evaluations
    - ATWS rule, long term shutdown (> 72 hr), seismic
  - DCD contains availability controls for selected NSS features
    - Similar to Tech Spec, but without plant shutdown requirements

AP1000 System Importances

Important			Medium Imortance	Marginally Important	
1.0E-02	**1.0E-03**	**1.0E-04**	**1.0E-05**	**1.0E-06**	**1.0E-07**
PMS	ADS	IRWST Inject	CMT	AC power[2]	RNS [2]
	Cont Recirc		Accum		MFW [2]
	1E DC		PRHR HX		SFW [2]
			PLS [2]		DG [2]
			non-1E DC[2]		CCW/SWS[2]
			DAS [2]		CAS [2]

Notes:

(1) CDF assuming system has failure probability of 1.

(2) Non safety features.

Importance on Nonsafety Systems

	Base AP1000	w/o NNS Systems (1)	NRC Safety Goal
Core Damage Frequency			
Internal Events at Power	2.40E-07	2.10E-06	
Internal Events at Shutdown	1.20E-07	9.70E-07	
Total	**3.60E-07**	**3.07E-06**	**1.0E-04** /yr
Large Activity Release Frequency			
Internal Events at Power	1.90E-08	4.30E-07	
Internal Events at Shutdown	2.00E-08	3.80E-07	
Total	**3.90E-08**	**8.10E-07**	**1.0E-06** /yr

Notes:

(1) Sensitivity study with same IE frequencies but no mitigation credit for nonsafety systems (CVS, SFW, RNS, onsite / offsite AC power, DAS).

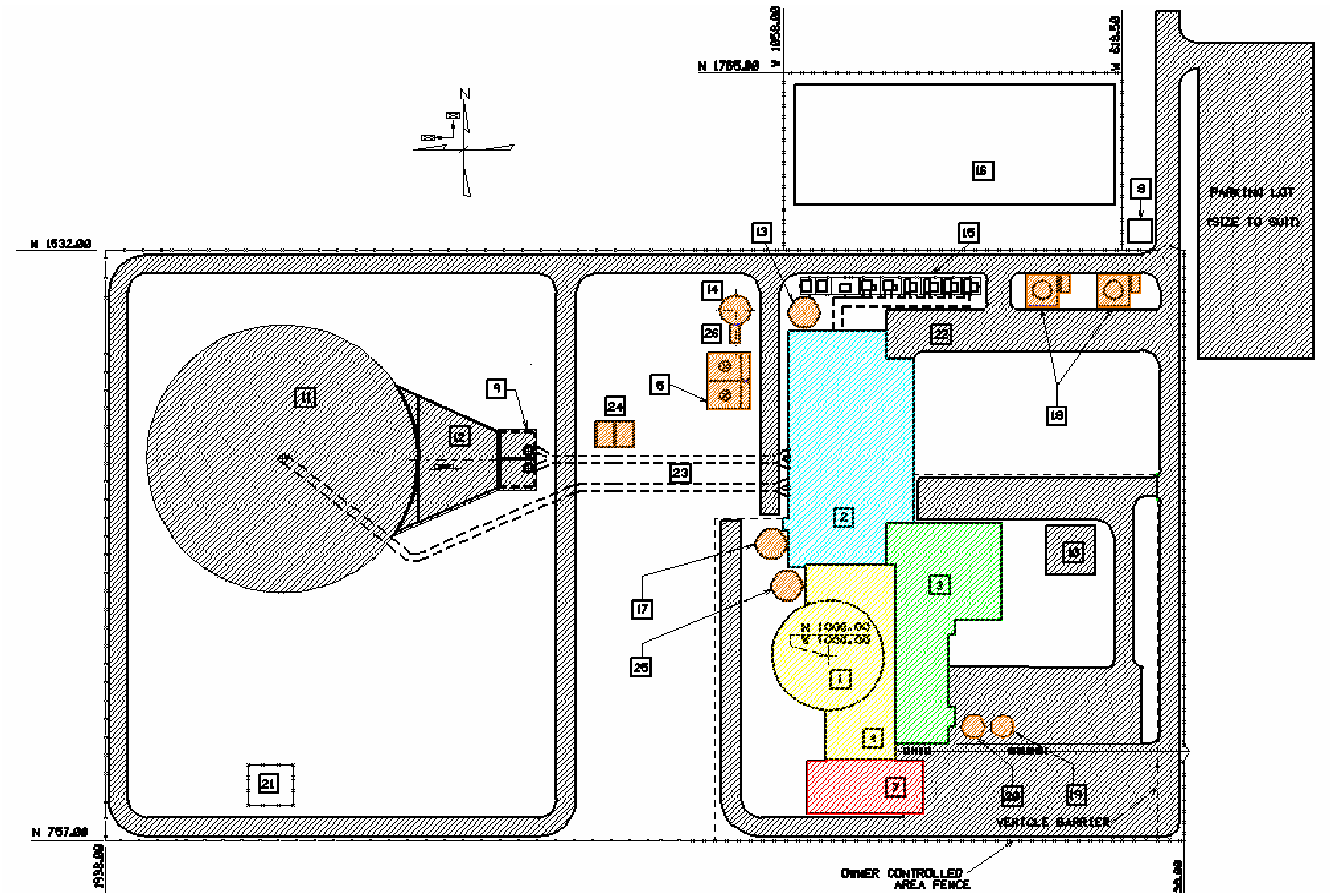
AP1000 CMF Insights

- Passive Systems Are Very Reliable
  - Very simple designs with few components that need to function
  - Not dependent on support systems; AC power, cooling water, HVAC, instrument air
- Single System / Component Failures Not Very Important
  - Different passive safety features provide redundancy / diversity
- Nonsafety Mitigation Systems Are Less Important
  - Compared to current or advanced evolutionary plants
- Operator Actions Are Less Important
  - Compared to current or advanced evolutionary plants
- Containment Isolation Improved
  - Fewer penetrations; all open penetrations fail closed

Plant Layout and Construction

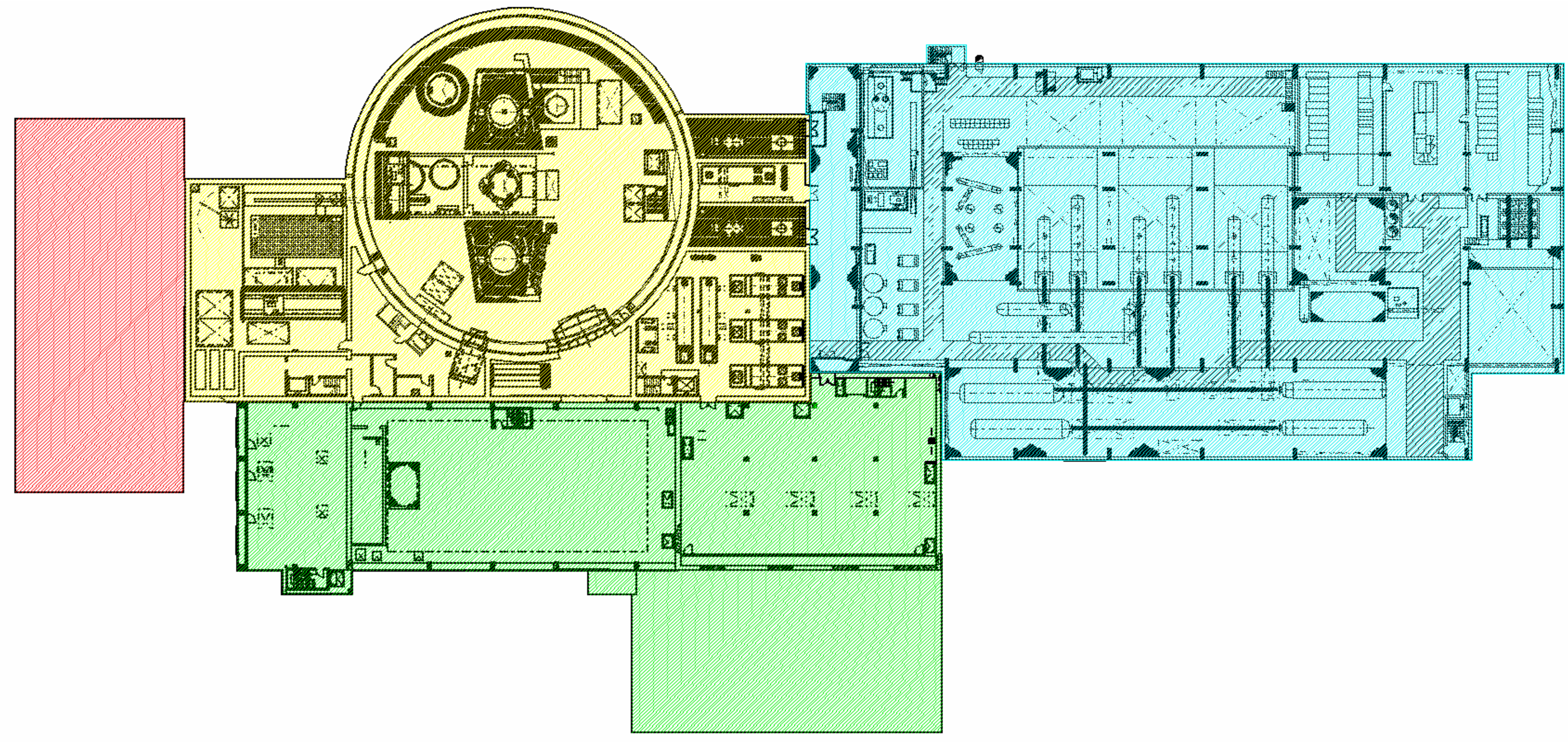
Jim Winters

AP1000 Plot Plan



AP1000 Plant General Arrangement

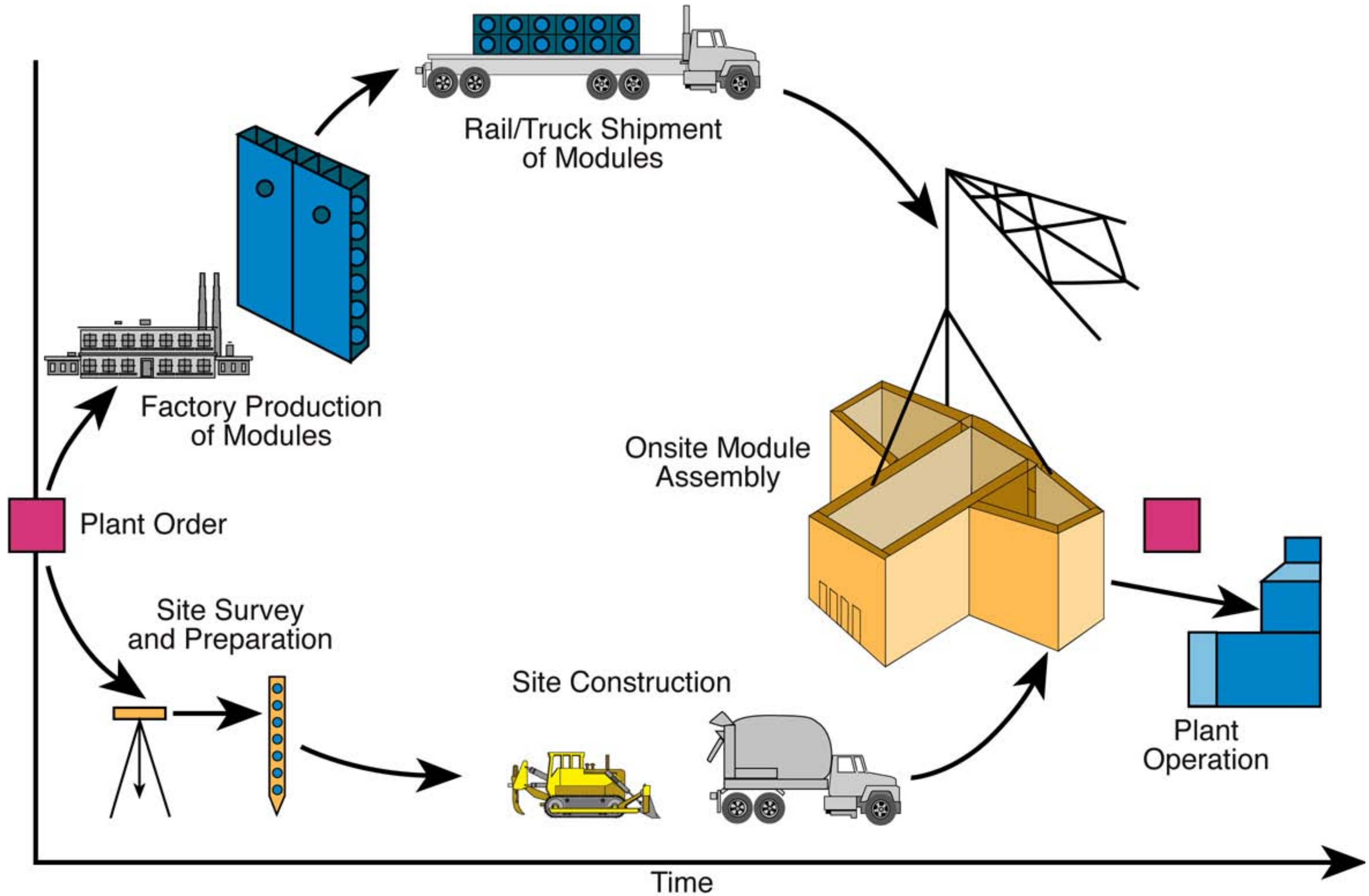
Plant Elevation 135’-3”



AP1000 Construction Approach

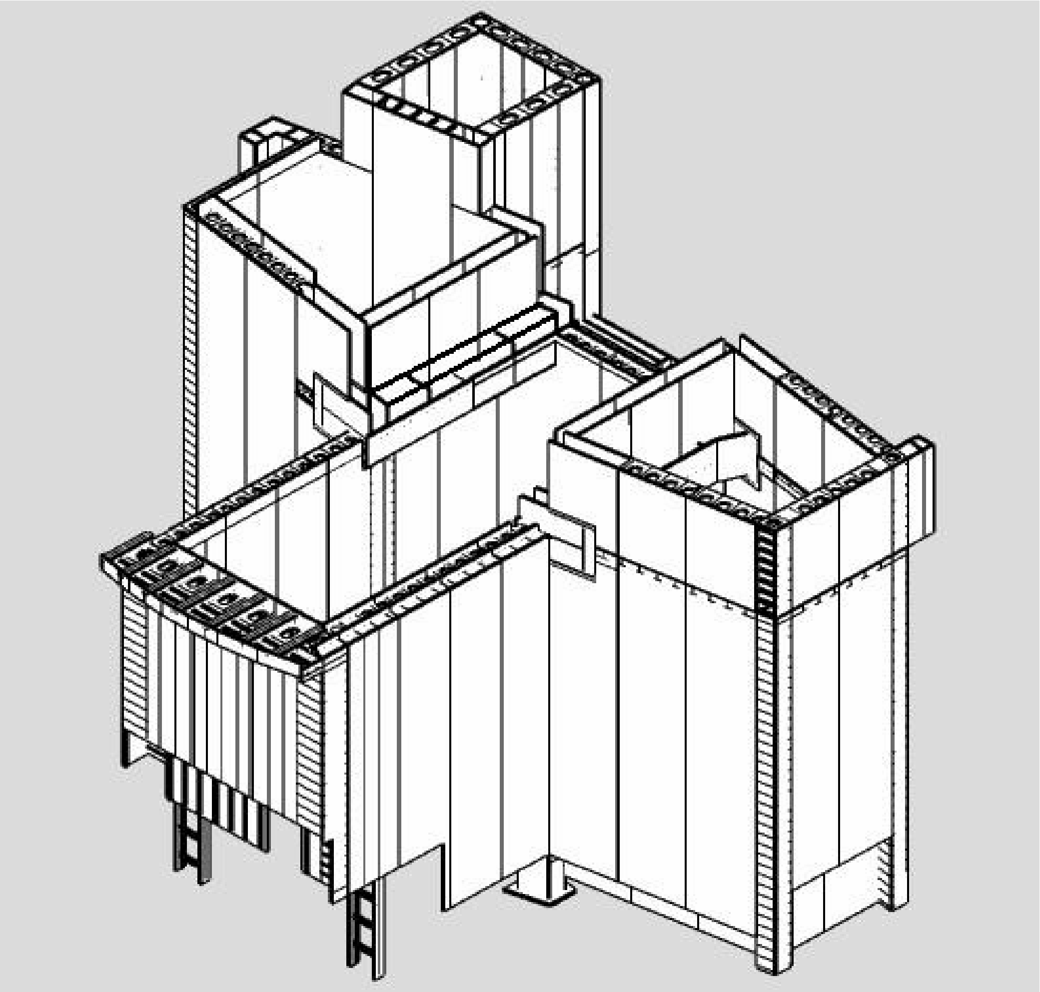
- Simplification of Systems
  - Major reduction in bulk materials and field labor
- Maximize Use of Modularization
  - 300 rail-shippable equipment and piping modules
  - 50 large structural modules
    - Assembled on-site from rail-shippable structural modules
  - Factory based manufacture and assembly of modules
    - Predictable, short manufacturing schedule
    - Improved quality control
      - Pre-testing and inspection prior to shipment
  - Streamlined field installation
    - Modules reduce field labor
    - Use of detailed work sequencing

