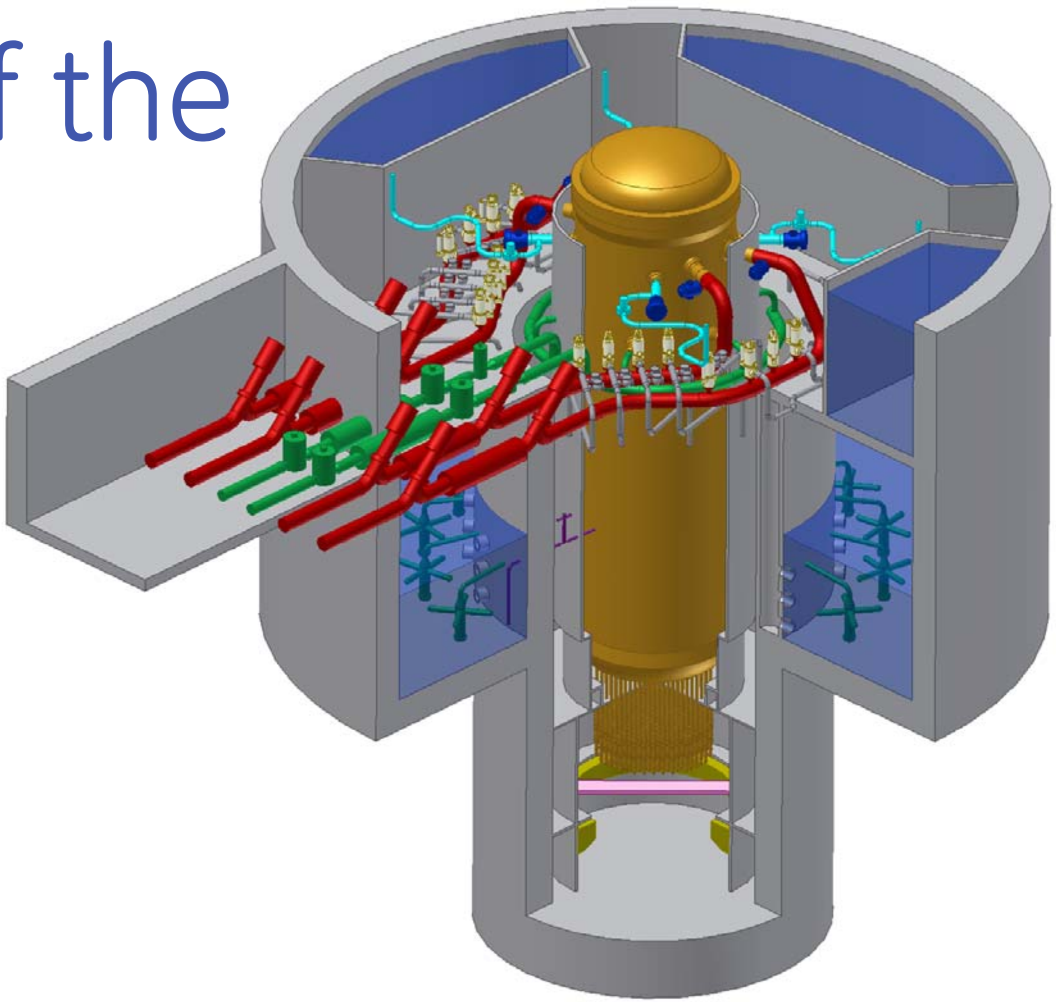
NRC Executive Overview of the ESBWR



September, 27, 2005
Steve Hucik
General Manager, New Plant Projects

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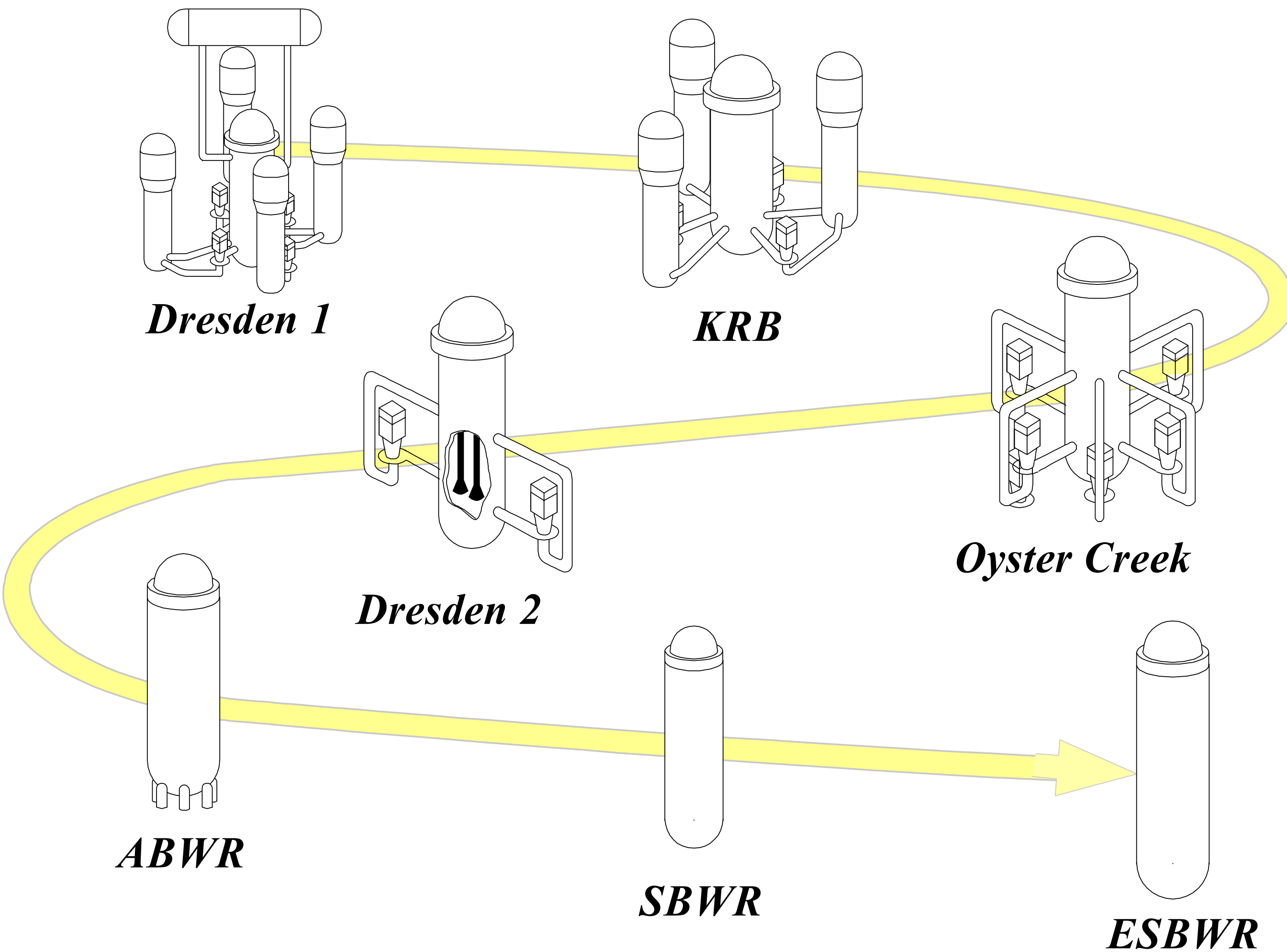
Presentation Content

- BWR Design Evolution
- DCD Status
- ESBWR Primary Characteristics
- ESBWR Passive Systems
  - Changes since start of pre-application
- ESBWR Active Systems
  - Differences from previous BWRs
- Digital Control and Instrumentation
- Summary

BWR Evolution



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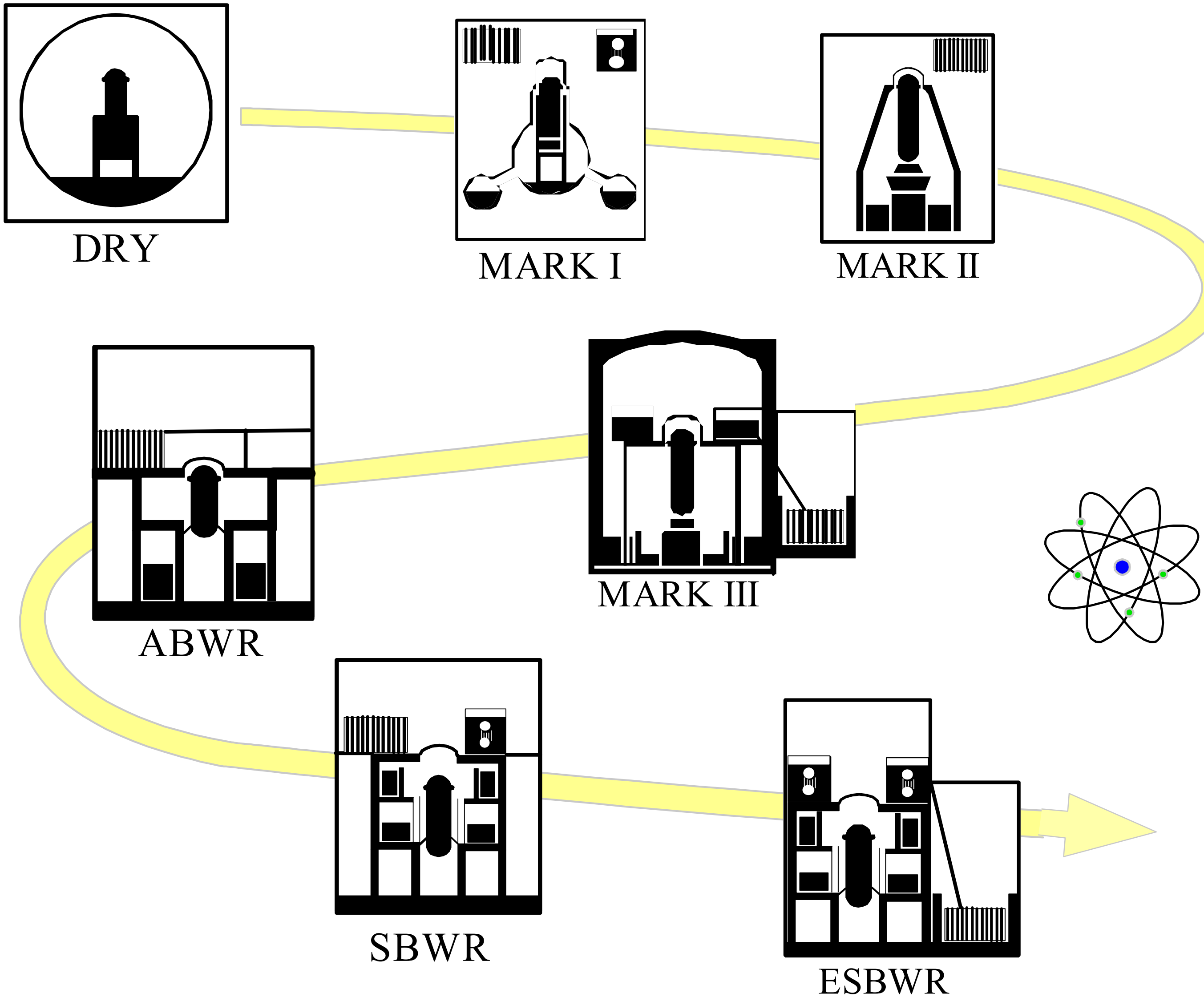
Containment Evolution



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ESBWR

- ABWR design certified
  - > Current project in progress in Lungmen
  - > Experience base developed from Lungmen and operating ABWRs at TEPCO's K6/7 site
- GE is committed to producing a quality product
- Continuing to build using experience and technology
- GE committed to work closely with the NRC to ensure sufficient detail and information exchange to support NRC licensing review—excellent interaction to date on pre-application review

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Lungmen Equipment Delivery & Installation