Parallel Tasks on Modular AP1000 Shorten Construction Schedule

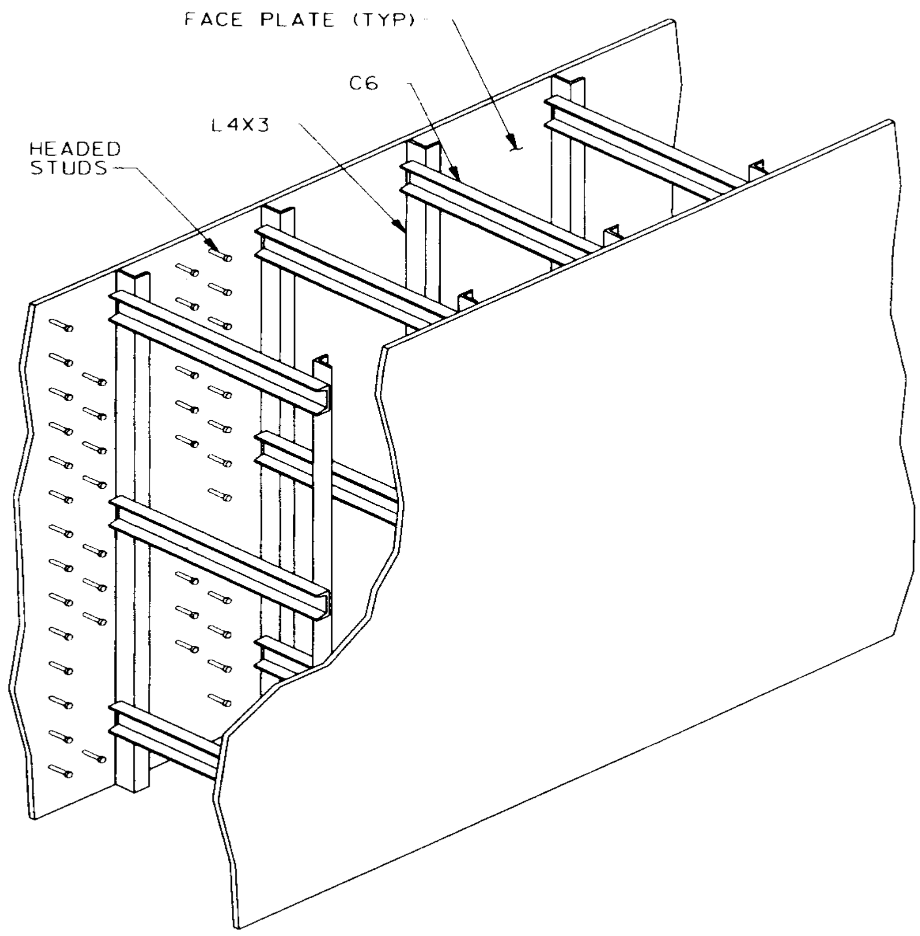


Loop Compartment Module

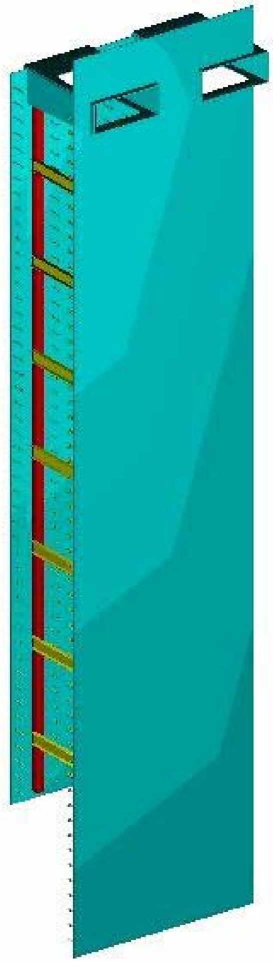
- **Use of Large Structural Modules Contributes to the 3-Year Construction Schedule**