Main Control Room Panels Testing

RHR Heat Exchanger Installation

Simulator testing at GENE San Jose

Installation of Reactor Pedestal Module


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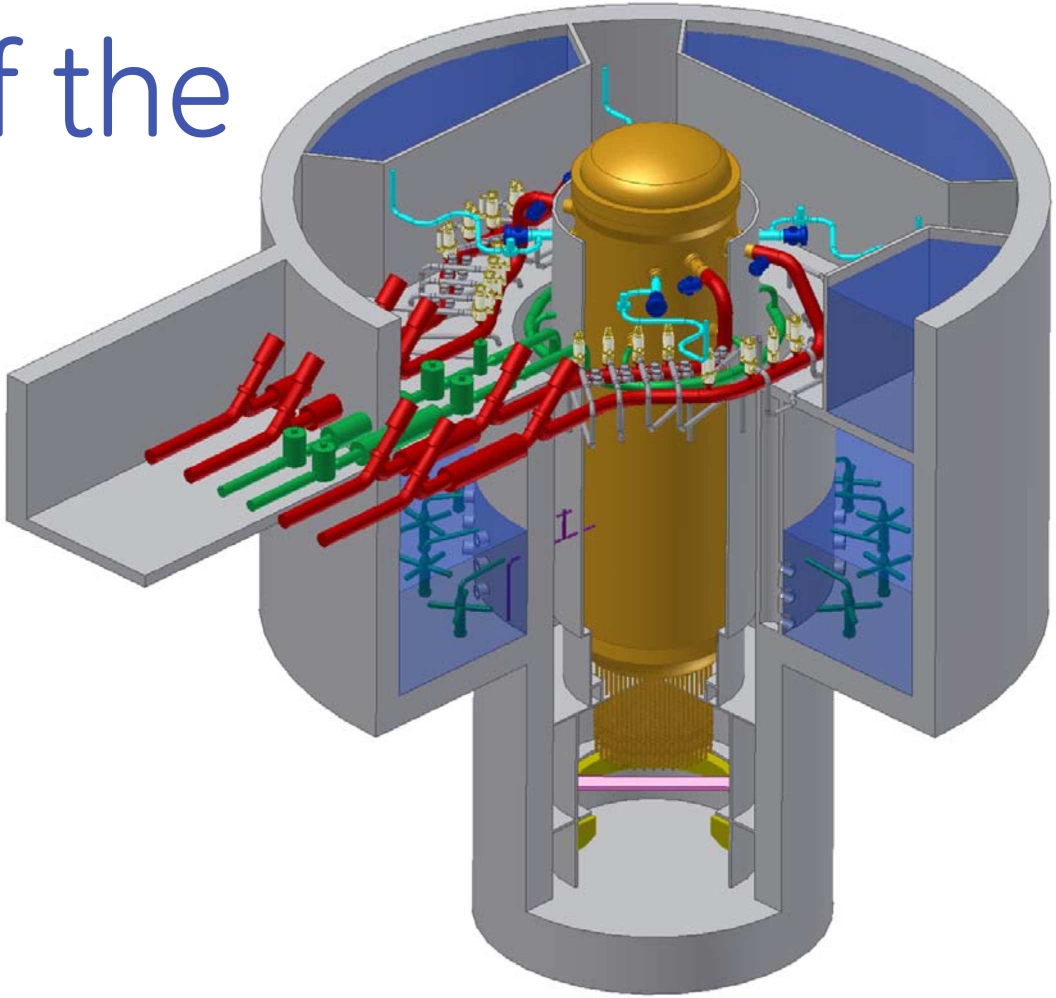
NRC Executive Overview of the ESBWR



September, 27, 2005
David Hinds
Manager, ESBWR Engineering

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ESBWR DCD Submittal

- Comprehensive DCD Submitted
  - Reg Guide 1.70 format
  - Built on experience of SBWR & ABWR
  - Incorporated lessons learned from AP-1000 review

Status of DCD Submittal

- DCD submitted 8/24/05
- Prompt and thorough review of application
- Acceptance review letter received
  - Identified areas requiring further detailed information
- GE is committed to aggressively provide the necessary details to accomplish the review
  - Plans and schedules to be submitted to review team

ESBWR Basic Parameters

- 4,500 Megawatt Core Thermal Power
- ~1,580 Megawatt Electric Gross
  - > ~1,520 Megawatt Electrical Net
- Natural Circulation
- Passive Safety Systems
  - > 72 hours passive capability

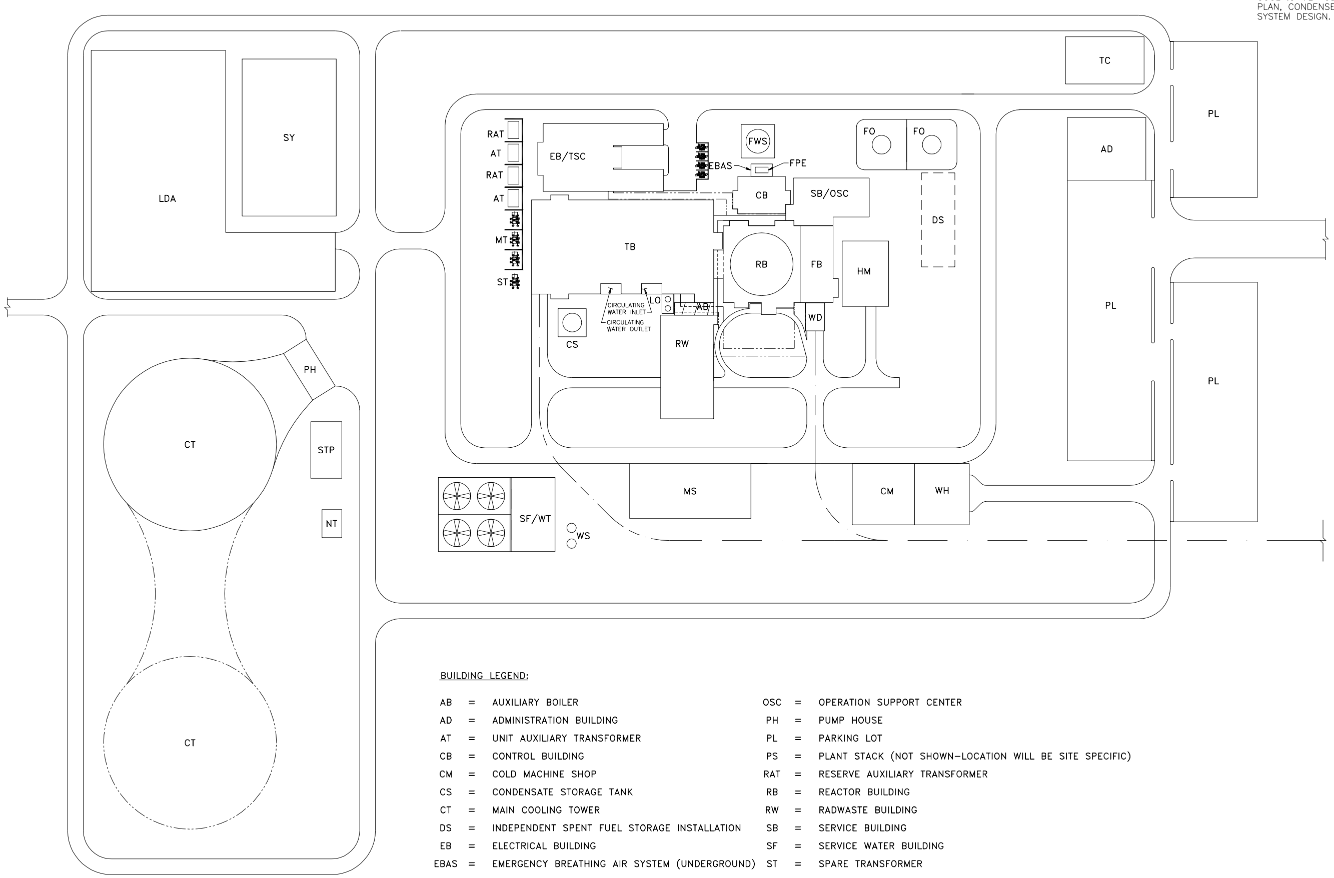
Site Parameters

- EPRI Utility Requirements Document Plus (+)
  - > Tornado
    - – 330 mph
  - > Extreme Winds
    - – 140 mph for safety-related
  - > Temperatures
    - – Bound the 3 ESP sites
  - > Seismic
    - – Reg Guide 1.60 plus a CEUS hard rock site

Site Plan

NOTES:

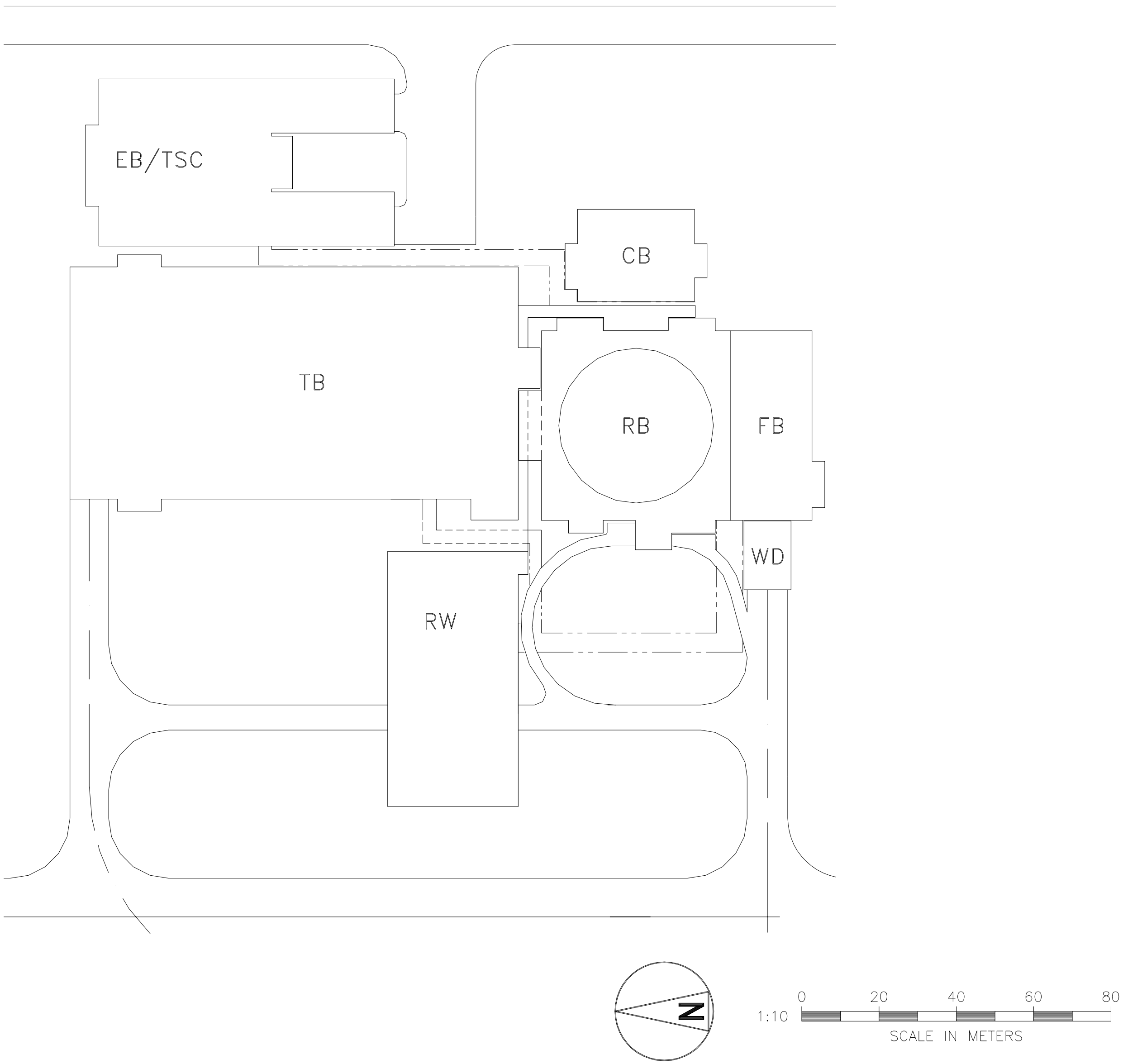
1. THIS PLOT PLAN REPRESENTS THE STANDARD ESBWR CONFIGURATION. THIS CONFIGURATION WILL BE MODIFIED FOR SITE SPECIFIC REQUIREMENTS DURING COMBINED OPERATING LICENSE APPLICATIONS.
2. THE REFERENCE NORMAL HEAT SINK IS SHOWN AS NATURAL DRAFT COOLING TOWERS; HOWEVER, SITE SPECIFIC AVAILABLE WET BULB AND COOLING WATER TEMPERATURES, ENVIRONMENTAL LIMITATIONS AND SPECIFIC TURBINE CONFIGURATION MAY DICTATE EITHER ONCE THROUGH OR MECHANICAL DRAFT TOWER COOLING. THESE SITE SPECIFIC ALTERNATE COOLING METHODS MAY ALSO CHANGE THE PLOT PLAN, CONDENSER AND CIRCULATING WATER SYSTEM DESIGN.



BUILDING LEGEND:

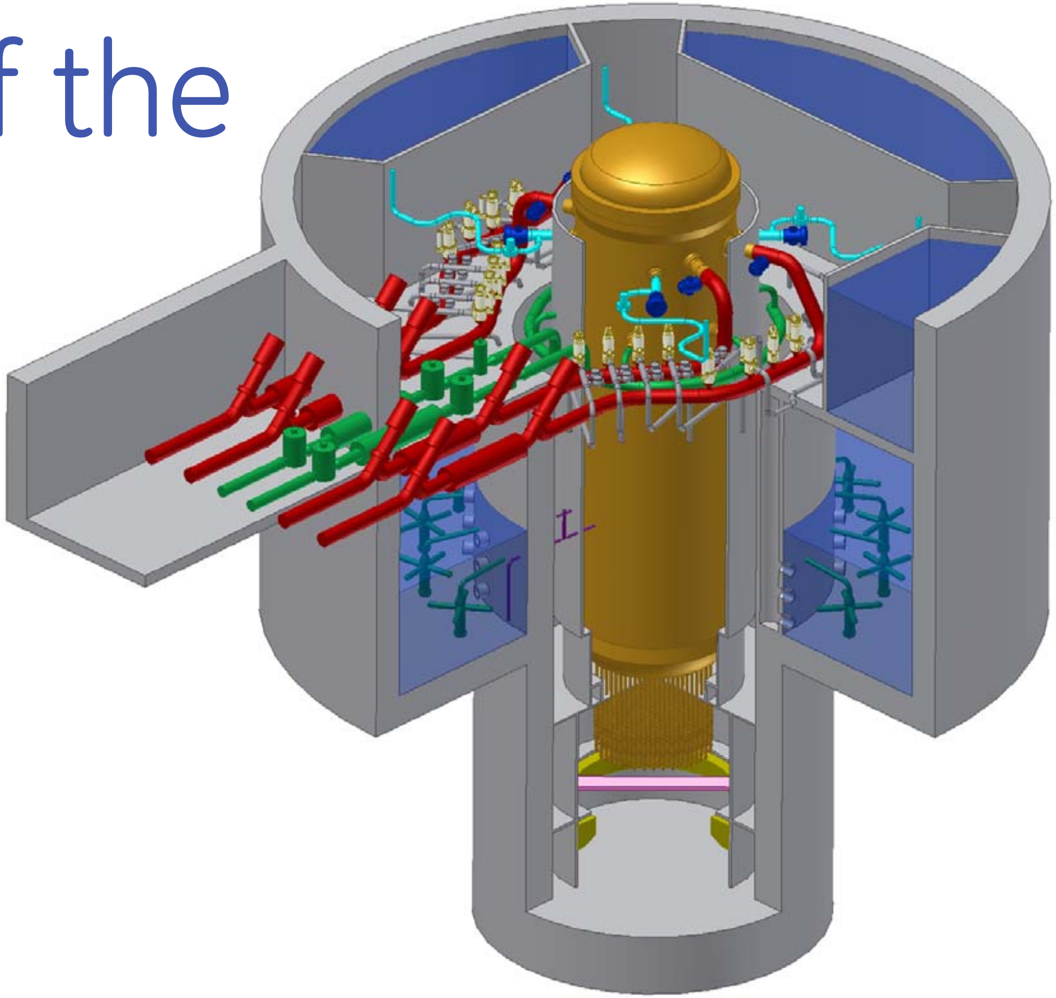
AB	=	AUXILIARY BOILER
AD	=	ADMINISTRATION BUILDING
AT	=	UNIT AUXILIARY TRANSFORMER
CB	=	CONTROL BUILDING
CM	=	COLD MACHINE SHOP
CS	=	CONDENSATE STORAGE TANK
CT	=	MAIN COOLING TOWER
DS	=	INDEPENDENT SPENT FUEL STORAGE INSTALLATION
EB	=	ELECTRICAL BUILDING
EBAS	=	EMERGENCY BREATHING AIR SYSTEM (UNDERGROUND)
FB	=	FUEL BUILDING
FO	=	DIESEL FUEL OIL STORAGE TANK
FPE	=	FIRE PUMP ENCLOSURE
FWS	=	FIRE WATER STORAGE TANK
HM	=	HOT MACHINE SHOP & STORAGE
LDA	=	LAY DOWN AREA
LO	=	DIRTY/CLEAN LUBE OIL STORAGE TANK
MS	=	MISCELLANEOUS SERVICE AREA
MT	=	MAIN TRANSFORMER
NT	=	NITROGEN STORAGE TANK
OSC	=	OPERATION SUPPORT CENTER
PH	=	PUMP HOUSE
PL	=	PARKING LOT
PS	=	PLANT STACK (NOT SHOWN—LOCATION WILL BE SITE SPECIFIC)
RAT	=	RESERVE AUXILIARY TRANSFORMER
RB	=	REACTOR BUILDING
RW	=	RADWASTE BUILDING
SB	=	SERVICE BUILDING
SF	=	SERVICE WATER BUILDING
ST	=	SPARE TRANSFORMER
STP	=	SEWAGE TREATMENT PLANT
SY	=	SWITCH YARD
TB	=	TURBINE BUILDING
TC	=	TRAINING CENTER
TSC	=	TECHNICAL SUPPORT CENTER
WD	=	WASH DOWN BAYS (EQUIPMENT ENTRY)
WH	=	WAREHOUSE
WS	=	WATER STORAGE
WT	=	WATER TREATMENT

Power Block Arrangement



imagination

NRC Executive Overview of the ESBWR



September, 27, 2005
J. Alan Beard

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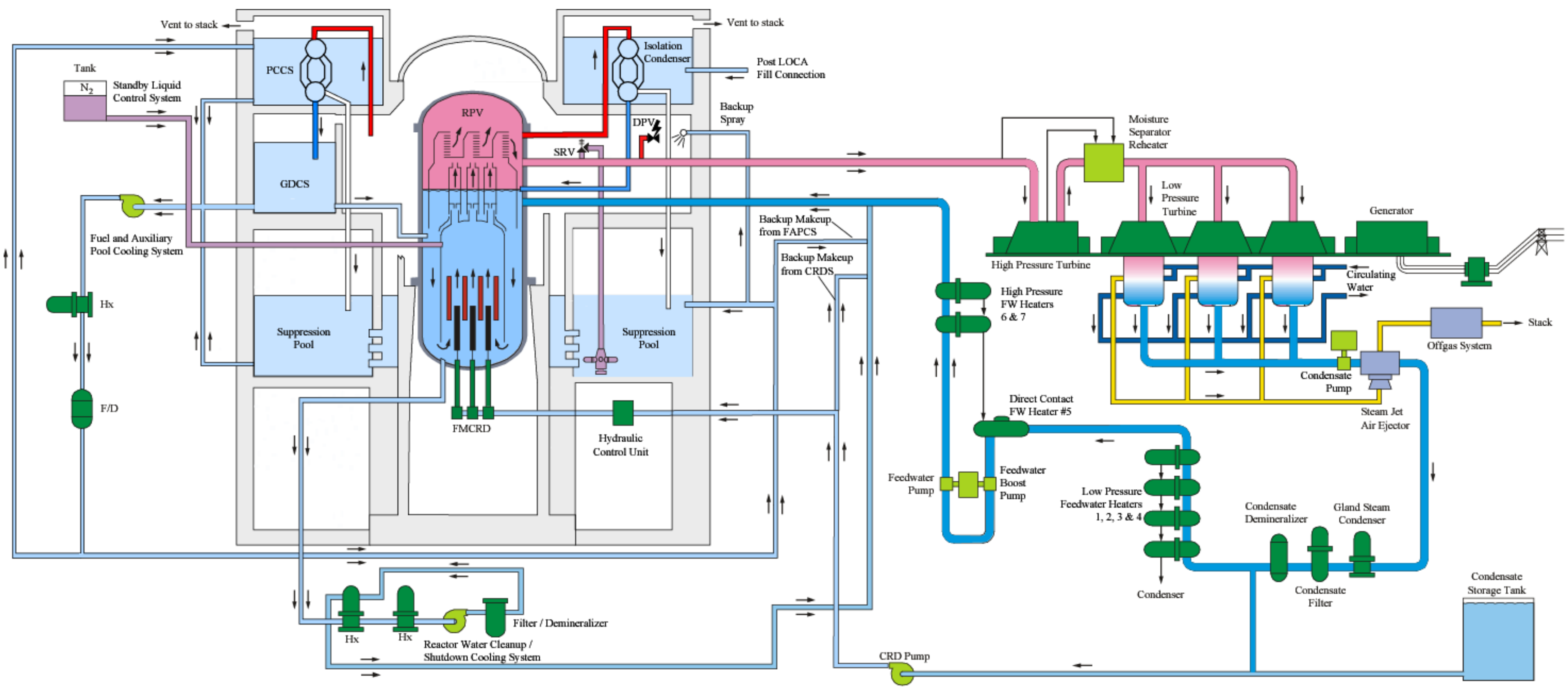
Vent to stack
Tank
N_2
Standby Liquid Control System
PCCS
GDCS
Fuel and Auxiliary Pool Cooling System
Hx
F/D
Suppression Pool
RPV
SRV
DPV
Isolation Condenser
Vent to stack
Post LOCA Fill Connection
Backup Spray
Suppression Pool
FMCRD
Hydraulic Control Unit
Backup Makeup from FAPCS
Backup Makeup from CRDS
Hx
Hx
Filter / Demineralizer
Reactor Water Cleanup / Shutdown Cooling System
CRD Pump
Moisture Separator Reheater
Low Pressure Turbine
Generator
High Pressure Turbine
Circulating Water
High Pressure FW Heaters 6 & 7
Stack
Offgas System
Condensate Pump
Steam Jet Air Ejector
Direct Contact FW Heater #5
Feedwater Pump
Feedwater Boost Pump
Low Pressure Feedwater Heaters 1, 2, 3 & 4
Condensate Demineralizer
Gland Steam Condenser
Condenser
Condensate Filter
Condensate Storage Tank

What's different about ESBWR

ABWR	ESBWR
Recirculation System + support systems	Eliminated
HPCF System (2 each)	Eliminated need for ECCS pumps
LPFL (3 each)	Utilize passive and stored energy
Residual Heat Removal (3 each)	Non-safety, combined with cleanup system
Safety Grade Diesel Generators (3 each)	Eliminated – only 2 non-safety grade diesels
RCIC	Replaced with IC heat exchangers
SLC –2 pumps	Replaced pumps with accumulators
Reactor Building Service Water (Safety Grade) And Plant Service Water (Safety Grade)	Made non-safety grade

Optimized Parameters for ESBWR

Parameter	BWR/4-Mk I (Browns Ferry 3)	BWR/6-Mk III (Grand Gulf)	ABWR	ESBWR
Power (MWt/GrossMWe)	3293/1098	3900/1360	3926/1350	4500/1580
Vessel height/dia. (m)	21.9/6.4	21.8/6.4	21.1/7.1	27.7/7.1
Fuel Bundles (number)	764	800	872	1132
Active Fuel Height (m)	3.7	3.7	3.7	3.0
Power density (kw/l)	50	54.2	51	54
Recirculation pumps	2(large)	2(large)	10	zero
Number of CRDs/type	185/LP	193/LP	205/FM	269/FM
Safety system pumps	9	9	18	zero
Safety diesel generator	2	3	3	zero
Core damage freq./yr	1E-5	1E-6	1E-7	3E-8
Safety Bldg Vol (m^3/MWe)	115	150	160	~ 130