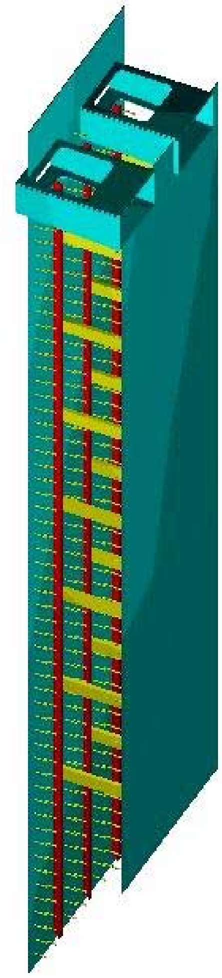


Steel Plate Structural Wall Module

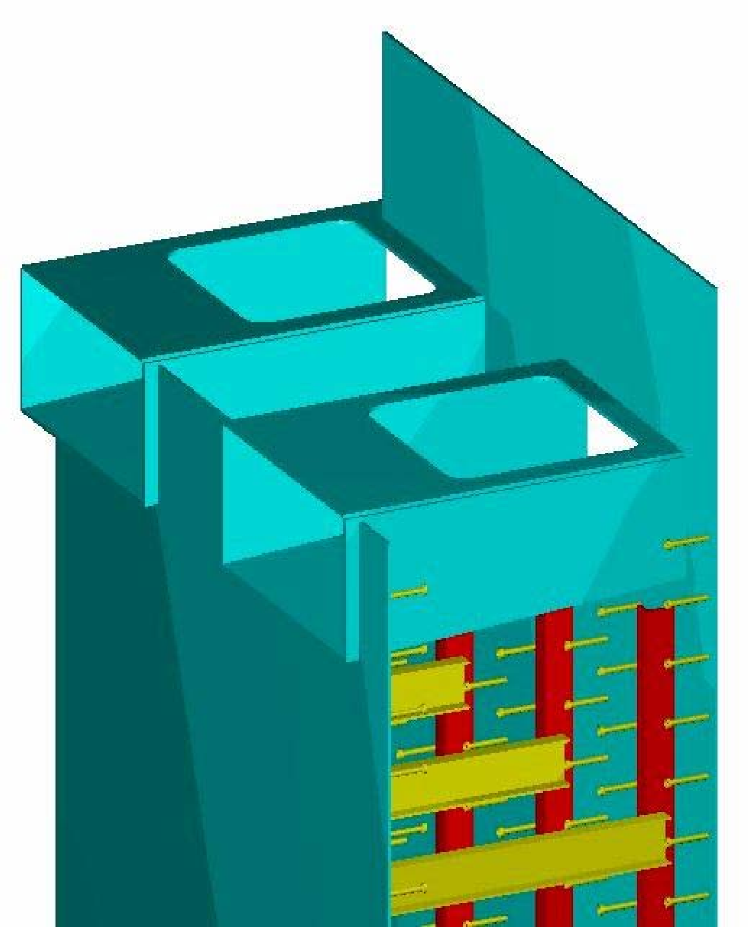


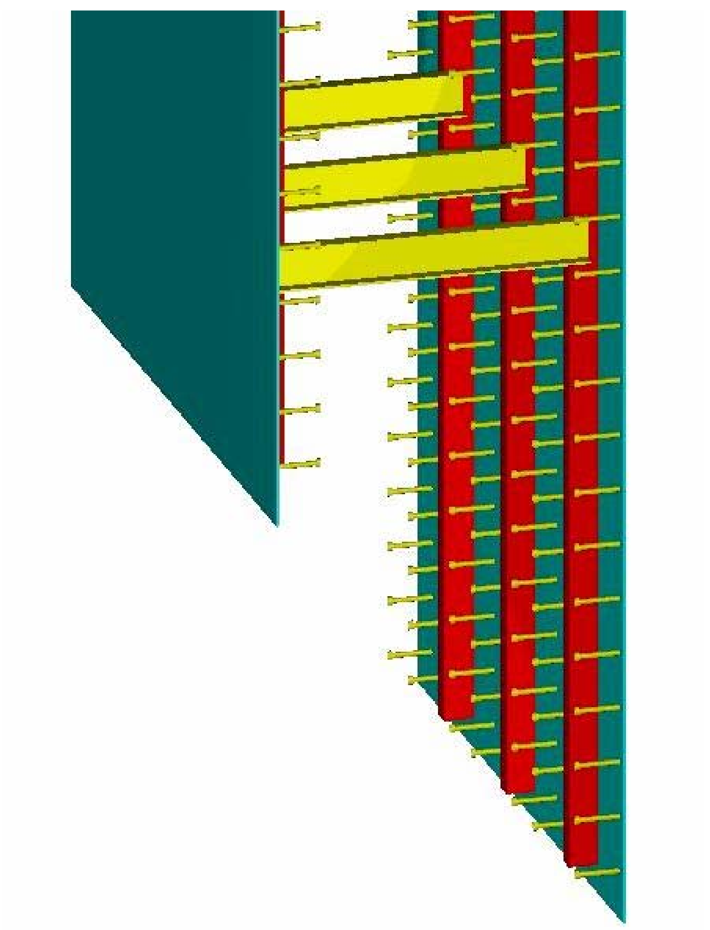
CA01 Submodule



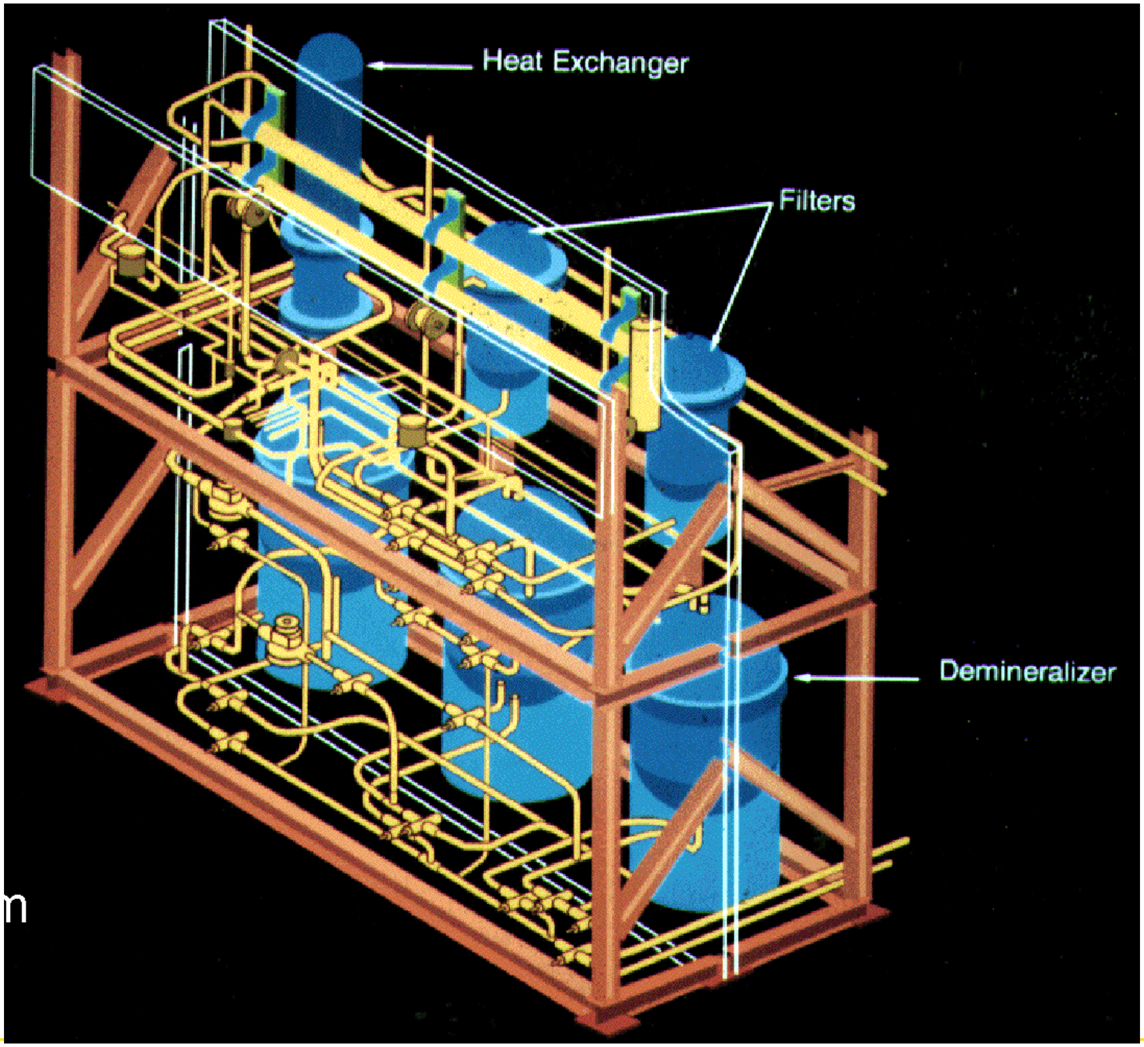


CA01 Submodule Details

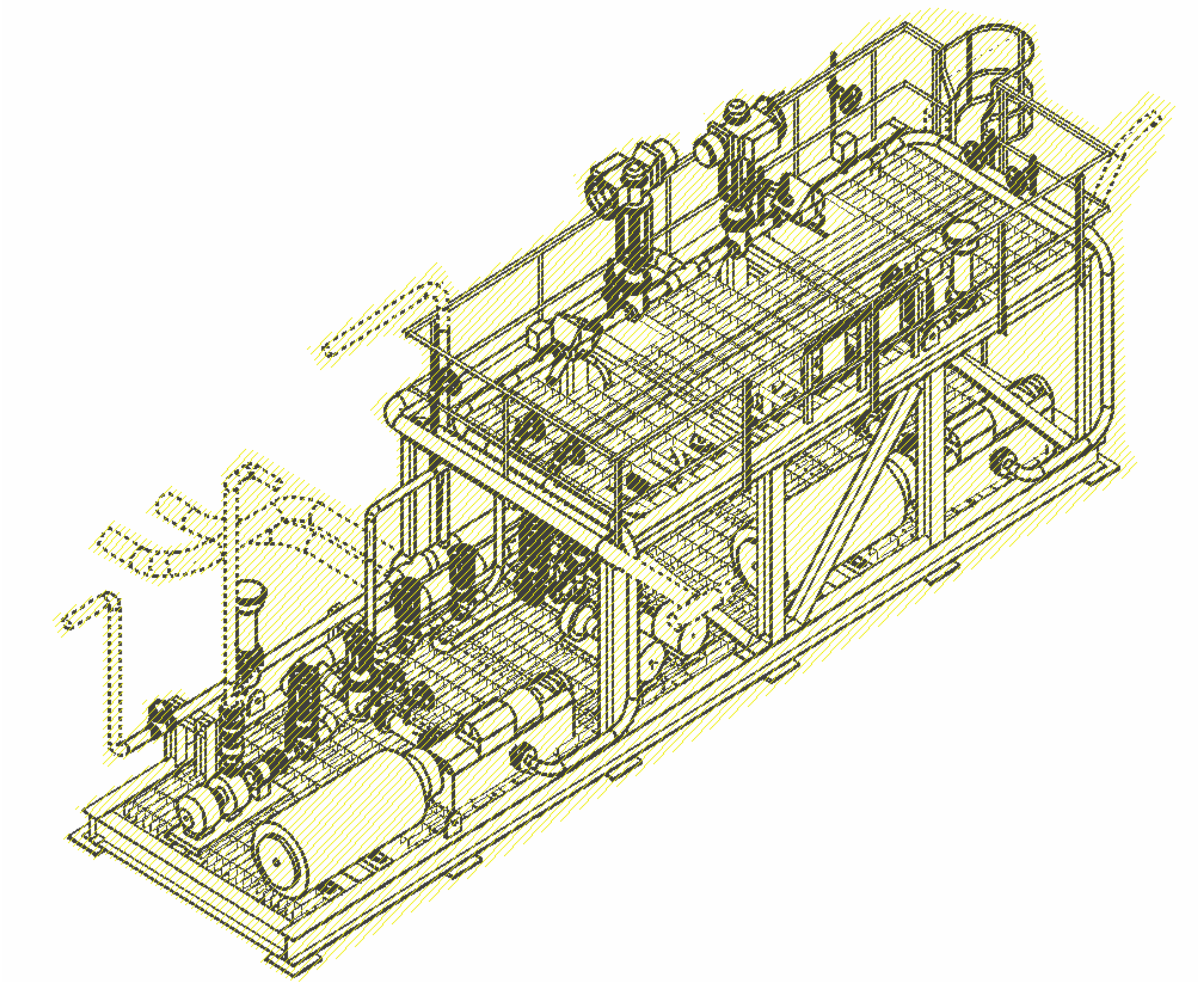




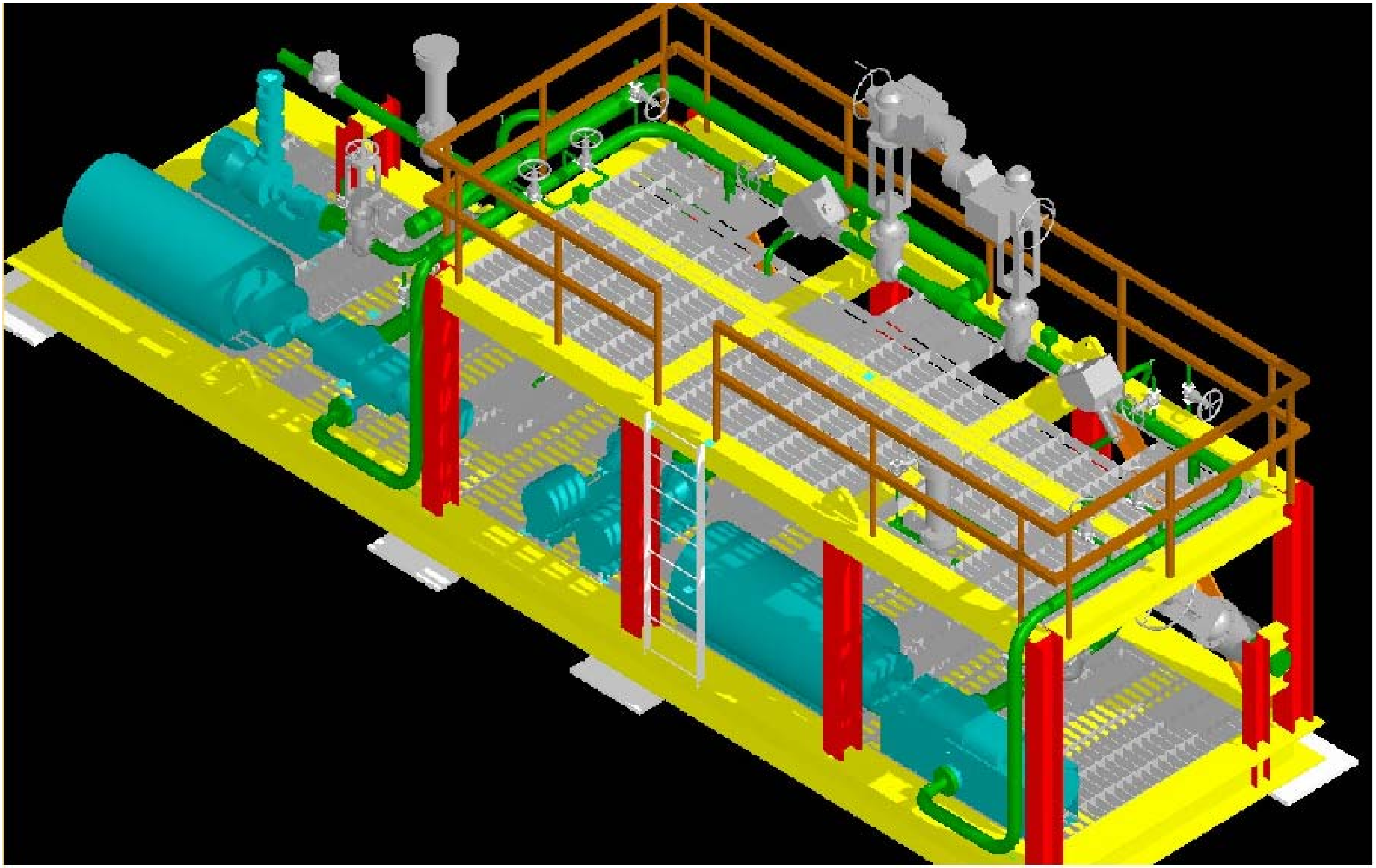
CVS Equipment Module



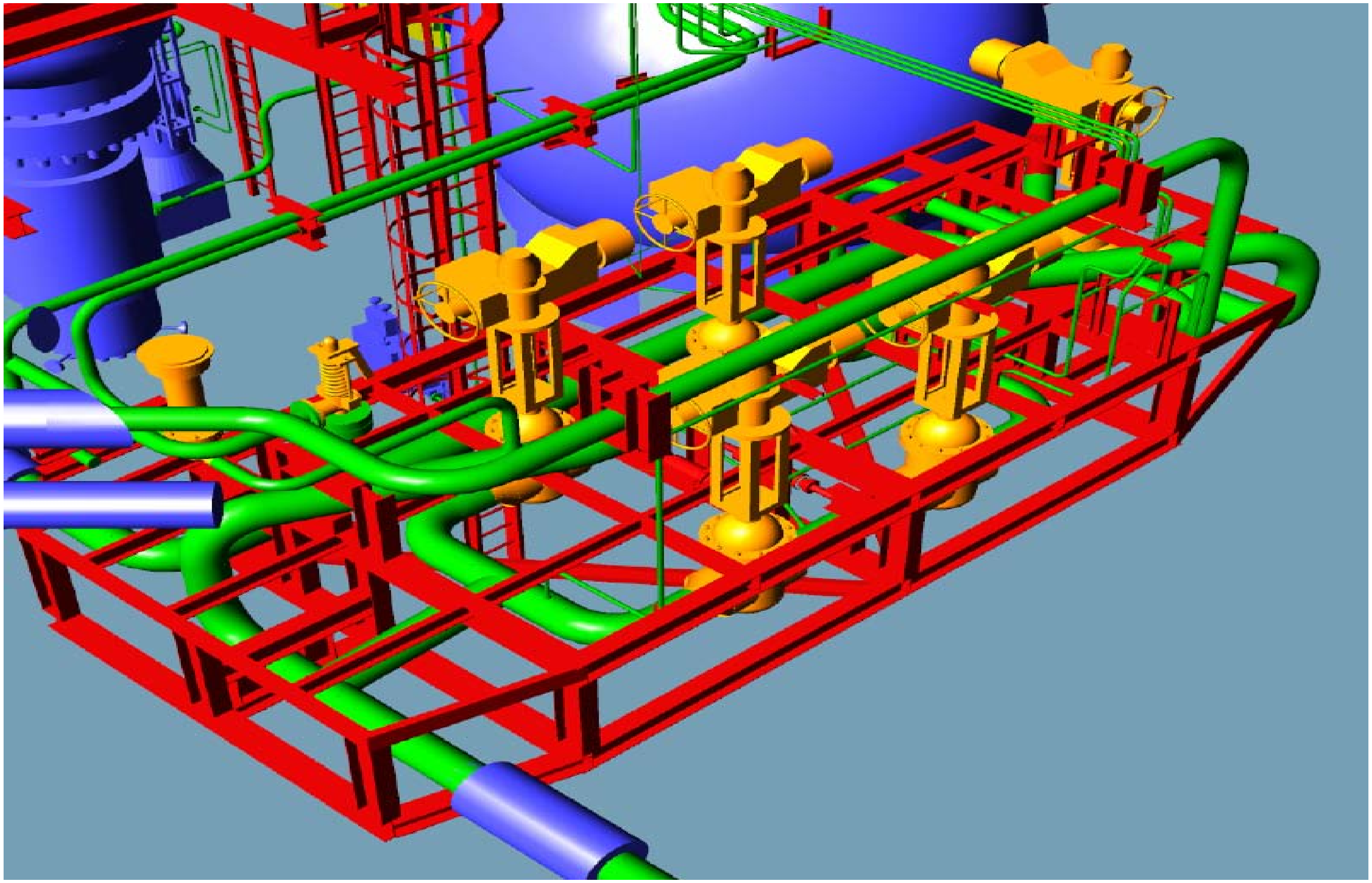
Startup Feedwater Pump Module



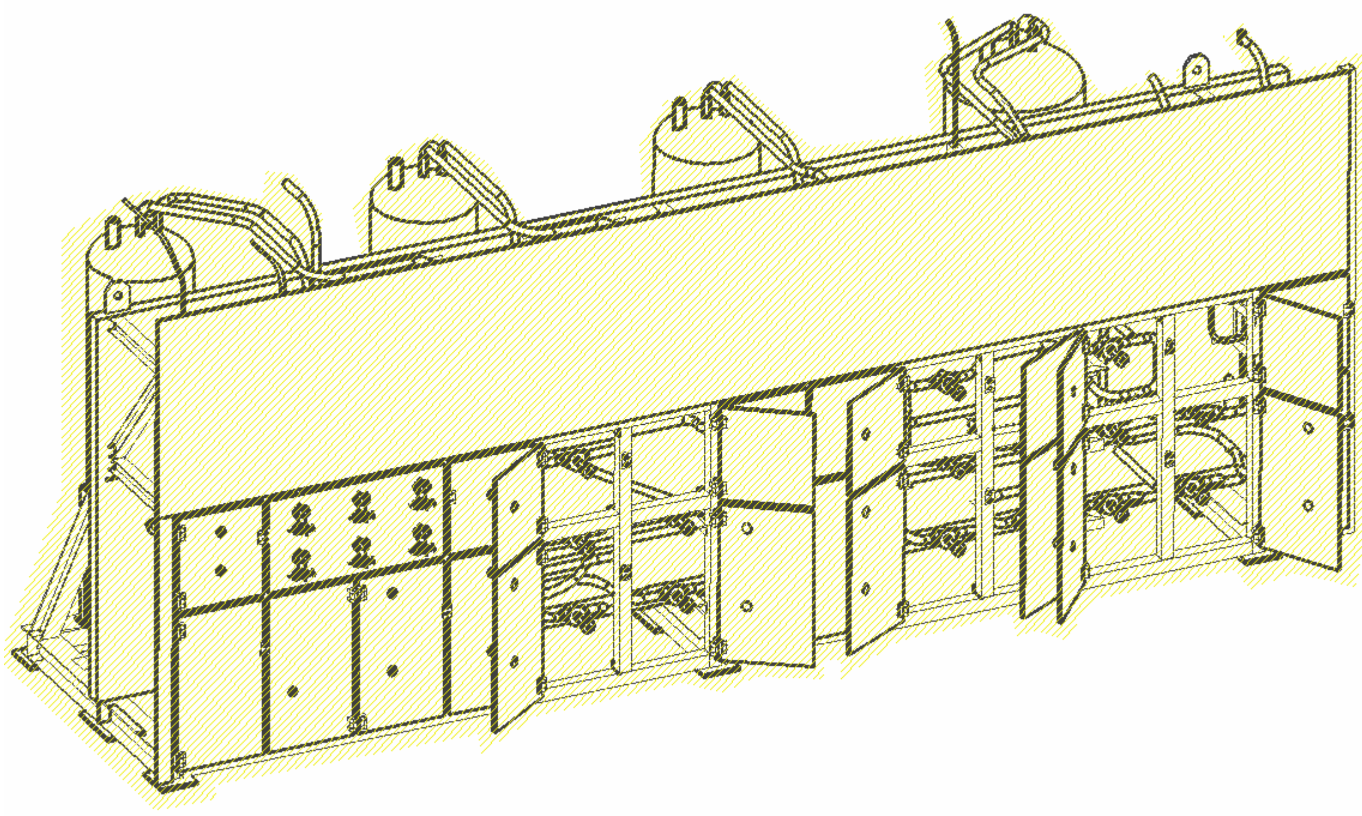
Startup Feedwater Pump Module



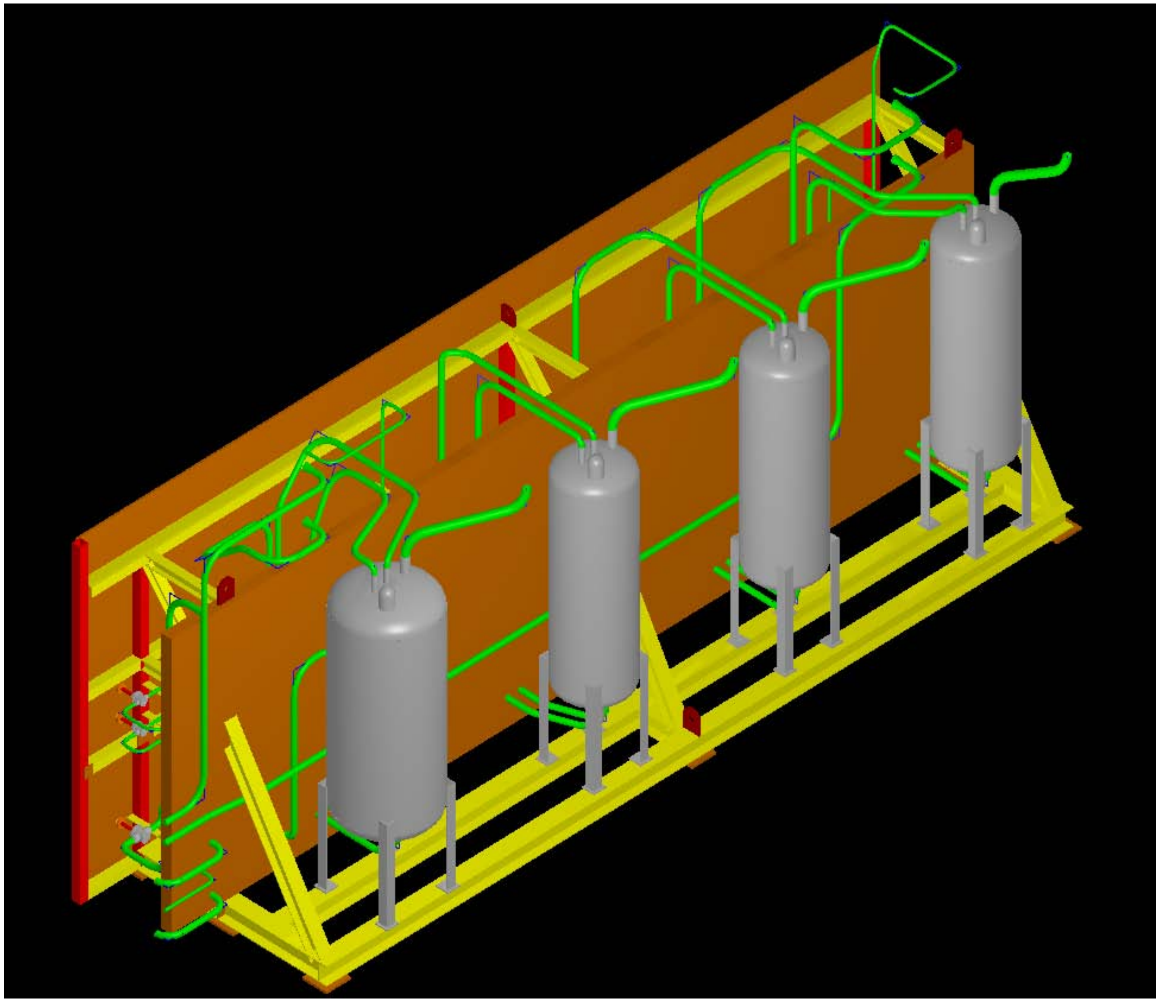
RNS Pipe / Valve Module



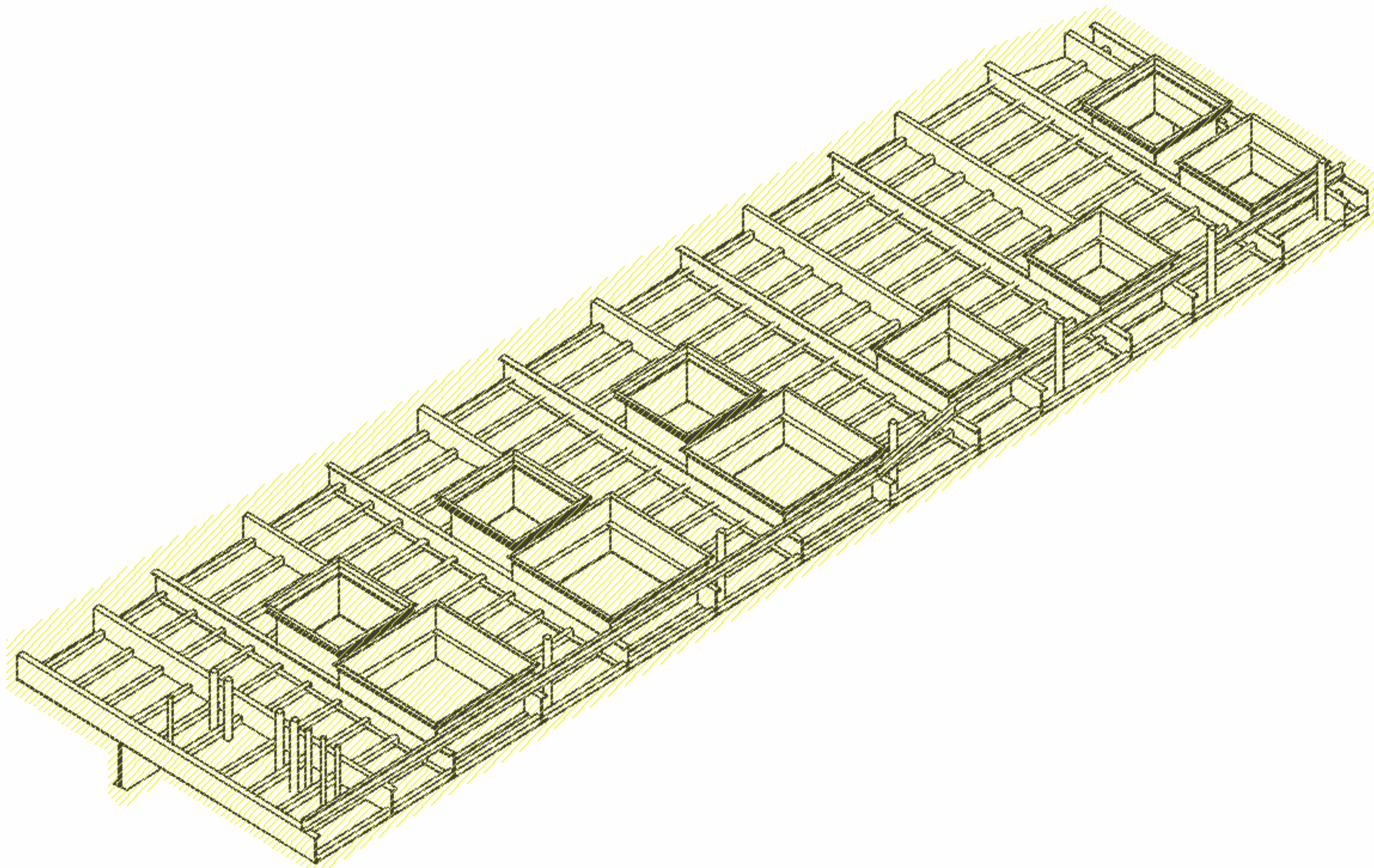
Waste System Demineralizers



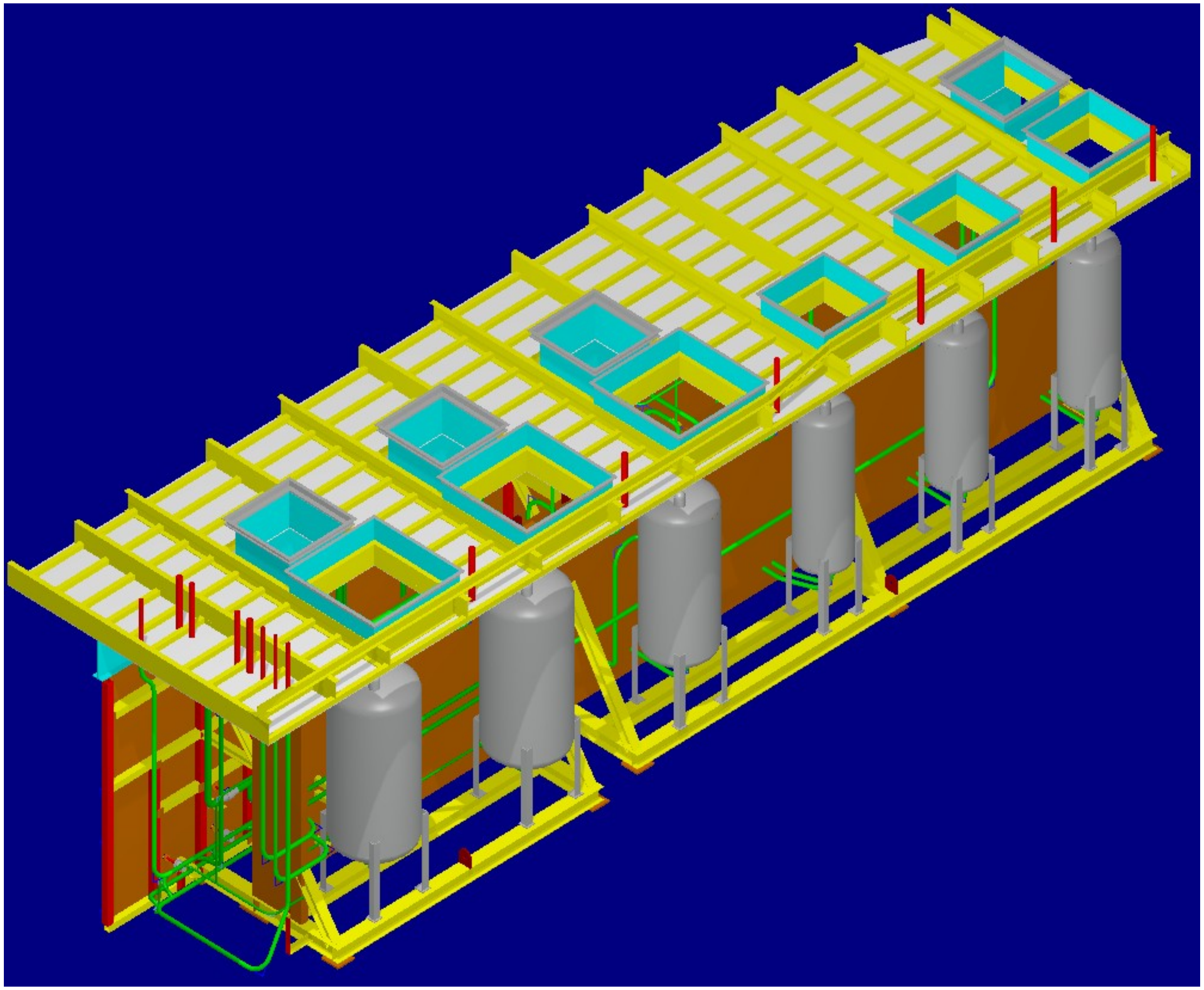
Waste System Demineralizers