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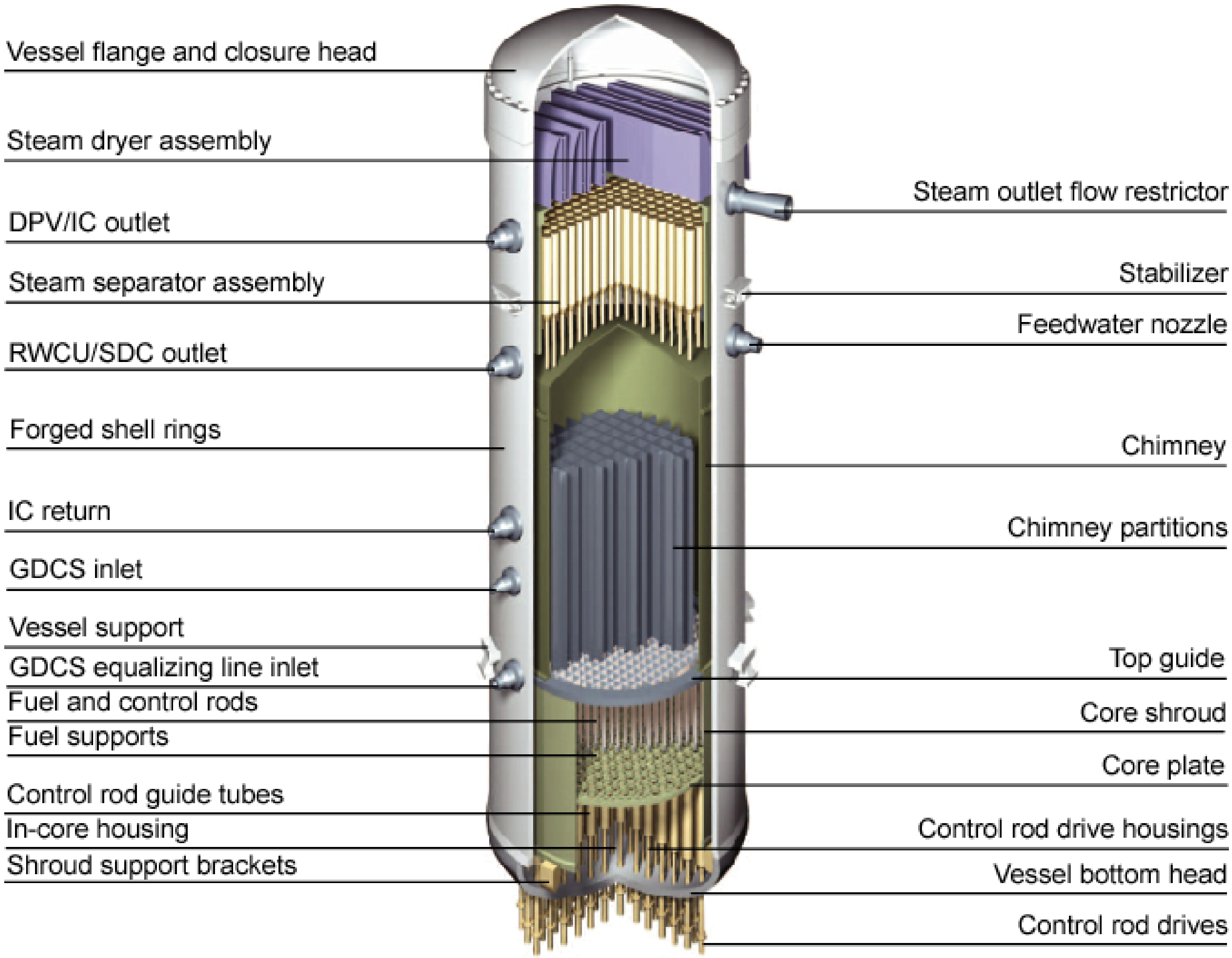
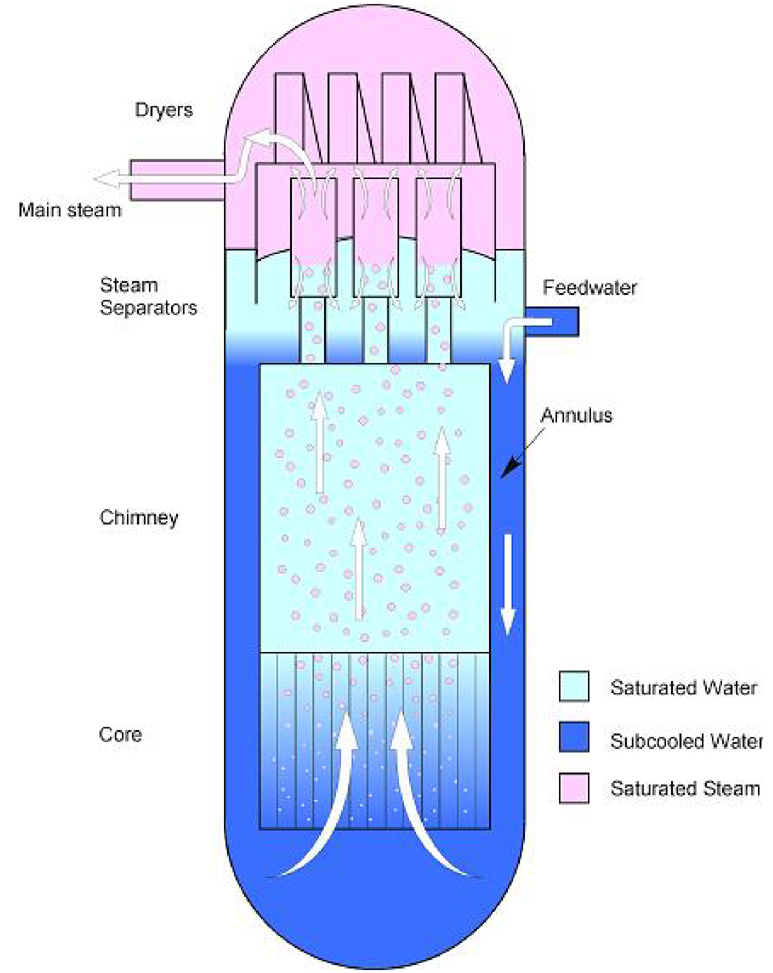


Vessel flange and closure head
Steam dryer assembly
DPV/IC outlet
Steam separator assembly
RWCU/SDC outlet
Forged shell rings
IC return
GDCS inlet
Vessel support
GDCS equalizing line inlet
Fuel and control rods
Fuel supports
Control rod guide tubes
In-core housing
Shroud support brackets
Steam outlet flow restrictor
Stabilizer
Feedwater nozzle
Chimney
Chimney partitions
Top guide
Core shroud
Core plate
Control rod drive housings
Vessel bottom head
Control rod drives

Natural Circulation

Simplification without performance loss ..

- **Passive safety/natural circulation**
  - Increase the volume of water in the vessel
  - Increase driving head
- **Significant reduction in components**
  - Pumps, motors, controls, HXers
- **Power Changes with Control Rod Drives**
  - Minimal impact on maintenance



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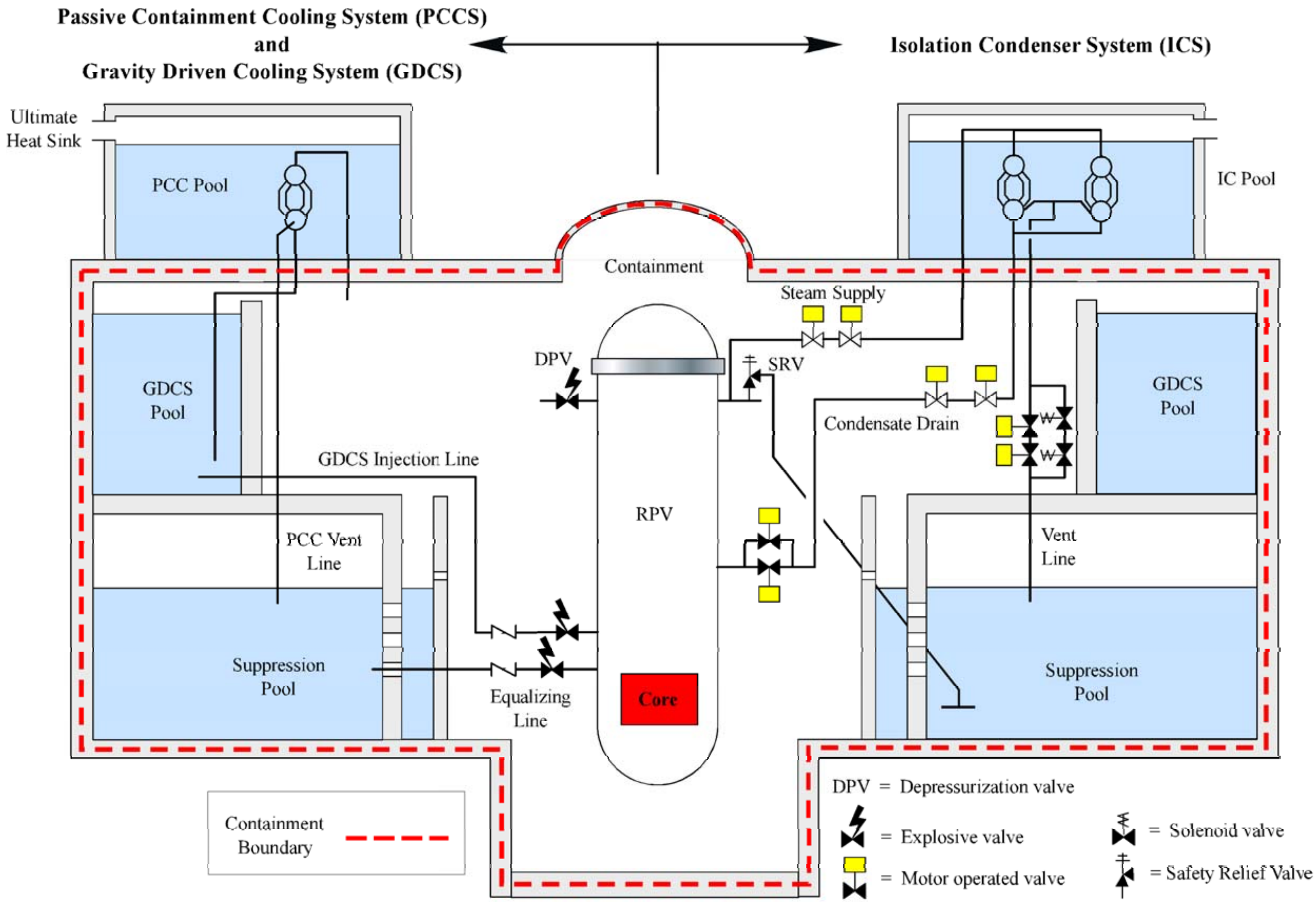
Passive Safety



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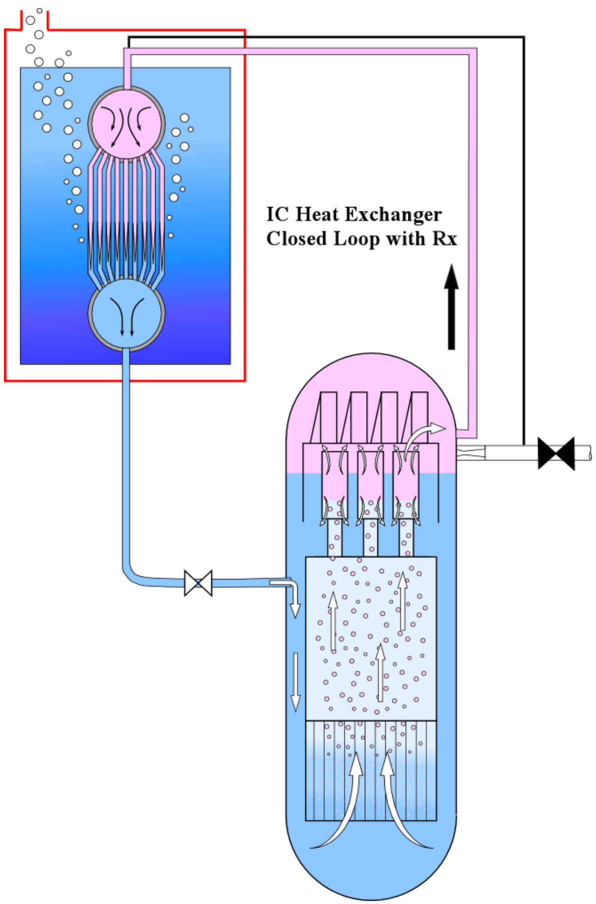
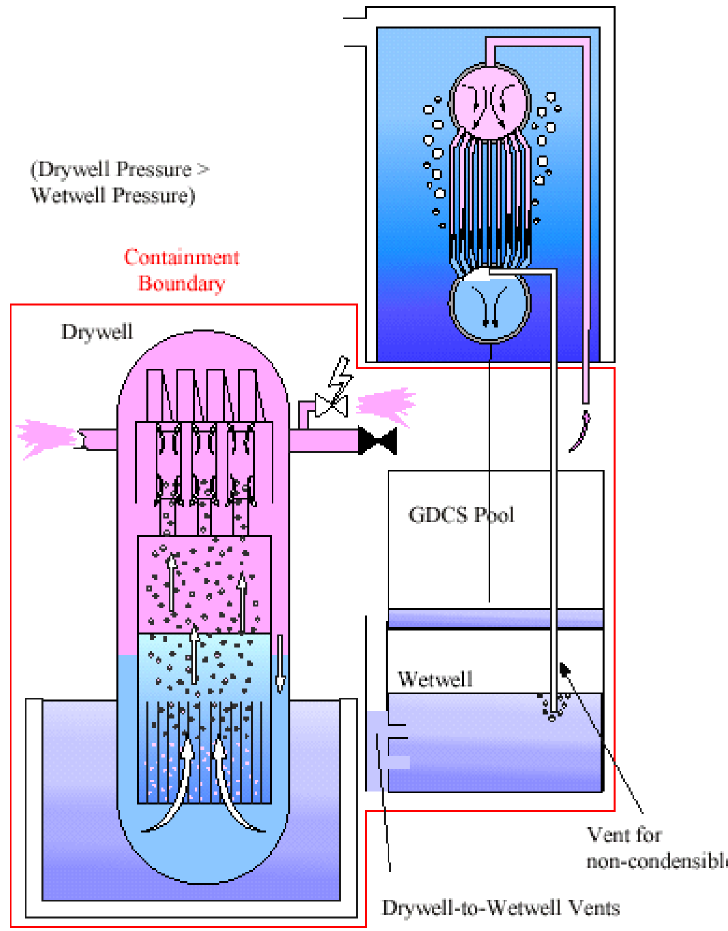
Passive Safety Systems …