Waste System Floor/Fitter Module



Integration Three Waste Modules



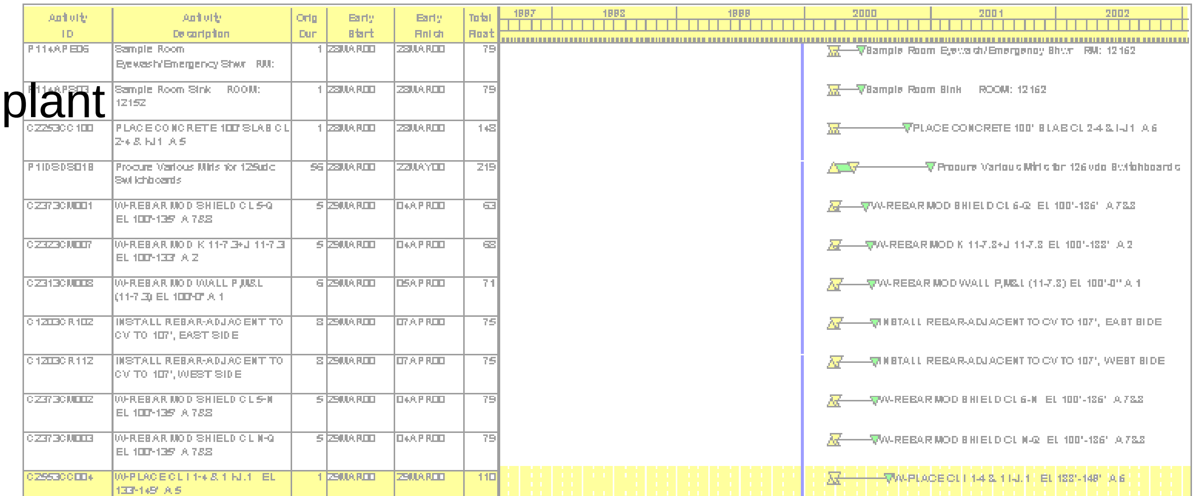
AP1000 Short Construction Schedule Has Been Verified Using 4D Virtual Construction Method

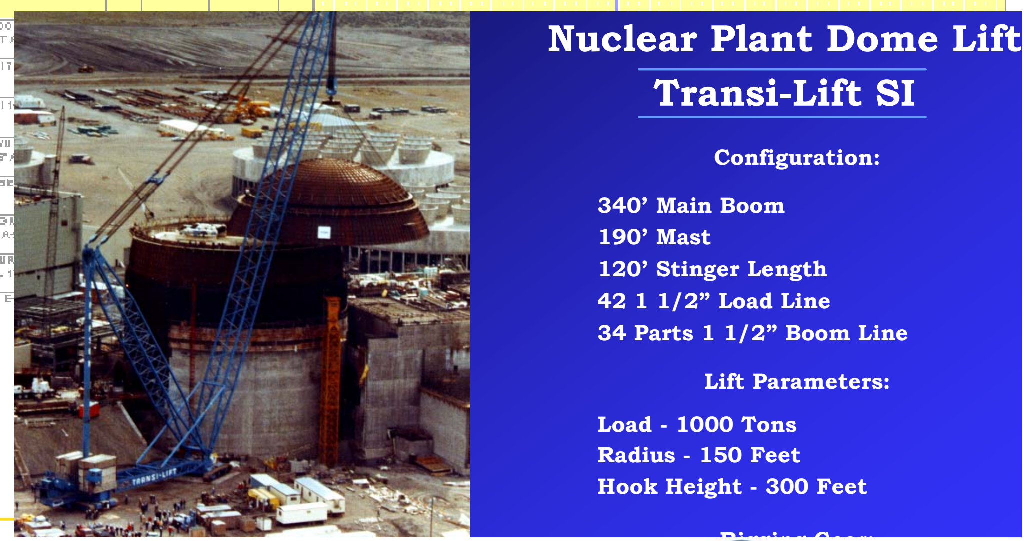
Based on AP1000 Data

- 3D detailed model of entire plant
- Construction schedule, 36 months
- Construction plan, >5600 activities
- Modularization plan
- Startup plan

Benefits of 4D Method

- Improves construction expert review
- Shortens construction schedule
- Increases schedule confidence

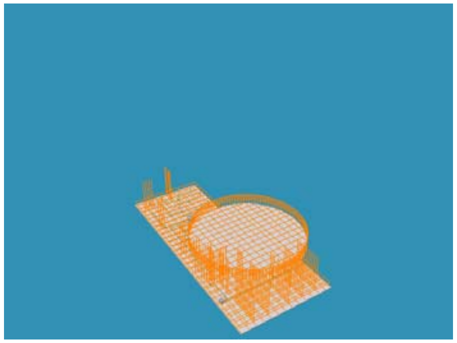
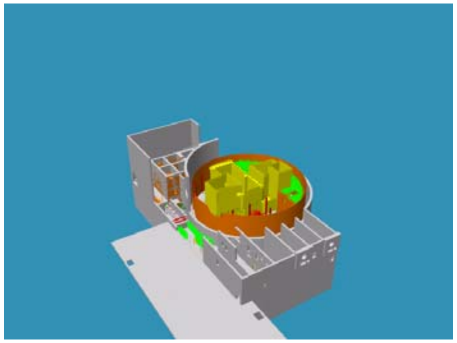
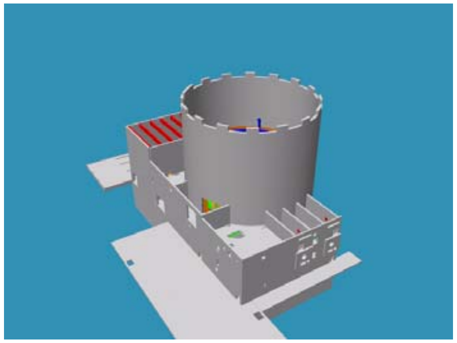
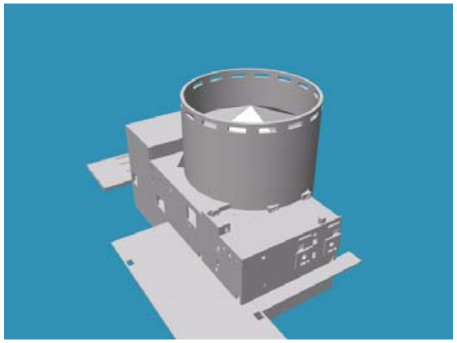




Westinghouse

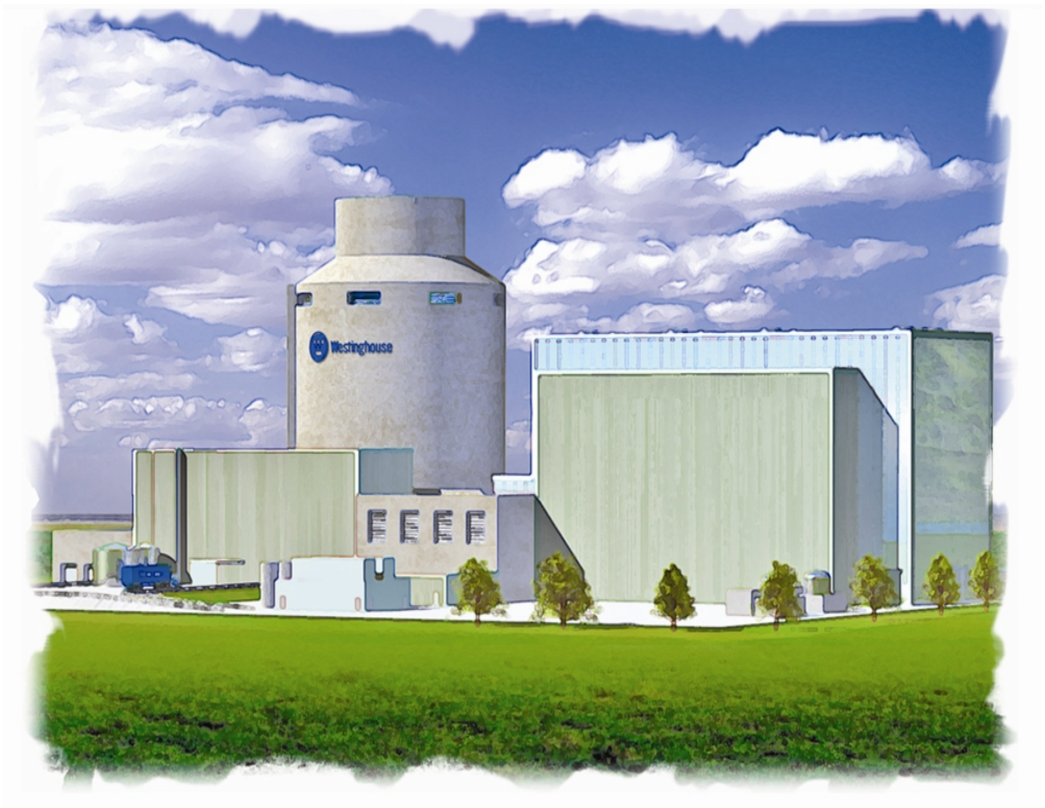
Construction Optimization

Schedule Validation and Optimization via 4D tools

AP1000 Instrumentation and Controls

Jim Winters



AP1000 I&C Systems

- Protection System (PMS)
  - Plant wide system for all safety displays & controls
  - Microprocessor / software based
- Diverse System (DAS)
  - Limited scope system, PRA based displays & controls
  - Backs up PMS where common mode failure is risk important
  - Different hardware & software than PMS
- Control System (PLS/DDS)
  - Plant wide system for all normal displays & controls
  - Microprocessor / software based
- Special Purpose Systems (SJS, RMS, IIS, etc.)

AP1000 Protection System (PMS)

- Plant-wide Class 1E system for all safety displays & controls
- Based on Common Q product line
- Detects off-nominal conditions and actuates safety functions
- Provides Class 1E post-accident monitoring functions
  - Regulatory Guide 1.97 Category 1 and some Category 2 variables
- Microprocessor / software based
- Multiplexed communications

AP1000 Protection System (PMS)

- Redundant Trains
  - 4 divisions, physically separated with improved isolation (fiber-optic)
    - Each with own independent battery-backed power supply
    - Improved HVAC separation/fire protection (2 separate HVAC systems)
  - 2-out-of-4 bypass logic, fail safe when appropriate
  - Different plant parameters provide functional diversity
- Verification and Validation
- Equipment Qualification
  - Environmental, seismic, EMC
- Improved In-Plant Testing
  - Built-in continuous self-testing and manual periodic testing
  - Modular repair

AP1000 Diverse System (DAS)

- Limited scope system
  - PRA based displays & controls
  - Backs up PMS where common mode failure is risk important
- Microprocessor / software based for automatic functions
- Manual controls and indications use no software
  - Direct wiring to indicators and actuation devices
  - Compliance with USNRC Branch Technical Position HICB-19, Position 4
- Different architecture, hardware & software than PMS
- No multiplexing
- Separate sensors from PMS and PLS

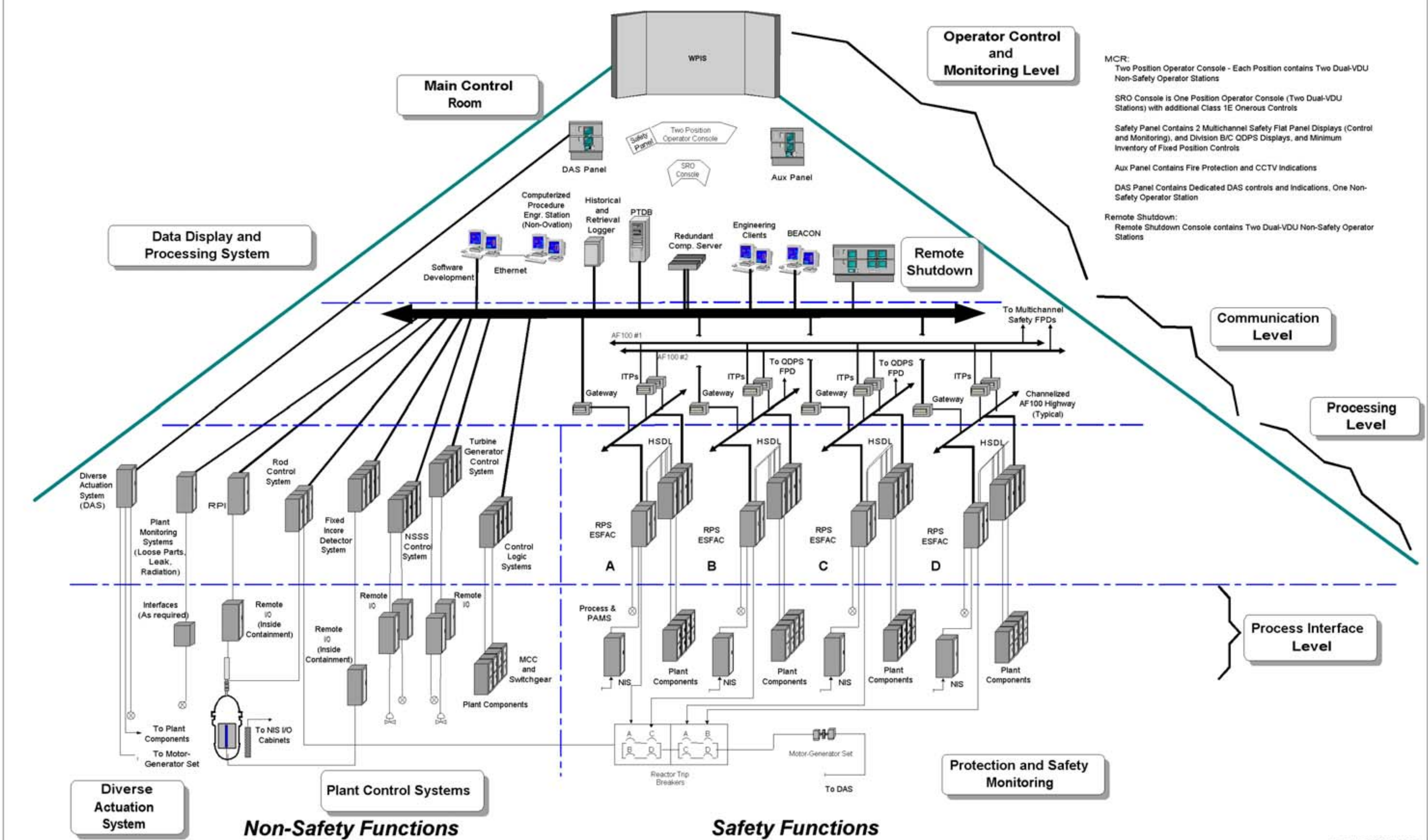
AP1000 Diverse System (DAS)

- 2-out-of-2 logic, energize-to-actuate, to minimize spurious actuation
- DAS shares some actuated equipment (e.g., valves) with PMS
  - DAS signals isolated from PMS
  - Separate actuation devices
    - Solenoid valves on AOVs
    - Igniters on squib valves
    - Relays in MCCs controlling MOVs
- Non-Class 1E

AP1000 Control System (PLS / DDS)

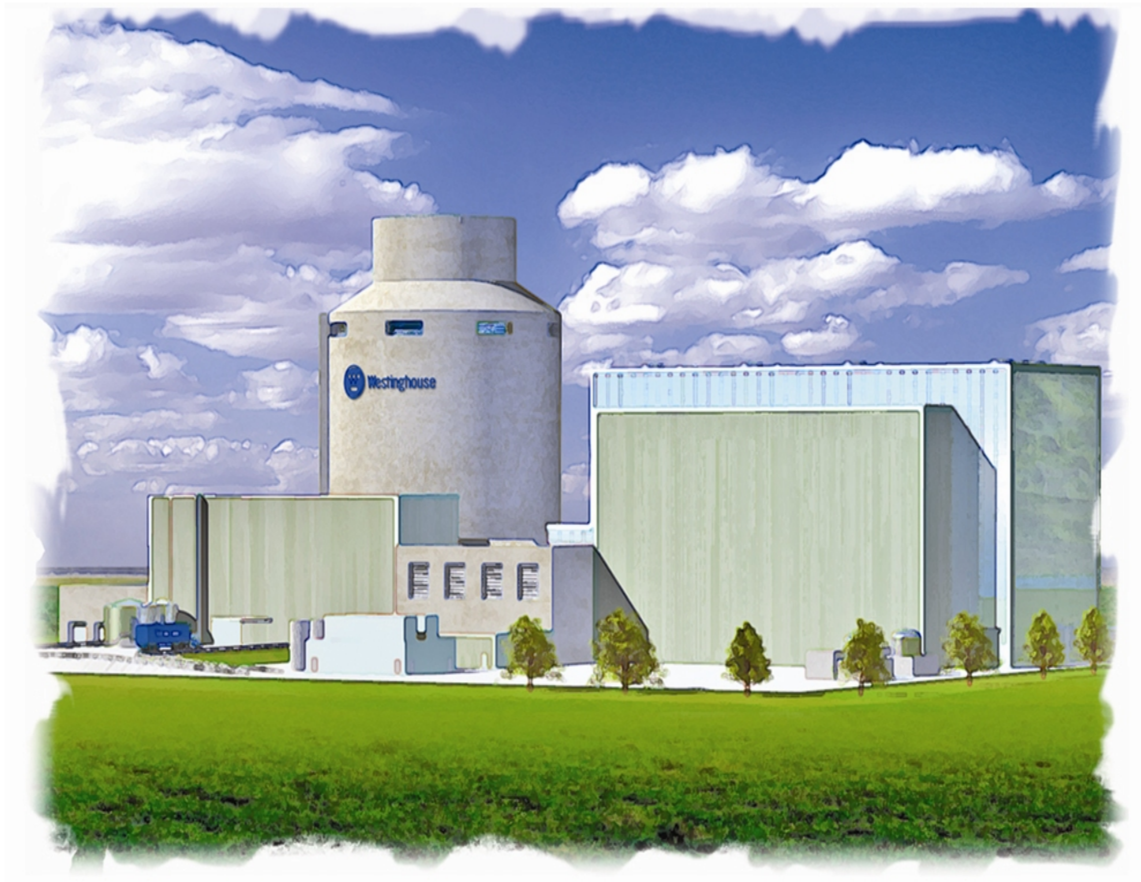
- Plant-wide system for all normal displays & controls
- Microprocessor / software based
- Expected to be ‘Ovation’ product
- Highly redundant
- Multiplexed communications
- Includes plant computer functions
- Self diagnostics / self test / continuously used
- Modular repair
- Non-Class 1E
  - Equipment Class D

AP1000 I&C System Architecture



Secondary Systems and Fire Protection

Don Hutchings

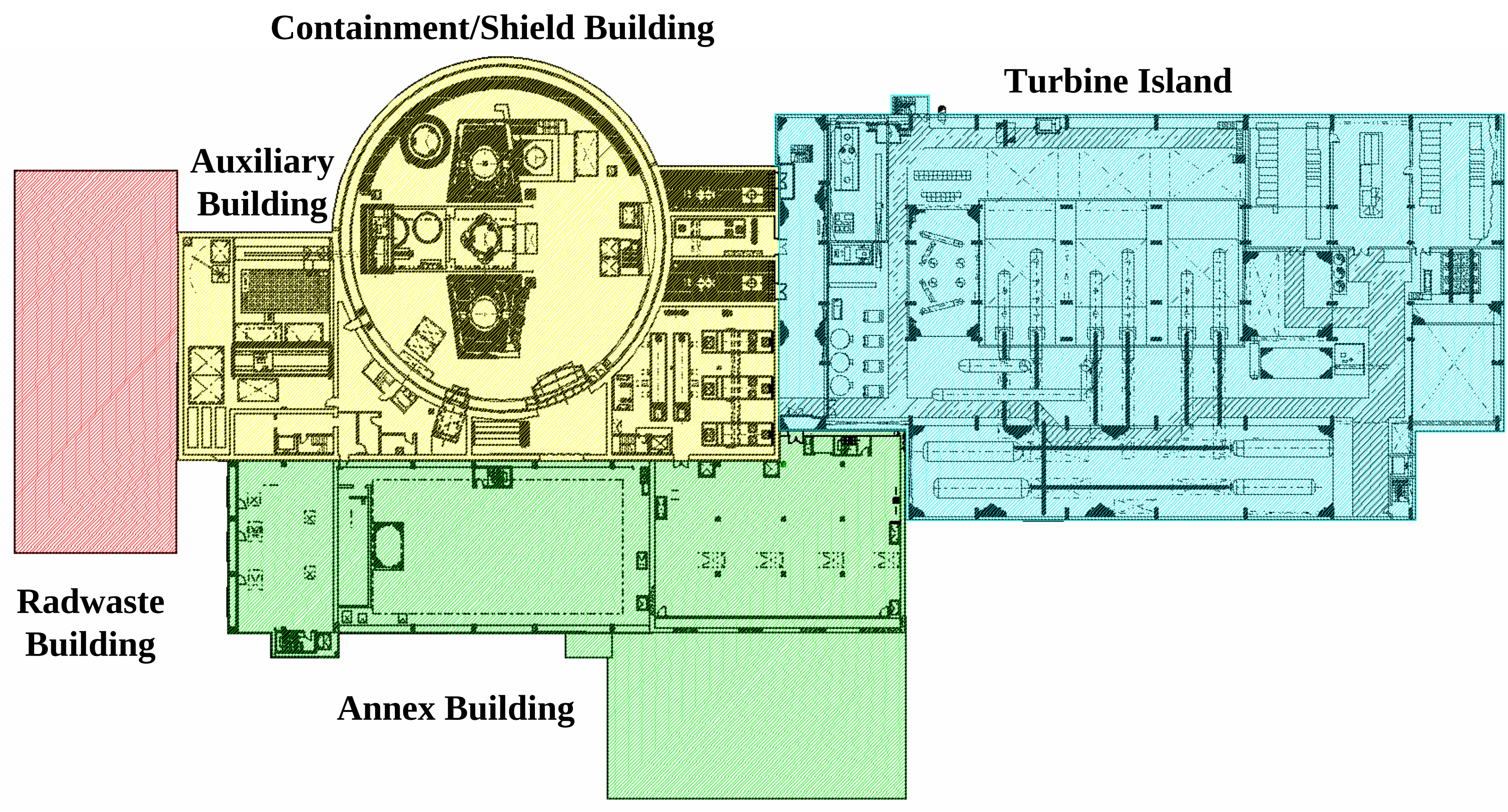


Secondary Systems and Fire Protection

- Turbine-Generator
- Steam and Water systems
- HVAC
- Fire Protection

AP1000 Plant General Arrangement

Plant Elevation 135'-3"