Isolation Condenser System



Passive Containment Cooling



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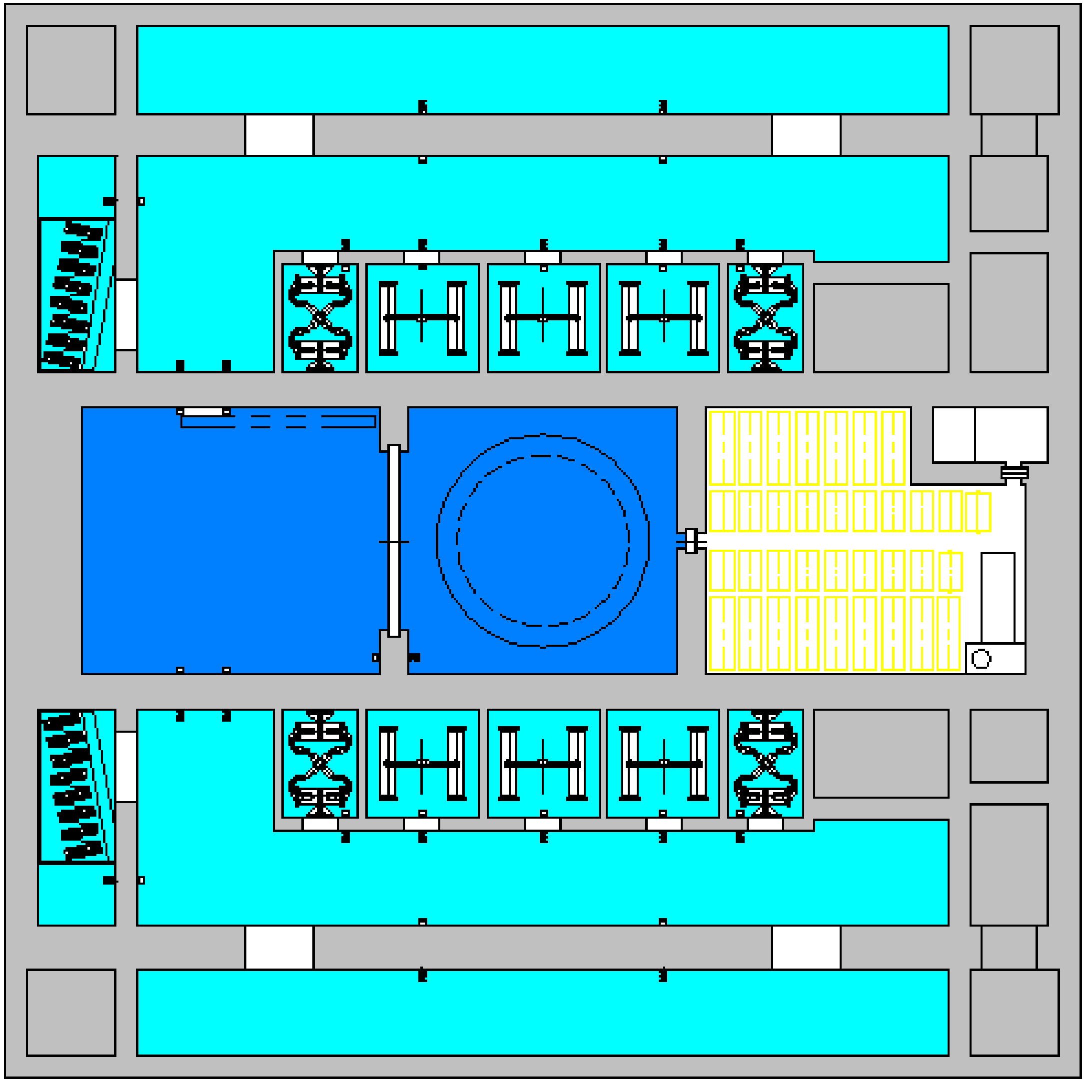
72 Hours Passive Capability



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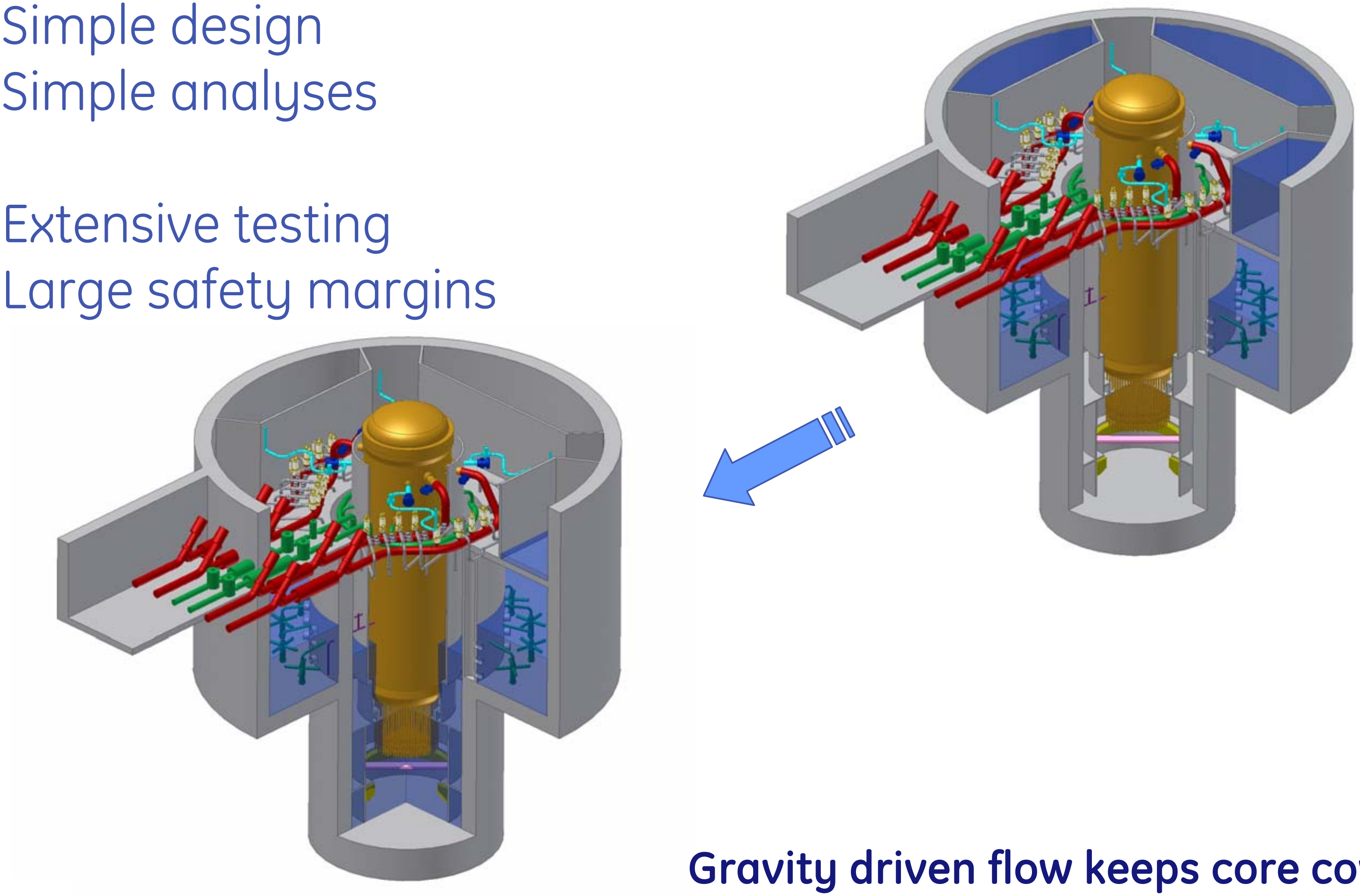
Gravity Driven Cooling System …

Simple design
Simple analyses

Extensive testing
Large safety margins



Gravity driven flow keeps core covered

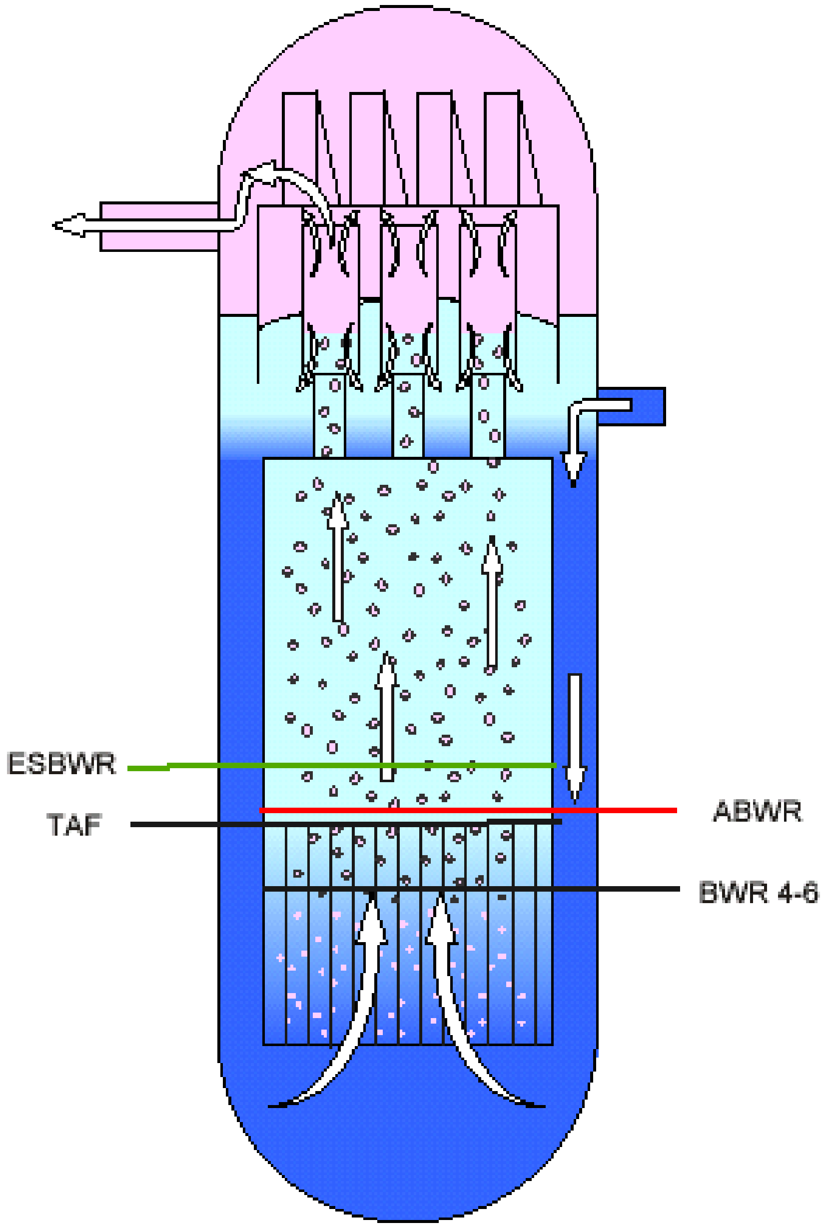
Anticipated Operational Occurrences

- Reliable controls eliminate most limiting AOOs
- Large steam volume in reactor mitigates pressure increases
  - > No pressure overshoot in any AOO
- IC prevents SRV opening in all AOOs
- CPR change lower than forced circ. BWRs
  - > Loss of FW Heating is Limiting CPR, slow quasi-static response
- Loss of Coolant Accidents (LOCA)
  - > Large margin to fuel uncovery in all pipe breaks
    - – Only Passive systems credited
    - – Designed for 72 hrs w/o external AC power or operator action