Functional Allocation of System Components

SHIELD BLDG
- PCS Water Storage Tank
- PCS Air Baffle
- PCS Air Diffuser

CONTAINMENT BLDG
- RCS Water
- CMT/ACC
- IRWST
- Automatic Depress. System
- CVS Purification
- RCDT/Hx

RADWASTE BLDG
- Waste Processing

AUXILIARY BLDG
- Spent Fuel Pool
- Cask Loading Area
- New Fuel Storage
- New Fuel Inspection
- SFS Pumps
- SFS Hx
- SFS Demin. & Filters
- RHR Pumps
- CVS Makeup Pumps
- Rod Control SWGR
- Reactor Trip SWGR
- Sampling Room
- Gaseous Radwaste
- Liquid Radwaste
- Solid Radwaste
- Main Control Room
- Remote Shutdown Rm
- 1E Batteries
- IPS/ICS
- MSIV Compartment
- HVAC
- RC Pump Trip SWGR

TURBINE BLDG
- Turbine-Generator
- Condensers
- Deaerator
- Condensate System
- Feedwater System
- Startup Feedwater
- Condensate Polisher
- Closed Cooling Water System
- Makeup Purification System
- SWGR
- Main Steam/Bypass/Reheat Extraction
- Circulating Water System
- S/G Blowdown
- Chillers

D-G BLDG
- Standby D/G
- Air Start Unit
- D/G Control Room
- Day Tank
- Ventilation Cooling

ANNEX BLDG
- Hot Machine Shop
- Truck Bay
- Maintenance Area
- Storage/Staging Area
- Non 1E Batteries
- Non 1E DC SWGR
- Non 1E AC SWGR
- M/G Sets
- Main Entrance
- Health Physics
- Technical Support
- Security
- Computer Room
- Locker Room

Design Status

	Containment Building	Auxiliary Building	Annex Building	Rad Waste Building	Diesel Building	Turbine Building
Structures & Layout	80%	70%	65%	65%	60%	10%
Structural Modules	75%	65%	NA	NA	NA	0%
Systems	Safety Related - 50% / Non-Safety Related - 50%					
Mechanical Modules	40%	20%	20%	20%	20%	0%
Components	40%	30%	30%	30%	30%	5%
I&C	15%					
Licensing	75%					

- The AP1000 extent of design completion is ~60%.
- Remaining work is focused on the detailed engineering to support procurement of equipment, manufacturing, fabrication and construction

Balance Of Plant Features

- Turbine building houses all traditional nonsafety systems necessary to support steam and power conversion systems
  - Condensate system, main feedwater system, main steam system, turbine-generator systems, circulating water system, demineralized water system, compressed air system
- Turbine building also houses active nonsafety support systems
  - Startup feedwater system, component cooling water system, service water system, instrument air
- BOP includes redundant nonsafety diesels to support active nonsafety systems
- Only a single source of off-site power is required
- No safety-related compressed air system
- All HVAC is non-safety
  - Safety-related control room habitability is passive
- No active safety-related heat sink -- ultimate heat sink is passive
- Smaller security perimeter

AP1000 Turbine Island Basic Parameters

- Single Turbine-Generator (MHI)
  - 1 x HP, 3 x LP turbines
  - 1800 RPM
  - 54" Last Stage Blades
    - Testing complete, first installation ~ 2006
- 2 Moisture Separator Reheaters
- 3 Condensers
  - 3 x 50% Condensate Pumps
- 4 LP Feedwater Heating Stages
- 1 Deaerator
- 3 Feedwater Pumps
  - 3 x 33% motor driven pumps
- 1 HP Feedwater Heating Stage

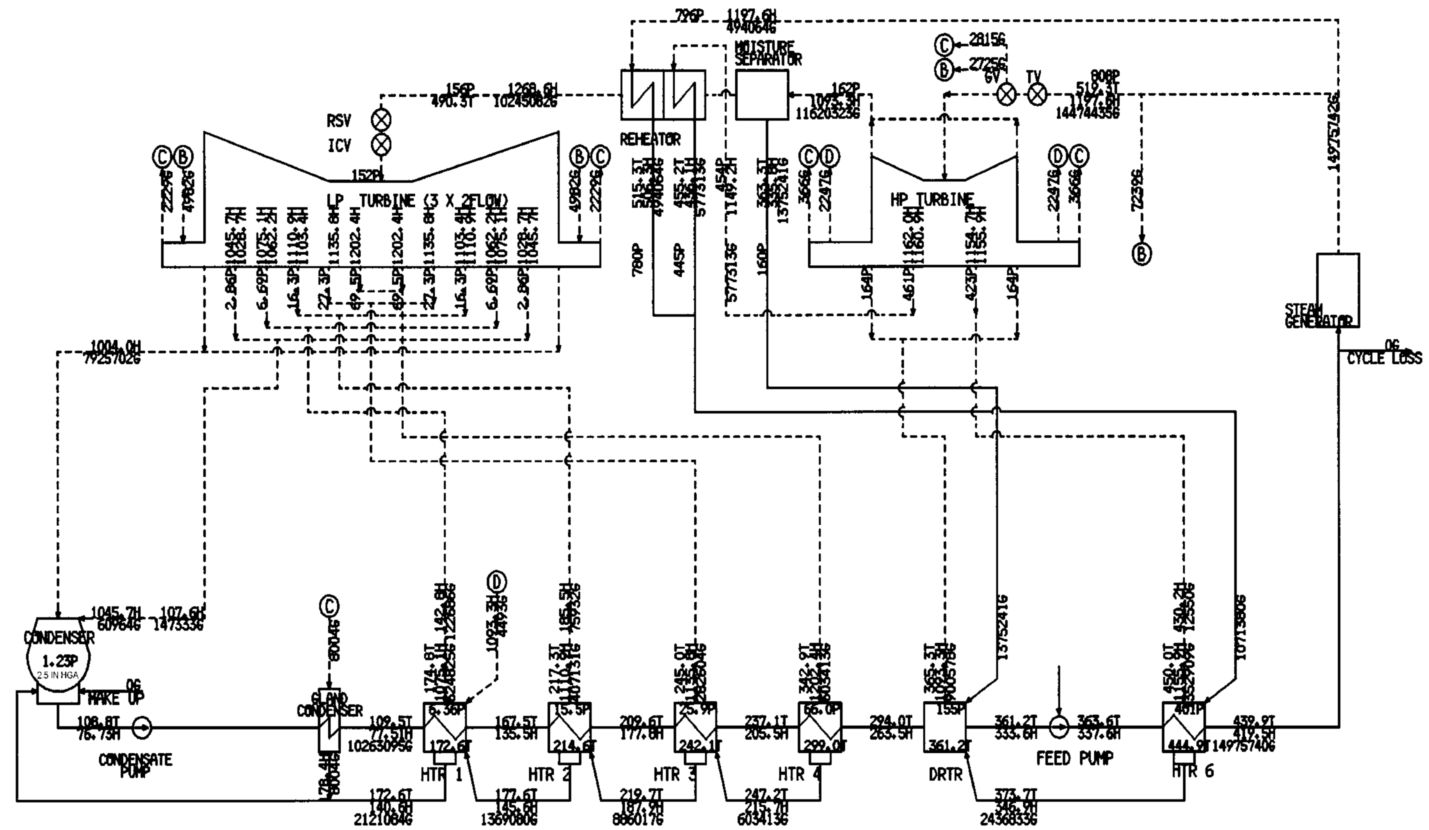
Turbine-Generator

- Turbine Extractions for 6 Stages of Feedwater Heating   [7 Stages]
- Turbine Valve Inspection Interval changed to match 18-month fuel cycle [24-month fuel cycle]

Turbine-Generator (T-G)

- MHI Turbine
- ~1200 MWe Gross
- 3 Low-Pressure (LP) Turbines
- 54-inch Last-Stage Blades
- 1375 MVA, Gas/Water Cooled Generator
- 2 Moisture Separator Reheaters (MSRs)
- 2-stage Reheater

AP1000 Heat Balance



P: PRESSURE (PSIA)
H: ENTHALPY (BTU/LB)
G: FLOW (LBS/H)
T: TEMPERATURE (DEG. F.)

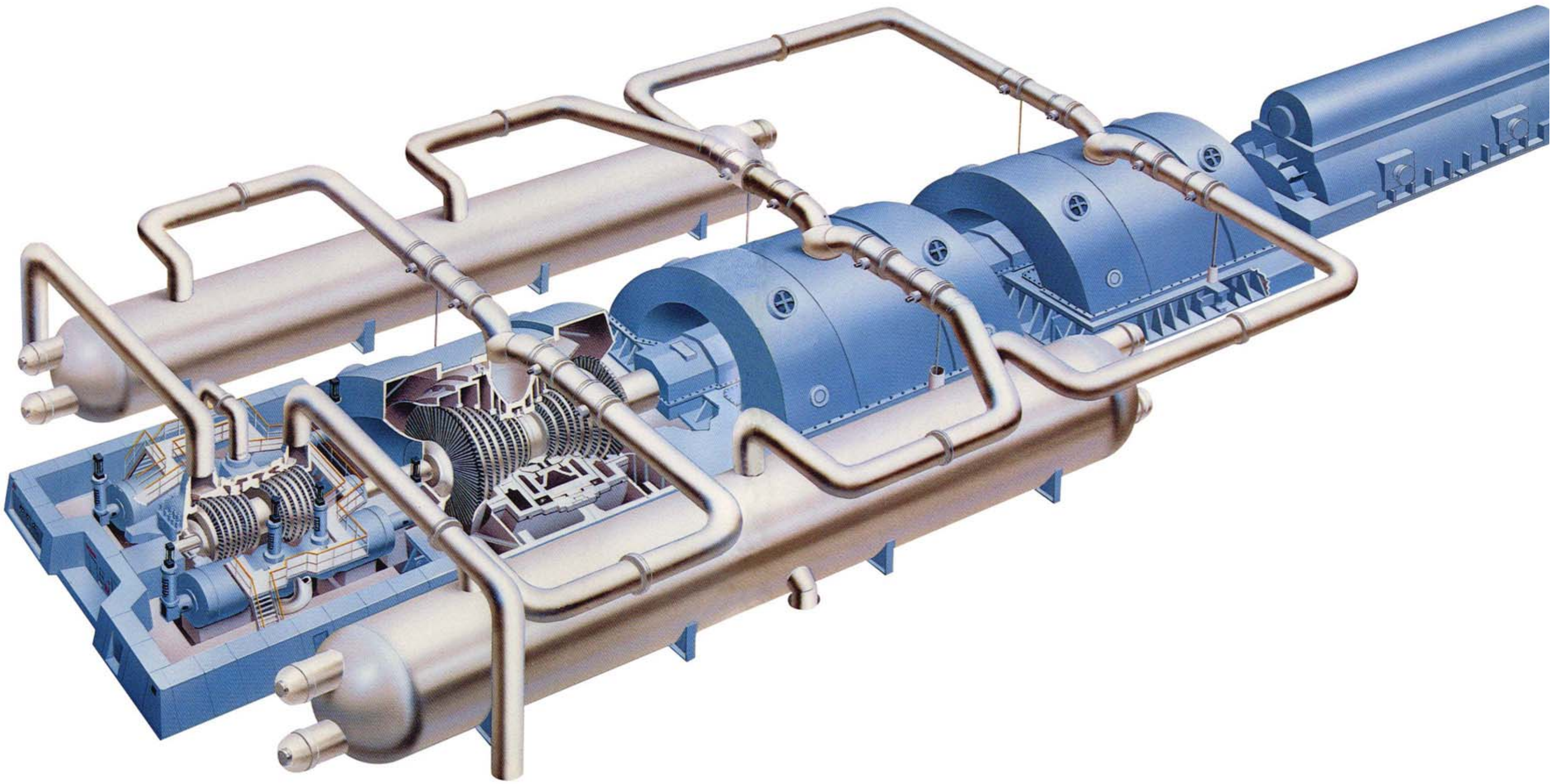
$$\text{GROSS HEAT RATE} = \frac{14{,}975{,}742^{*}\,(1197.6 - 419.5)}{1199{,}500} = 9715 \text{ Btu/kW-Hr}$$