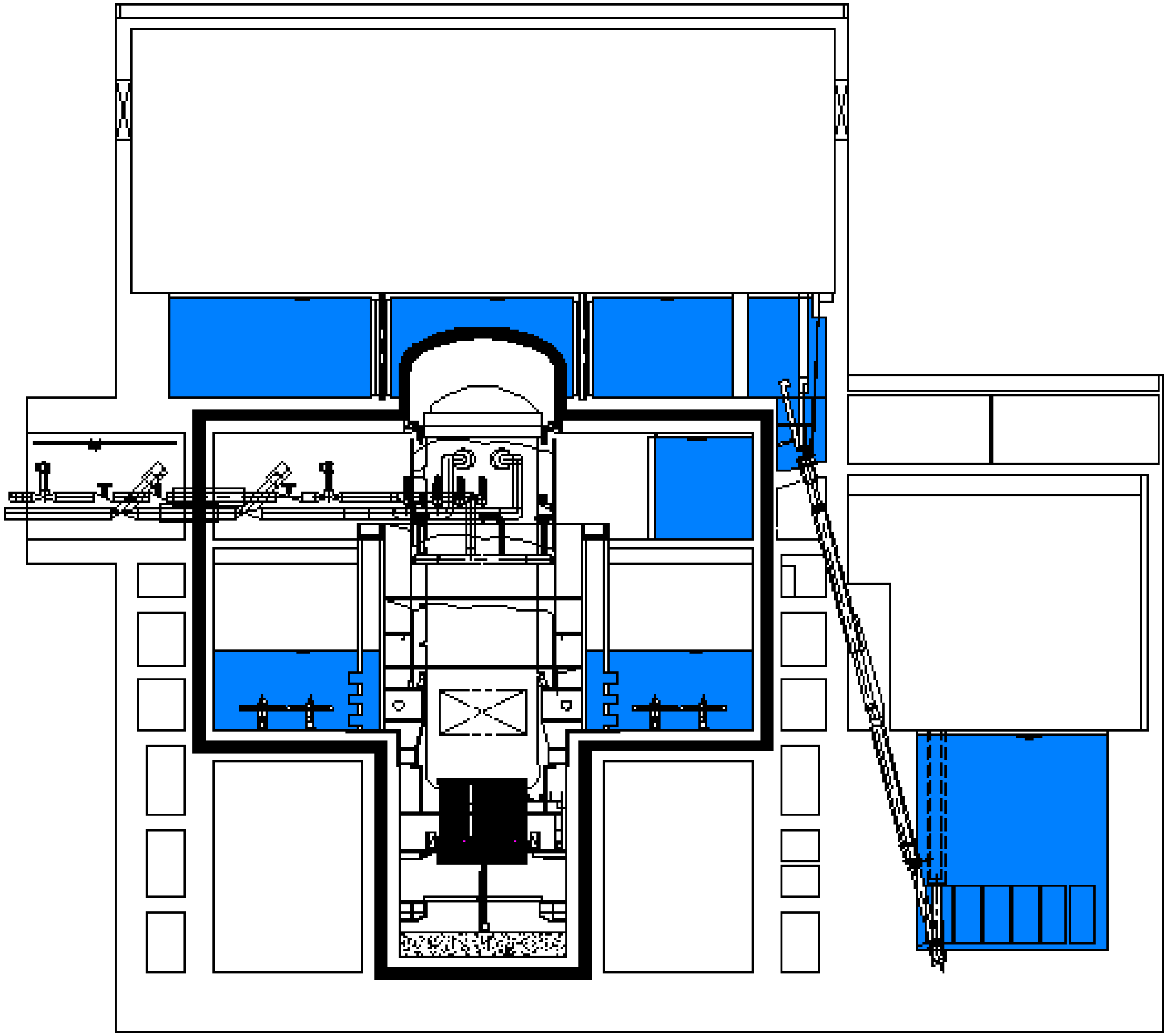
AOO Without Scram (ATWS)

- Scram discharge volume eliminated
  - > Eliminates common mode failure
- Electric Control Blade insertion diverse from hydraulic scram
- FW runback results in decreased water level, core flow, & power reduction; automated and diverse from scram logic
- Boron Injection is direct to core bypass
  - Eliminates lower plenum boron stratification
- Boron accumulator initial flowrate exceeds 10CFR50 requirement
  - > Shutdown achieved quickly w/o depressurizing
- After shutdown IC operation terminates steam flow to suppression pool and pool heatup

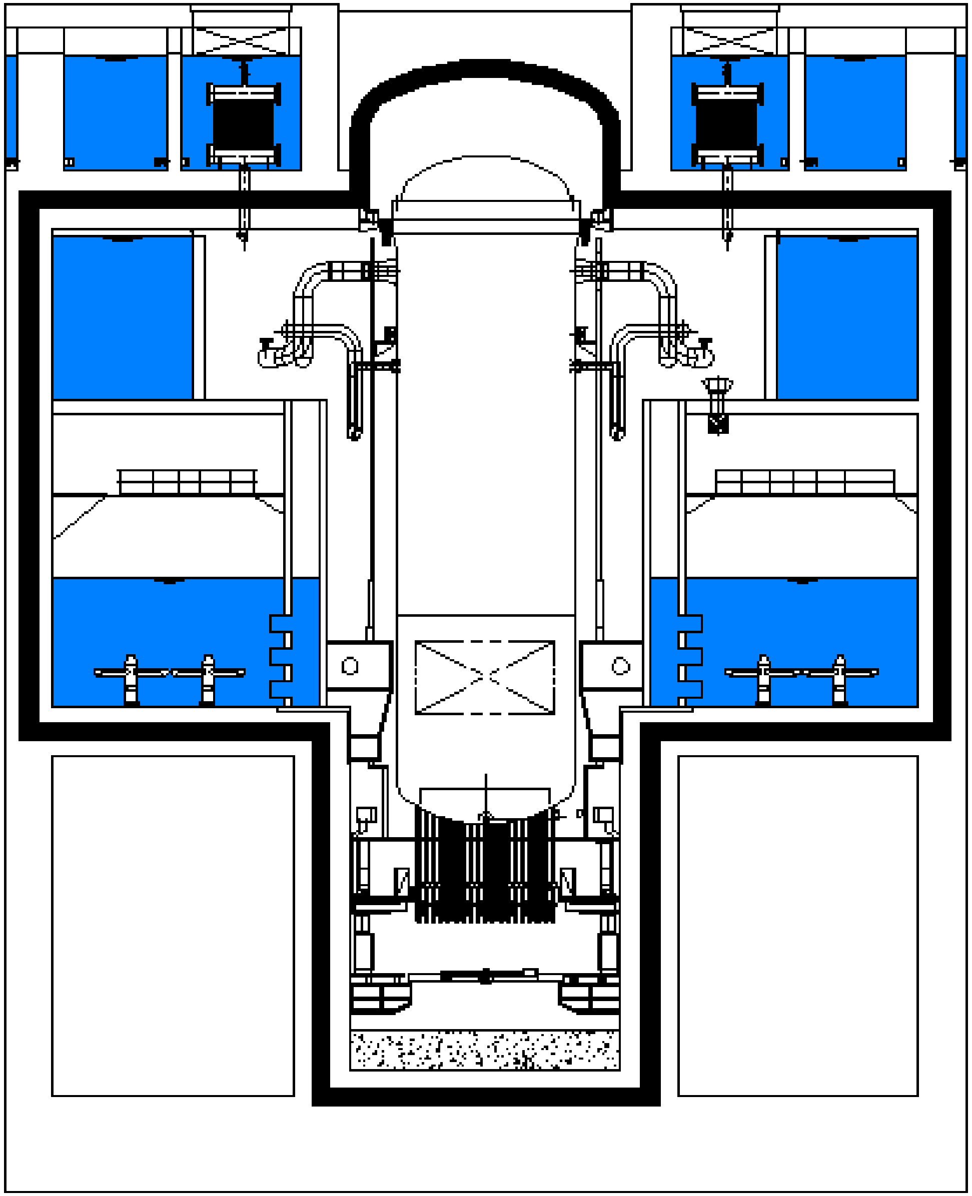
LOCA Water Level Response



Reactor and Fuel Building

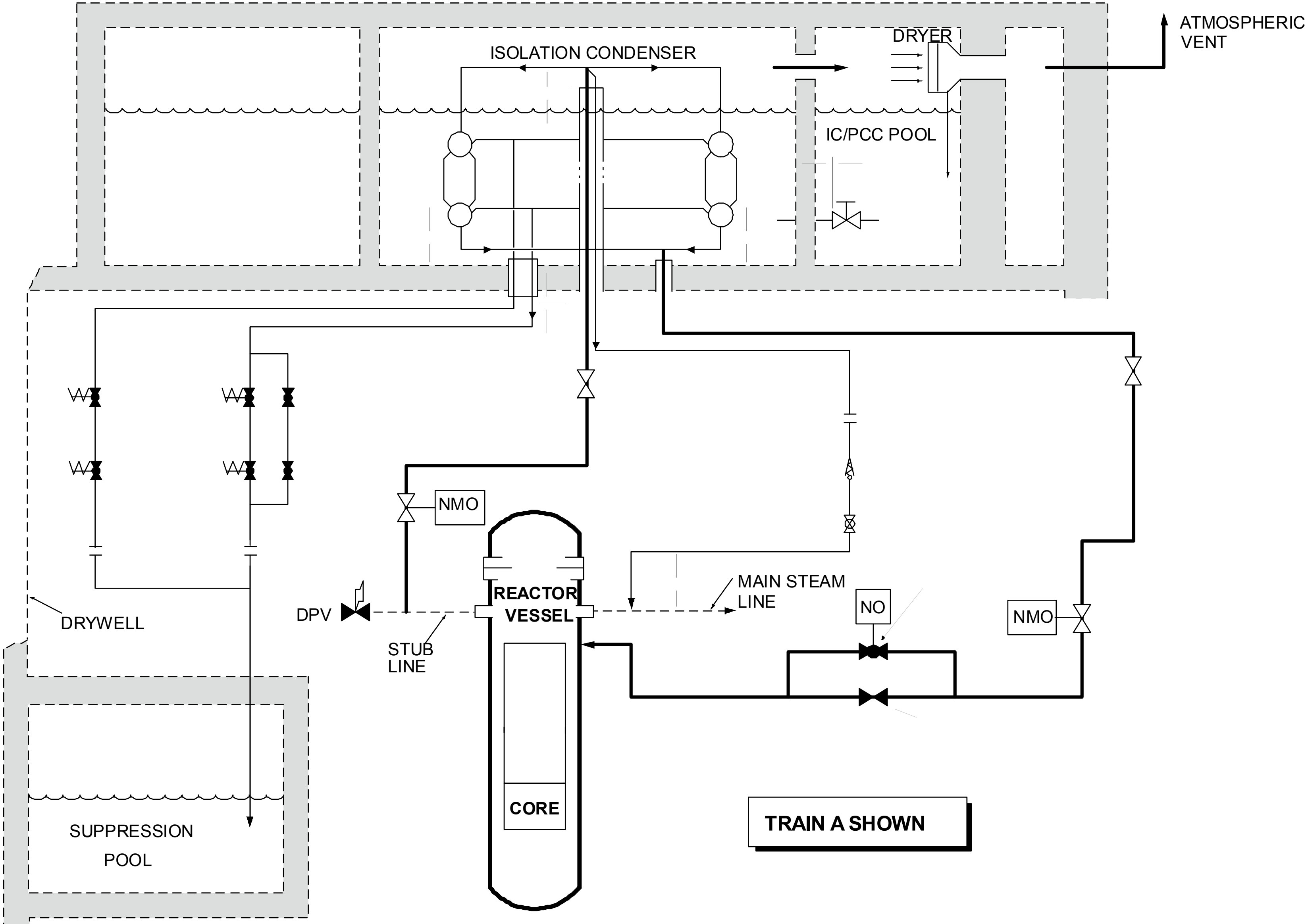


Containment



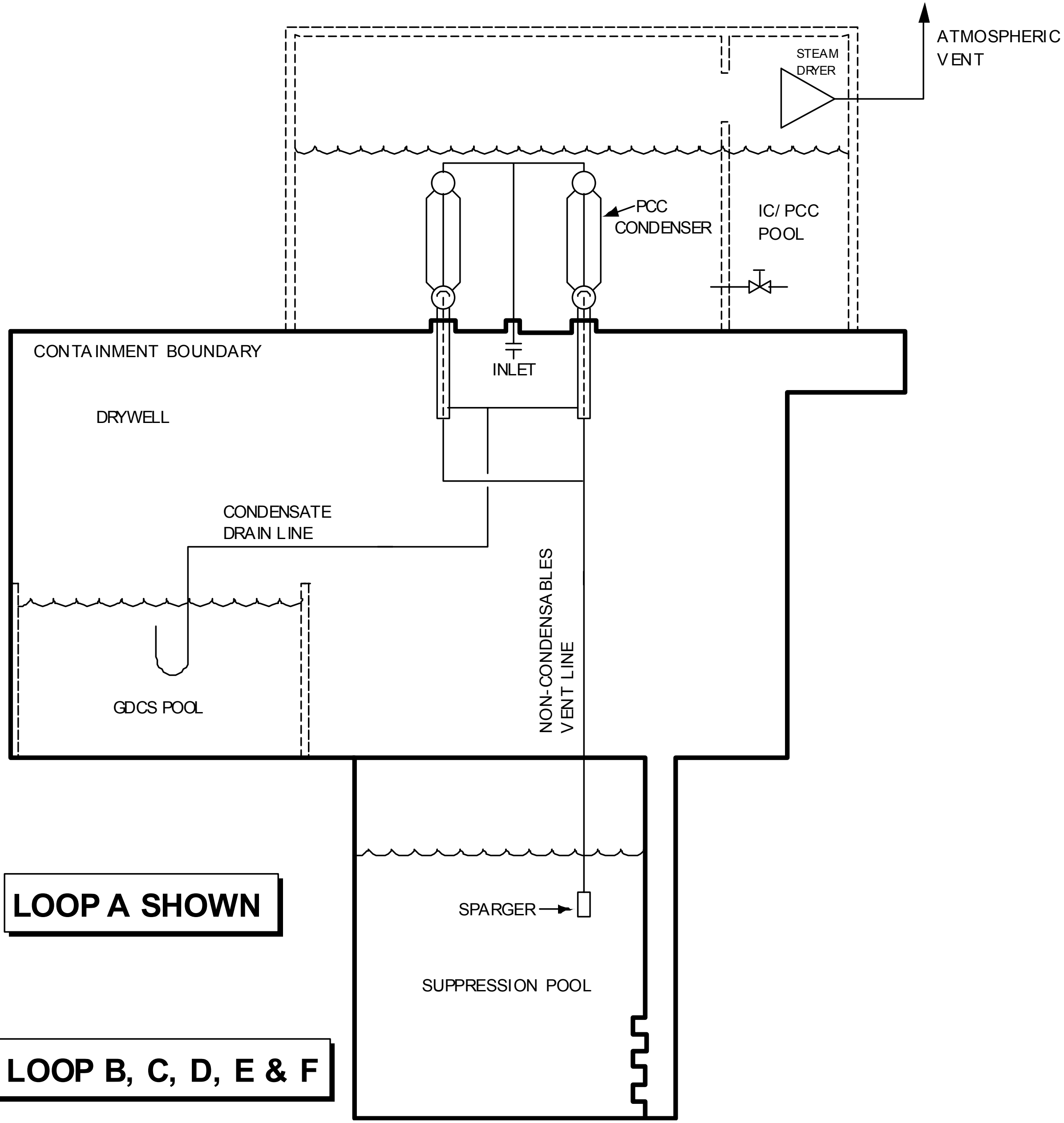
Isolation Condensers

- ICs provide passive decay heat removal
  - > Single Failure Criteria apply
  - > No lift of the Safety Relief Valves (SRVs)
  - > Operates in all Design Basis Conditions except medium and large break LOCAs
  - > ICs transport decay heat direct from NSSS to the Ultimate Heat Sink
    - No steaming in the primary containment
  - > Rapidly reduces RPV pressure
  - > Redundant Active Components


ISOLATION CONDENSER
DRYER
ATMOSPHERIC VENT
IC/PCC POOL
NMO
REACTOR VESSEL
MAIN STEAM LINE
NO
NMO
DPV
STUB LINE
DRYWELL
CORE
SUPPRESSION POOL
TRAIN A SHOWN

Passive Containment Cooling

- PCCs provide passive decay heat removal from the primary containment
  - > Operates in medium and large break LOCAs
  - > Provides backup of ICs if needed
    - – RPV is fully depressurized using DPVs
  - > Entirely Passive
    - > ~40 hours
    - > Opening of four valves to extend to 72 hours
  - > PCCs transport decay heat direct from Primary Containment to the Ultimate Heat Sink



LOOP A SHOWN

TYP LOOP B, C, D, E & F

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Emergency Core Cooling (ECC)

- Gravity Driven Cooling System (GDCS)
  - Three Pools
  - Four Trains
- Automatic Depressurization System (ADS)
  - 10 of 18 Safety Relief Valves (SRV)
    - Pneumatic actuation
  - 8 Depressurization Valves (DPV)
    - Squib actuated

Emergency Core Cooling (cont)

- Core remains covered for entire range of Design Basis Accidents
  - No fuel heat-up
- Complies with 10 CFR 50.46
  - Codes have been approved by NRC
- Stored water is sufficient to flood RPV and containment (lower drywell) to above the top of fuel

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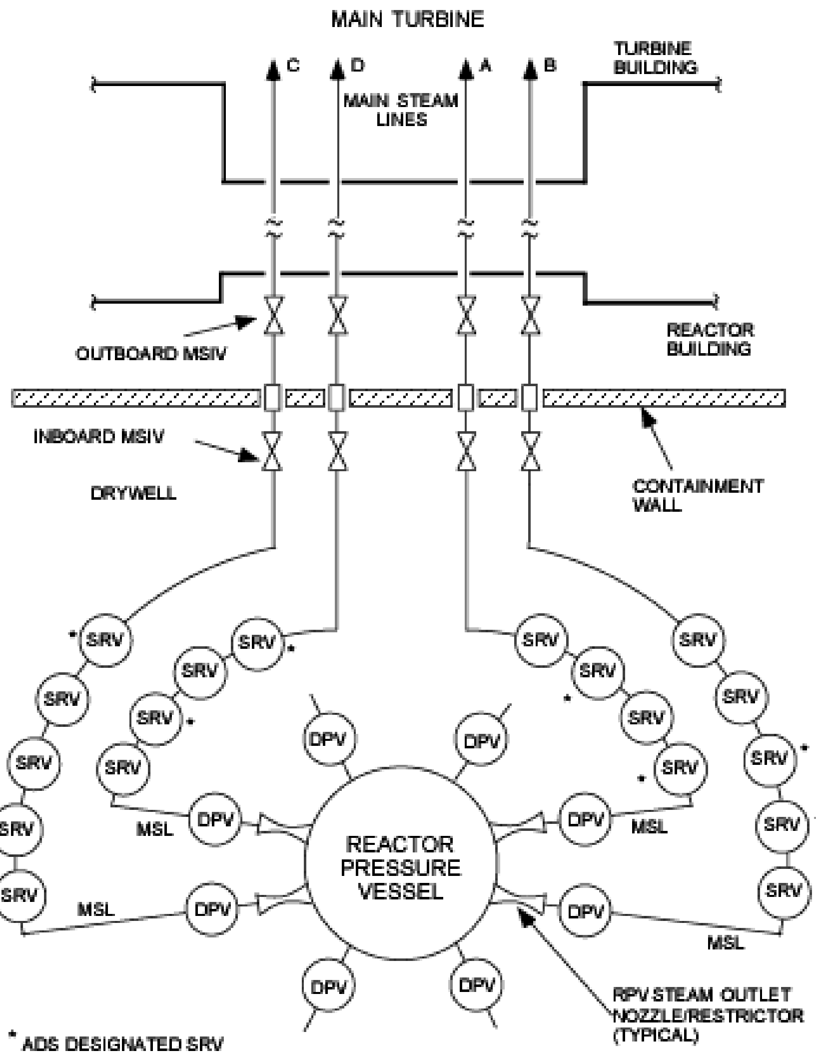
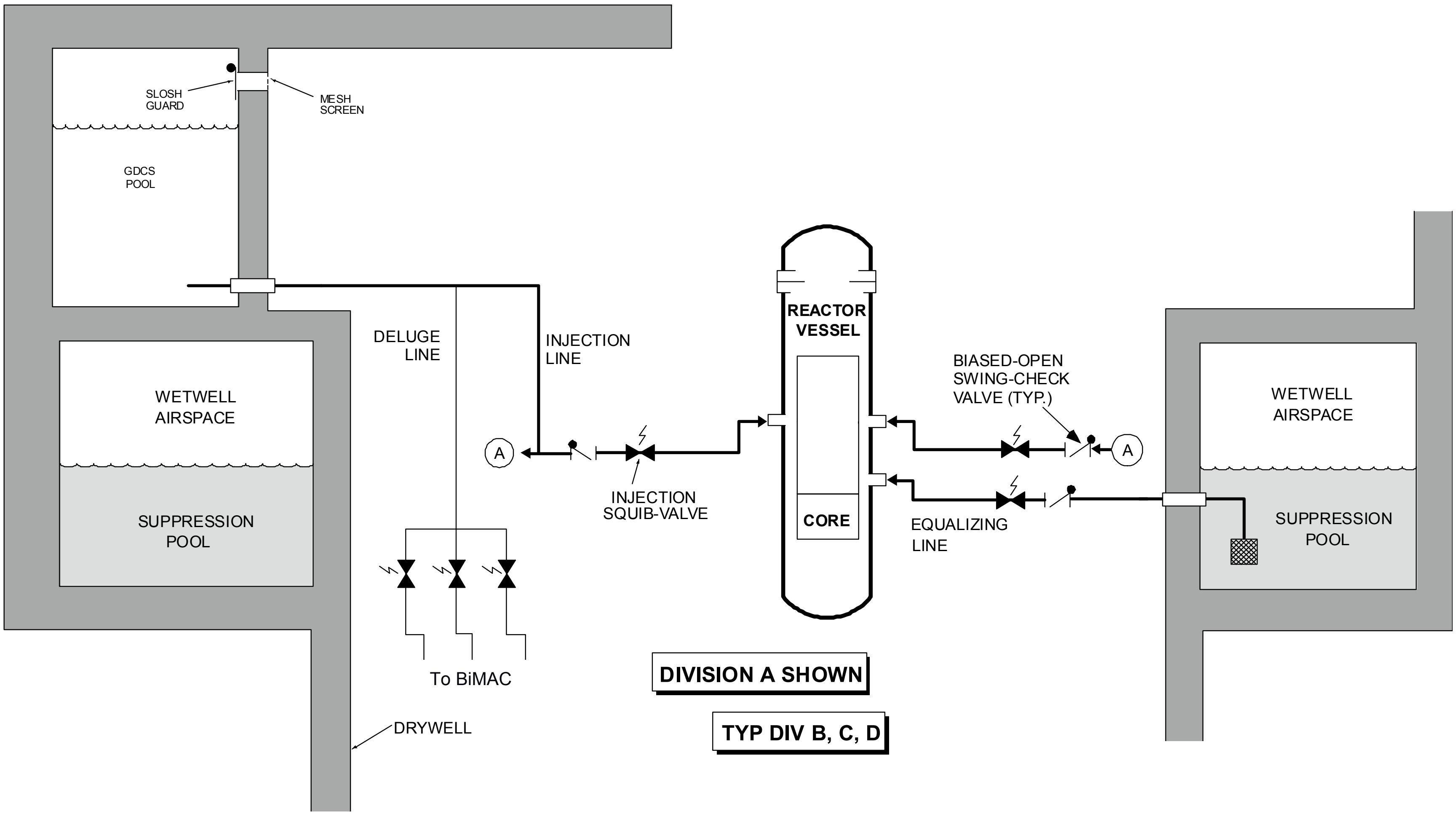
MSIV, SRV and DPV Arrangement





Gravity-Driven Cooling System

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Other Safety-Related Passive Systems

- DC Power Supplies
  - > Battery banks
  - > Inverters
  - > Battery Chargers
- Emergency Breathing Air System
  - > Main Control Room Habitability
- Standby Liquid Control (SLC)
  - > Two Pressurized Tanks of Boron

Safety-Related Electrical

- Four Divisions
- DC Backed
  - > Inverted power for AC loads
  - > 4 Divisions with 24 hours Capability
    - – Monitor
    - – Control
  - > 2 divisions with 72 hours Capability
    - – Monitor

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Regulatory Treatment of Non-Safety Systems (RTNSS)

- Enhanced QA will be imposed on some systems
  - Based on PSA insights
  - Post 72 hours through 7 days
- Fire Protection Systems
  - > IC/PCC pool fill
  - > Spent Fuel Pool makeup

Plant Investment Protection (PIP)

- Non-safety systems provide for defense in depth
  - Two redundant trains (active)
    - Significant contributors to plant availability
    - Asset Protection
  - On-Site AC Power (Diesel Generators)
    - Electrical Distribution
  - CRD Hydraulics
  - Reactor Water Cleanup
  - Fuel and Auxiliary Pool Cooling and Cleanup

Instrumentation & Control Systems

- Key Design Features
  - > Digital data network for plant-wide control & display
    - – Separate sub-systems
  - > Intelligent multiplexing system & fiber optics
  - > Standardized I&C equipment and components
  - > Plant Computer System supports extensive plant automation
  - > Online diagnostics
  - > Advanced control room design