TURBINE GENERATOR
1199,500KW
TC6F-54

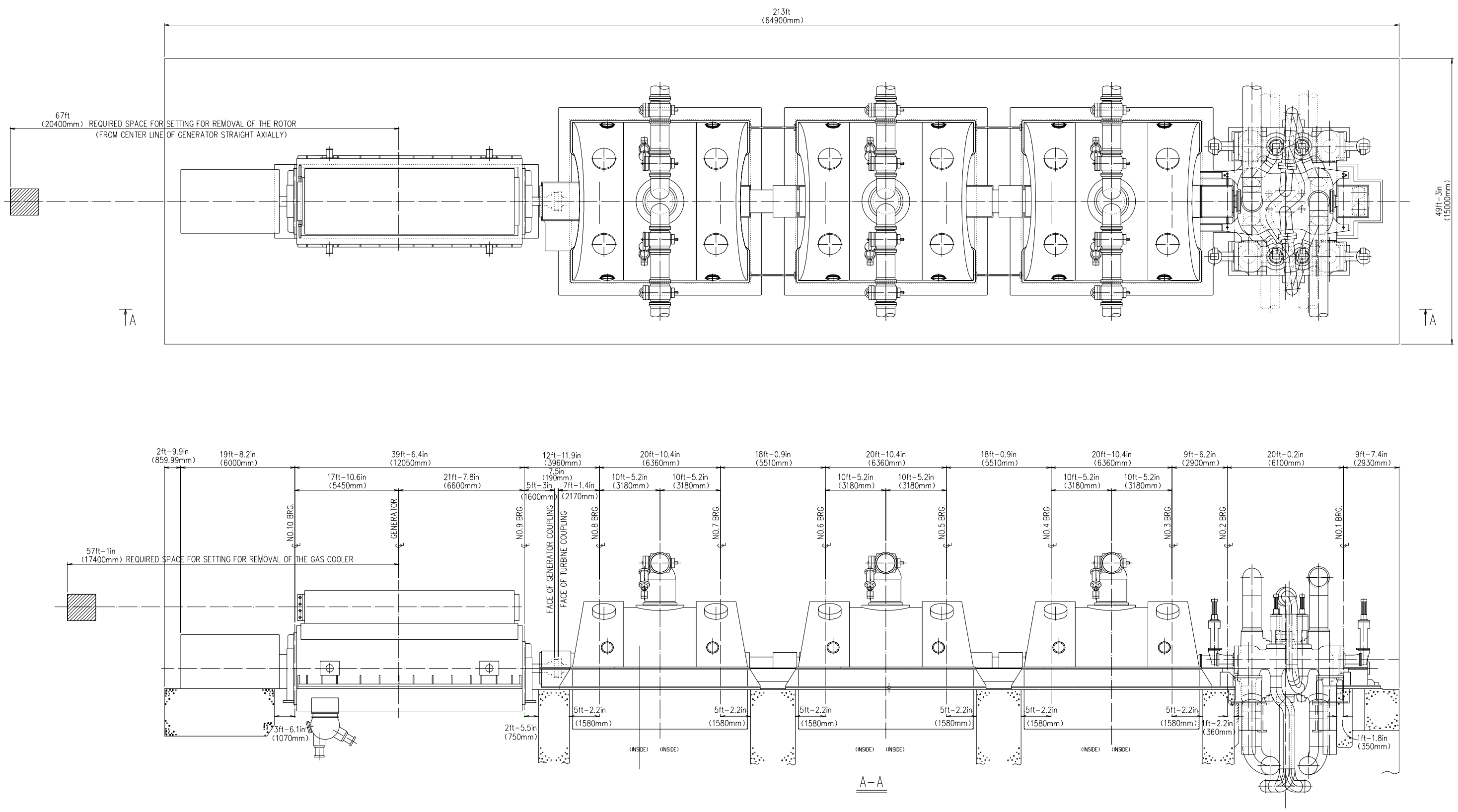
Figure 10.1-1

Heat Balance

AP1000 Turbine-Generator

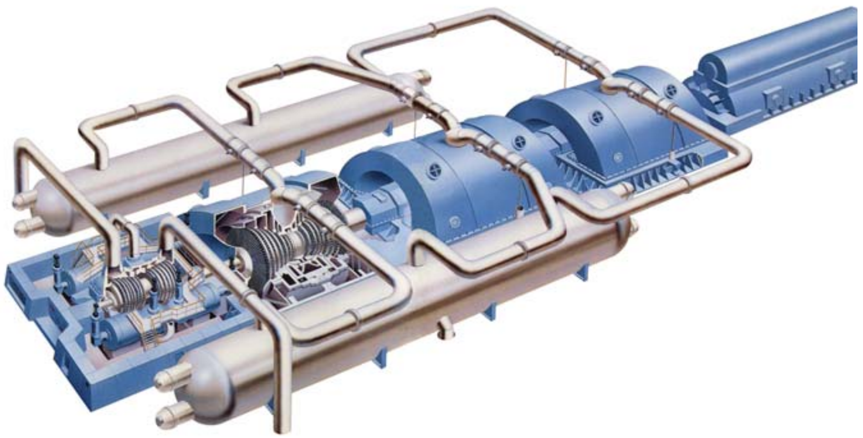


AP1000 Turbine-Generator



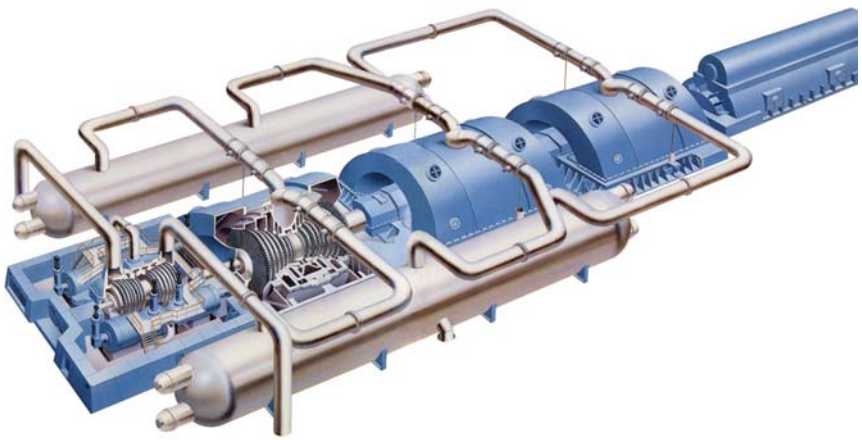
Turbine Island

- Turbine Island Design Status
  - Level of detail defined necessary to support Design Certification
    - Turbine - Generator configuration
      - 1 x HP, 3 x LP turbines
      - 1800 RPM
    - BOP Systems configuration defined
  - Design Criteria based on AP600 design & design criteria
    - Heavily influenced by Utility Requirements Document
  - Redesign is necessary to support AP1000 power uprating

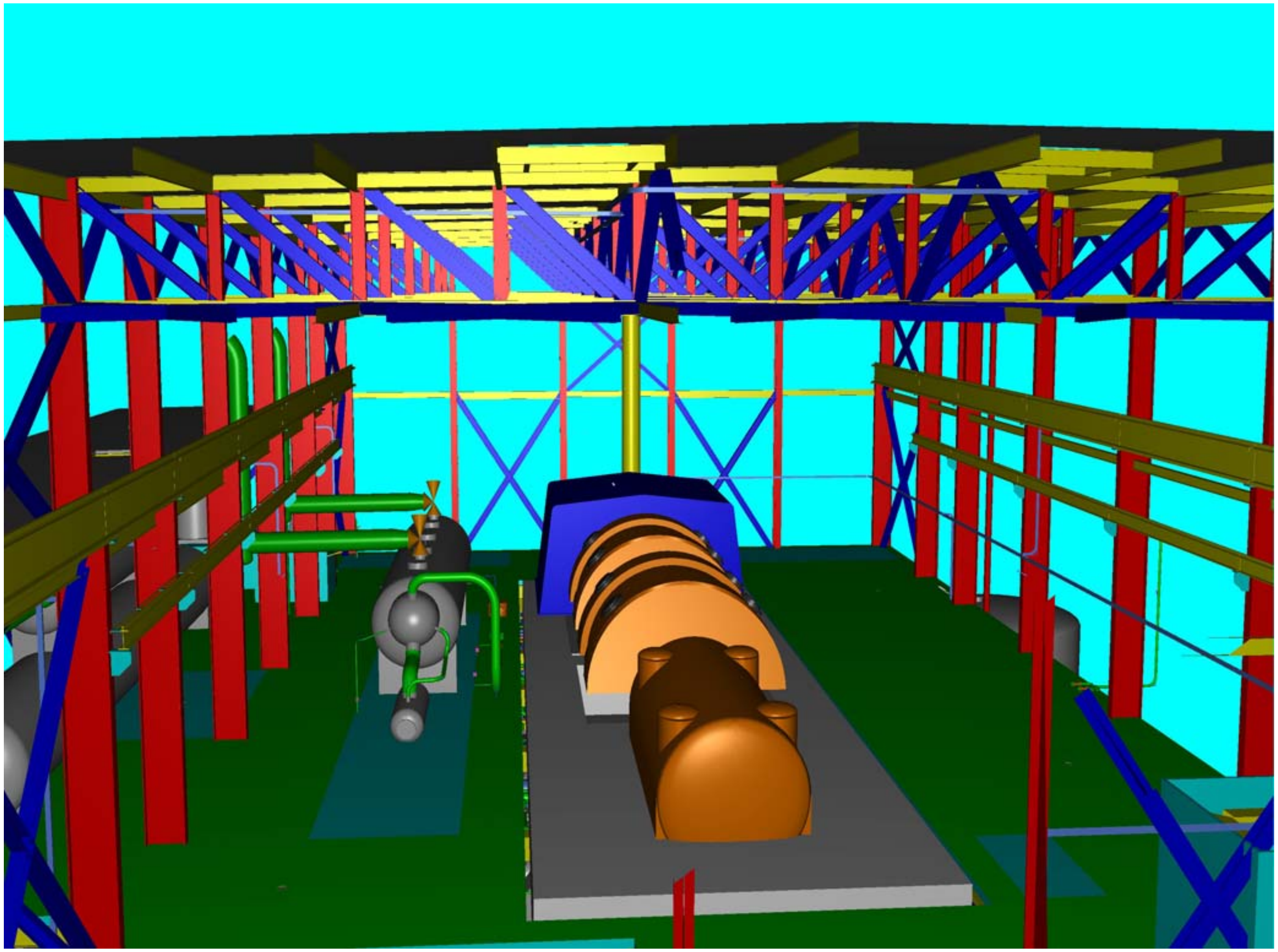


Turbine Island

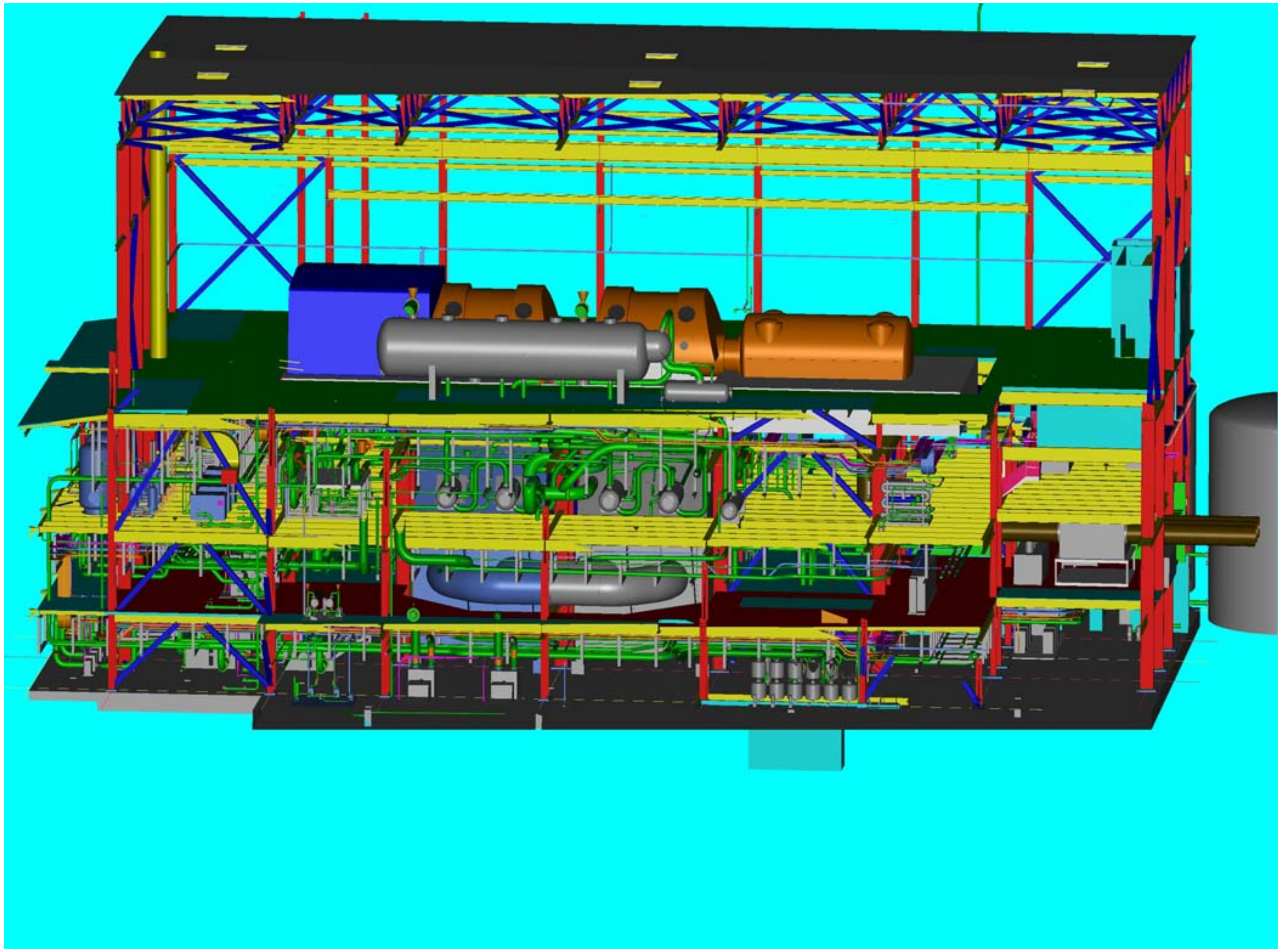
- Targeted design finalization has been initiated to reduce COL licensing, schedule and cost risk
  - Final Turbine-Generator selection process initiated
  - BOP systems design initiated
  - Turbine island layout and structures design to be initiated after DOE contract restructure



AP600 Turbine Operating Deck



AP600 Turbine Building Elevation View



Features of Steam and Power Conversion System

- Main Steam System
  - accommodates AP1000's higher pressure No Load Condition
  - accommodates AP1000's higher pressure Full Load Condition
  - has 6 safety valves per main steam line [3 valves per Line]
- Power Operated Relief Valve (PORV)
  - is the same as AP600's
  - has greater capacity than AP600's due to higher set pressure
- Turbine Bypass Design
  - has 6 valves to maintain 40% bypass capability [4 valves]

Features of Steam and Power Conversion System

- Condensate, Feedwater, and Circulating Water Systems are AP600 systems proportionally upsized to support the AP1000
- Condensate System
  - has 3 main condensers
  - has 3-50% condensate pumps
  - has 4 stages feedwater heating
- Condensate Storage Tank
  - volume is increased to 485,000 gal.
  - min. volume is increased to 325,000 gal.

Features of Steam and Power Conversion System

- Main Feedwater System
  - has 3-33.3% single speed motor-driven main feedwater pump trains [2-50% adjustable speed motor-driven feedwater pump trains]
  - has 1 deaerator and 1 stage of HP feedwater heating [1 deaerator and 2 stages of HP feedwater heating]
- Circulating Water System
  - has 3-33.3% circulating water pumps (in Reference Design) [2-50% pumps]

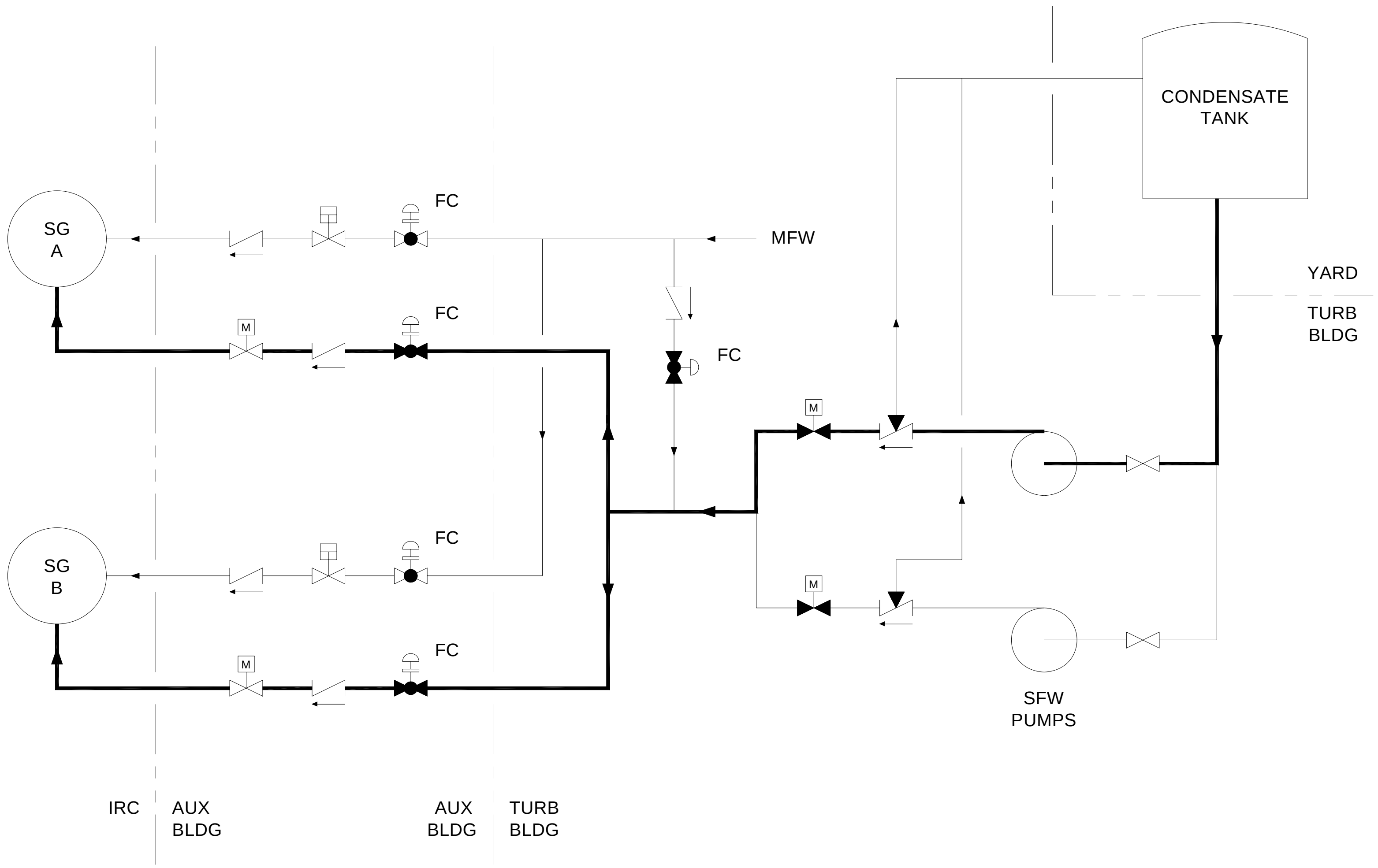
Features of Steam and Power Conversion System

- Startup Feedwater System
  - is the same as AP600's except that the
    - capacity of each pump is increased to 520 gpm [380 gpm]
    - head of each pump is increased to provide the noted capacity
- Blowdown System
  - has the same volumetric flow rate as AP600

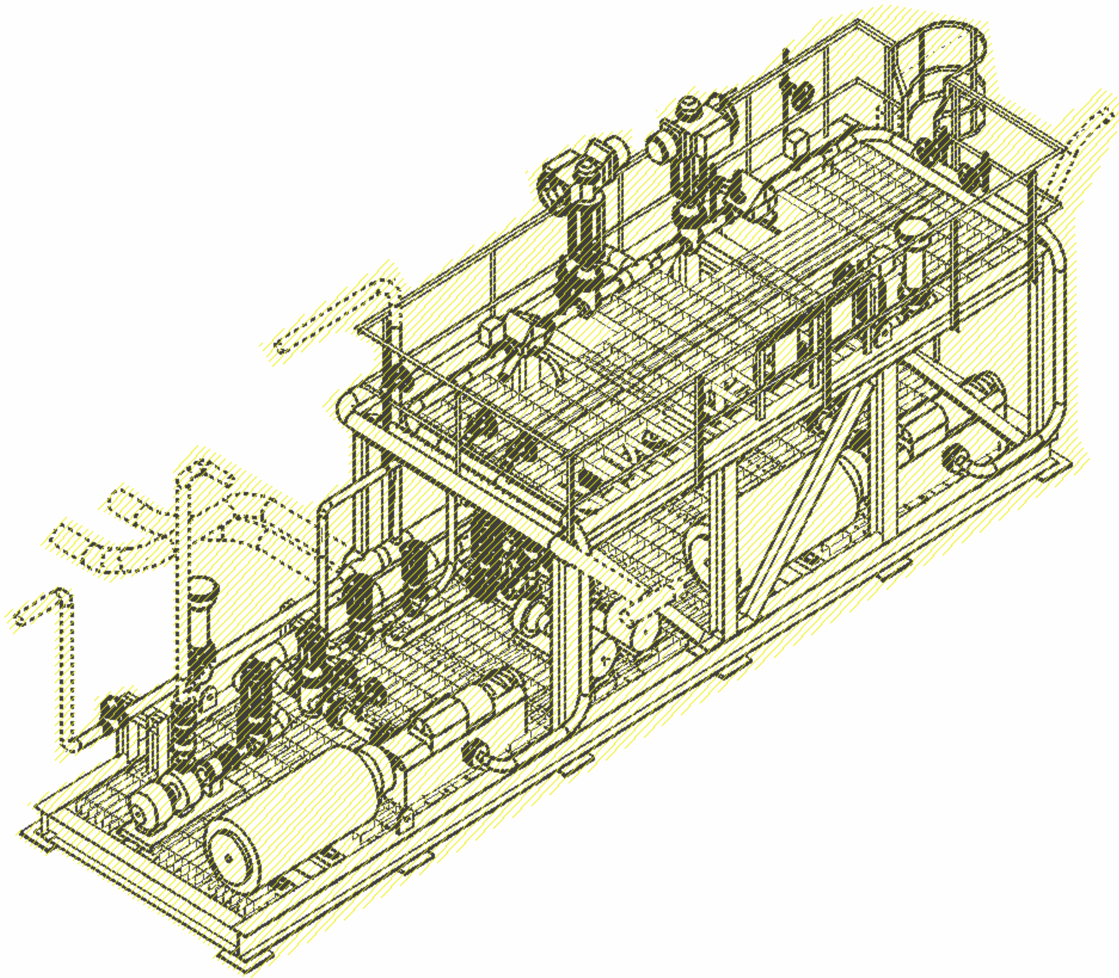
Startup Feedwater System

- Simplified Reliable Non-Safety System
  - Auto start on low SG level with auto SG level control
    - Same flow if one or two pumps start
    - Operation does not cause excessive RCS cooldown or SG overfill
  - Auto load on non-safety DG
  - Simple reliable system design
    - Two electric motor pumps, no steam turbine driven pumps
    - No physical separation requirements
  - PRHR HX not actuated if SFW works as designed

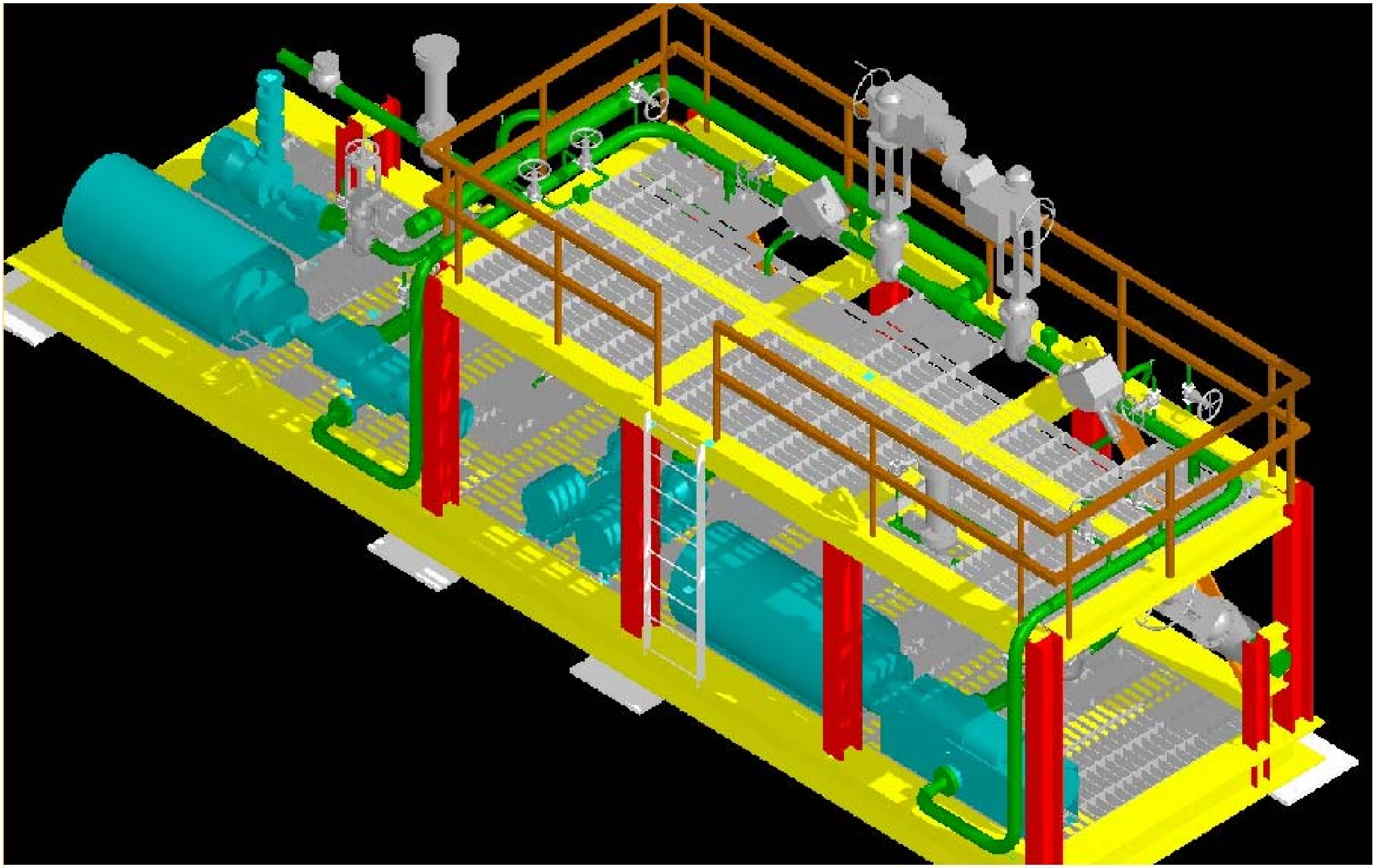
AP1000 Startup Feedwater System



Startup Feedwater Pump Module



Startup Feedwater Pump Module



HVAC Systems

- AP1000 HVAC Systems are identical to AP600
  - Separate, redundant systems for each building divided by potentially radioactive and not
  - the Containment Filtration System provides 0.21 air changes per hour

Fire Protection

- Design is the same as AP600 except that the:
  - Turbine building is larger to accommodate larger T-G
    - Additional combustibles are addressed
  - Arrangement of fire areas for RNS Pump Rooms and rooms containing associated cable trays is revised for simplification of design
    - The criteria to separate the RNS pumps and associated cable trays is maintained
  - Entrance enclosure to auxiliary building stairwell, S04, is a 3-hour enclosure to be consistent with other AP1000/AP600 entrance enclosures to stairwells

Fire Protection (continued)

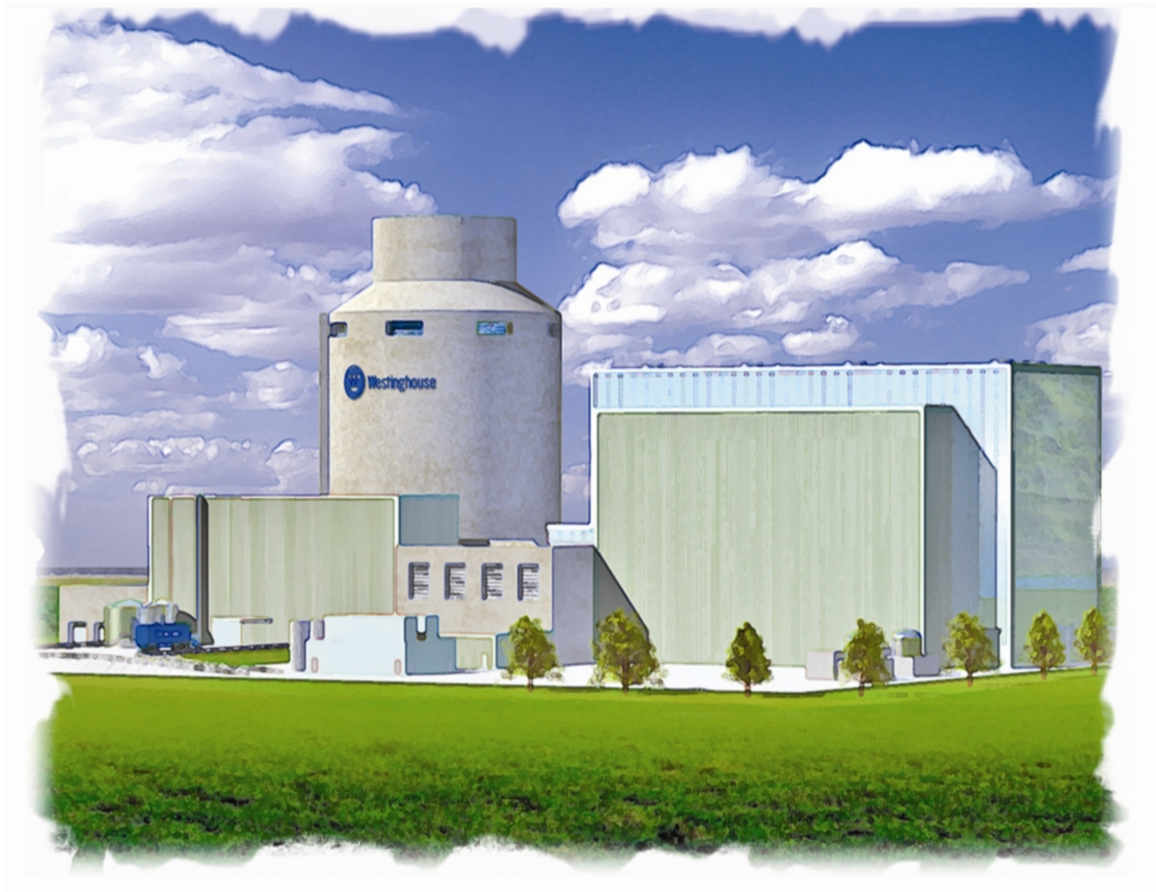
- Control room ceiling is not a two-way 3-hour rated barrier
  - The ceiling structure is not protected from control room fires as it is needed for passive cooling
  - Mechanical equipment room floor above the control room remains a 3-hour rated barrier
- The auxiliary building roof is non-fire rated
  - This is consistent with other roofs

Auxiliary Systems

- Turbine Building Closed Cooling Water System
  - has increased capacity to accommodate the larger T-G
- Secondary Sampling System
  - is the same as AP600 except that it has an additional sodium conductivity instrument for the 3rd condenser
- Ancillary Diesel Oil Tank
  - has increased capacity for the larger ancillary diesel

Electrical Systems

Don Hutchings



Electrical Systems

- AC Power
  - Only one offsite connection required
  - Two non-safety diesel generators (4000 kW ea)
  - Two very small non-safety DG (35 kW ea) for loss all AC coping
- DC Power
  - Safety (1E)
    - Provides power to a few safety valves and the I&C system
    - 4 trains provide 24 hour actuation, 72 hour monitoring
  - Non-Safety (non 1E)
    - Provides power to nonsafety functions such as I&C
    - 2 batteries provides 2 hours

Electrical Systems

- **Class 1E DC and UPS System (IDS)**
  - Provides electrical power to safety components
- **Non-Class 1E DC and UPS System (EDS)**
  - Provides electrical power to non-safety components requiring highly-reliable power
- **Main AC Power System (ECS)**
  - Provides bulk electrical power
- **Onsite Standby Power System (ZOS)**
  - Provides electrical power to defense-in-depth and investment protection loads when offsite power is lost

Class 1E DC & UPS System (IDS)

- 125 Vdc / 208Vac (uninterruptible)
- Four Divisions
  - Divisions A and D each have one 24-hour battery
  - Divisions B and C each have one 24-hour battery and one 72-hour battery
  - 72-hour battery is for monitoring only
- Provides electrical power to safety components
  - PMS
  - MCR lighting
  - Valve actuators, Reactor trip, RCP trip
- Class 1E
- Post-72 hour power provided by ancillary generators

Main AC Power System (ECS)

- Provides bulk electrical power
  - 6.9 kV, 480 V, 120/208 V, 60 Hz (US)
- Normal power supply from main generator
- Preferred power supply is offsite source through main step-up and auxiliary transformers
- Maintenance power supply is through reserve auxiliary transformer
- Standby power source is two diesel generators
- Two Load Groups
  - Each group is connected to one standby diesel generator, one auxiliary transformer and the reserve auxiliary transformer
- Non-Class 1E

Questions? / Thank You