Digital Control and Instrumentation

- Diversity
  > Four divisions of RPS
    - Manual scram and isolation

  > Four divisions of ECCS

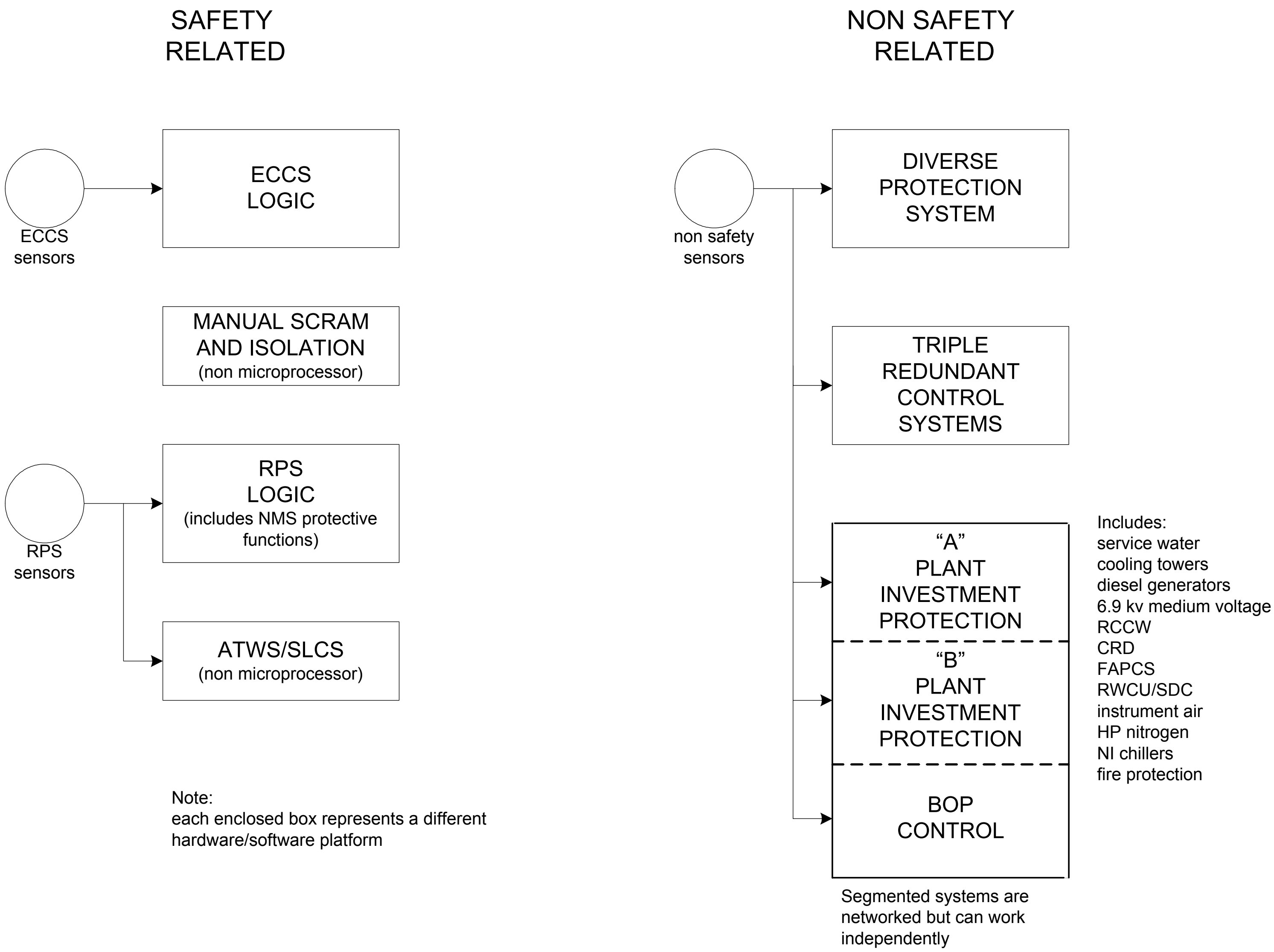
  > Four divisions on non microprocessor based ATWS/SLCS

  > Triple redundant controller for diverse RPS and ECCS

  > Triple redundant controllers for major nuclear control functions

  > Redundant controllers for investment protection and BOP control

Digital Control and Instrumentation



Reactor Protection

- Based on ABWR design
  - > 2/4 logic
  - > Fail safe
  - > Deterministic
  - > Diverse from ECCS
- Any two un-bypassed same parameters that exceed limits will always cause a scram with:
  - > Any single logic failure
  - > Any division of sensors bypass status
  - > Any division of logic bypass status
  - > Any single power failure
  - > Any possible main control room RPS control configuration

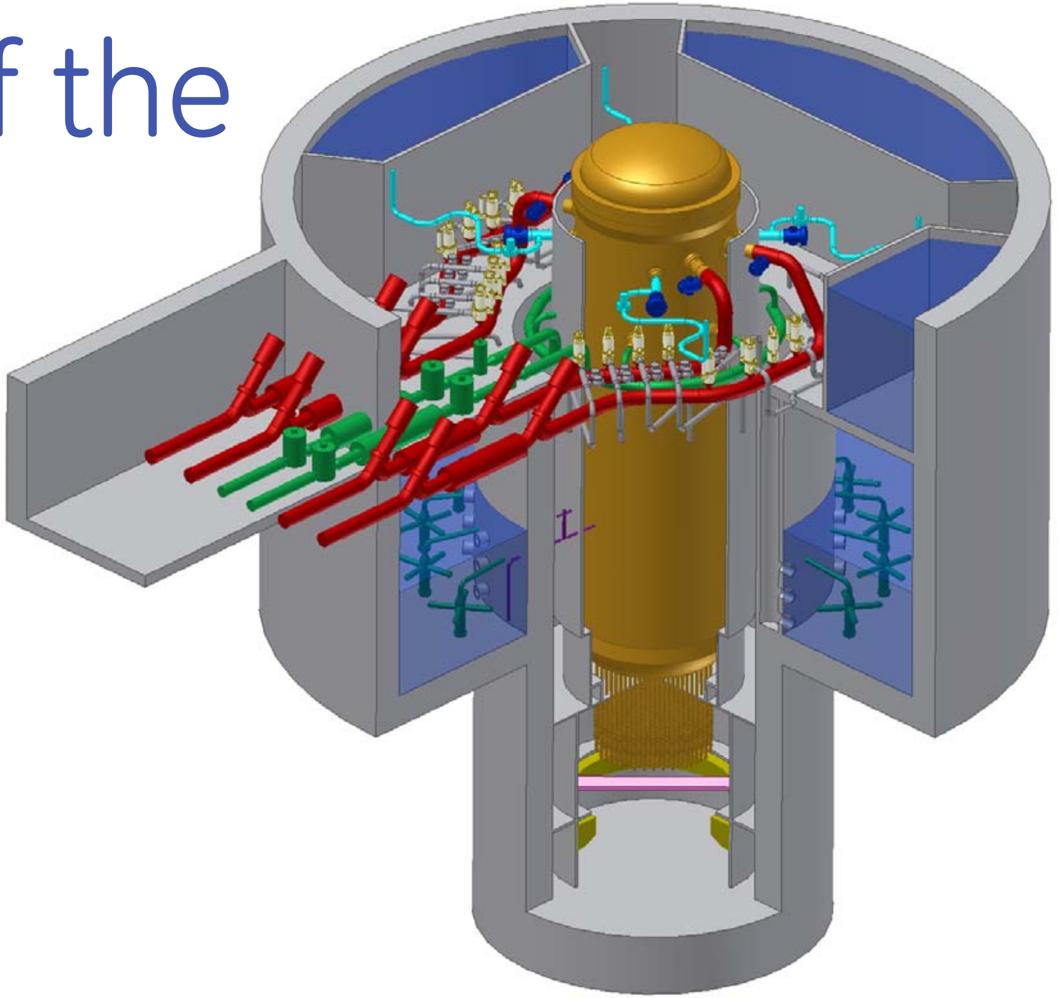
Engineered Safety Feature I&C

- Based on ABWR design
  - 2/4 logic
  - Fail As Is
  - Deterministic
  - Diverse from RPS
- Any two un-bypassed same parameters that exceed limits will always initiate ECCS with:
  - Any single logic failure
  - Any division of sensors bypass status
  - Any single power failure
  - Any possible main control room ECCS control configuration

Summary

- Enhanced Safety
  - > Continues improvement of BWR line
- Leverages ABWR design where appropriate
  - > Utilizes proven technologies
- Transient response is significantly improved
  - > No Safety Relief Valve (SRV) openings

NRC Executive Overview of the ESBWR



September, 27, 2005
Rick Wachowiak

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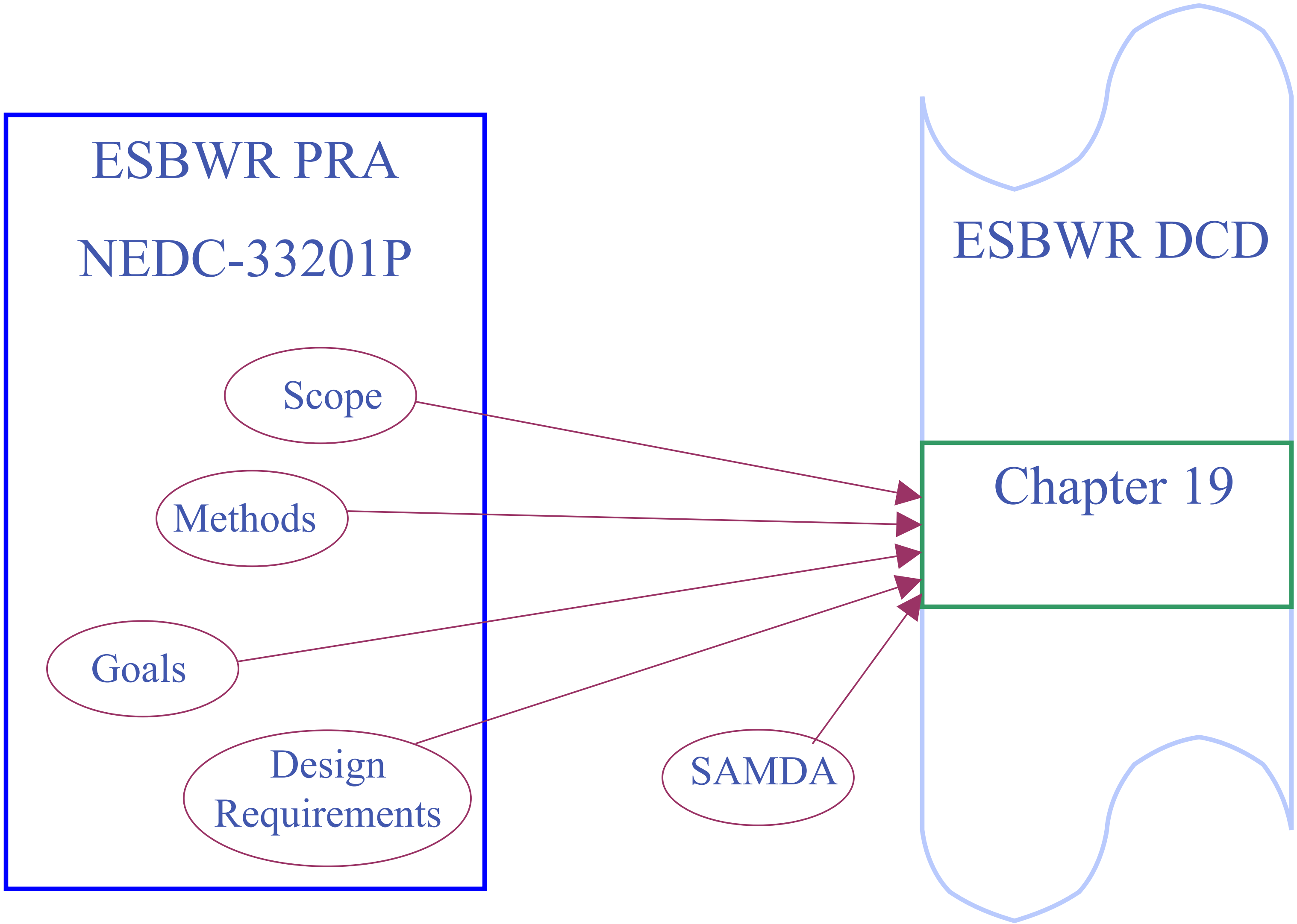
PRA Overview

Organization of the Documents

Attributes of the PRA

Summary of Results

Document Relationships



PRA Scope

Internal Events, Power Operation

- Level 1, 2, and 3

Internal Events, Shutdown

- Level 1
- 99% SDCDF in mode 6, so no level 2 required

External Events (non-Seismic)

- Screening shows no impact on risk

Seismic

- Seismic margins analysis identified no outliers

PRA Quality

Follows ASME Standard Principles

> Where applicable, meets capability category 3

> Some plant specific information not available until COL or construction

Certification PRA Capability

> Determine that ESBWR meets risk goals

> Determine importance at a system level

> Determine overall importance of operator action

Each Element Appropriate for Certification

Comprehensive System Analysis

Detailed Fault Tree Model

> 24 systems modeled
> Major components included
> Fully linked support systems
> Intra-system common cause
> Inter-system common cause for squib valves

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Containment Performance

Level 2 Linked Directly to Level 1

Phenomena Probabilities from ROAAM

> High confidence, rather than mean, values used

Shutdown

Detailed Model

- > Loss of decay heat removal
- > LOCA
- > Loss of Preferred Power

Includes Manual Shutdown for Refueling

The Bottom Line

Internal Events CDF	3.2×10^{-8}
Internal Events LRF	1×10^{-9}
CCFP	0.025
Probability of Exceeding 25 Rem at 1/2 Mile	2×10^{-9}
External Events Contribution	negligible
Shutdown CDF	4×10^{-9}

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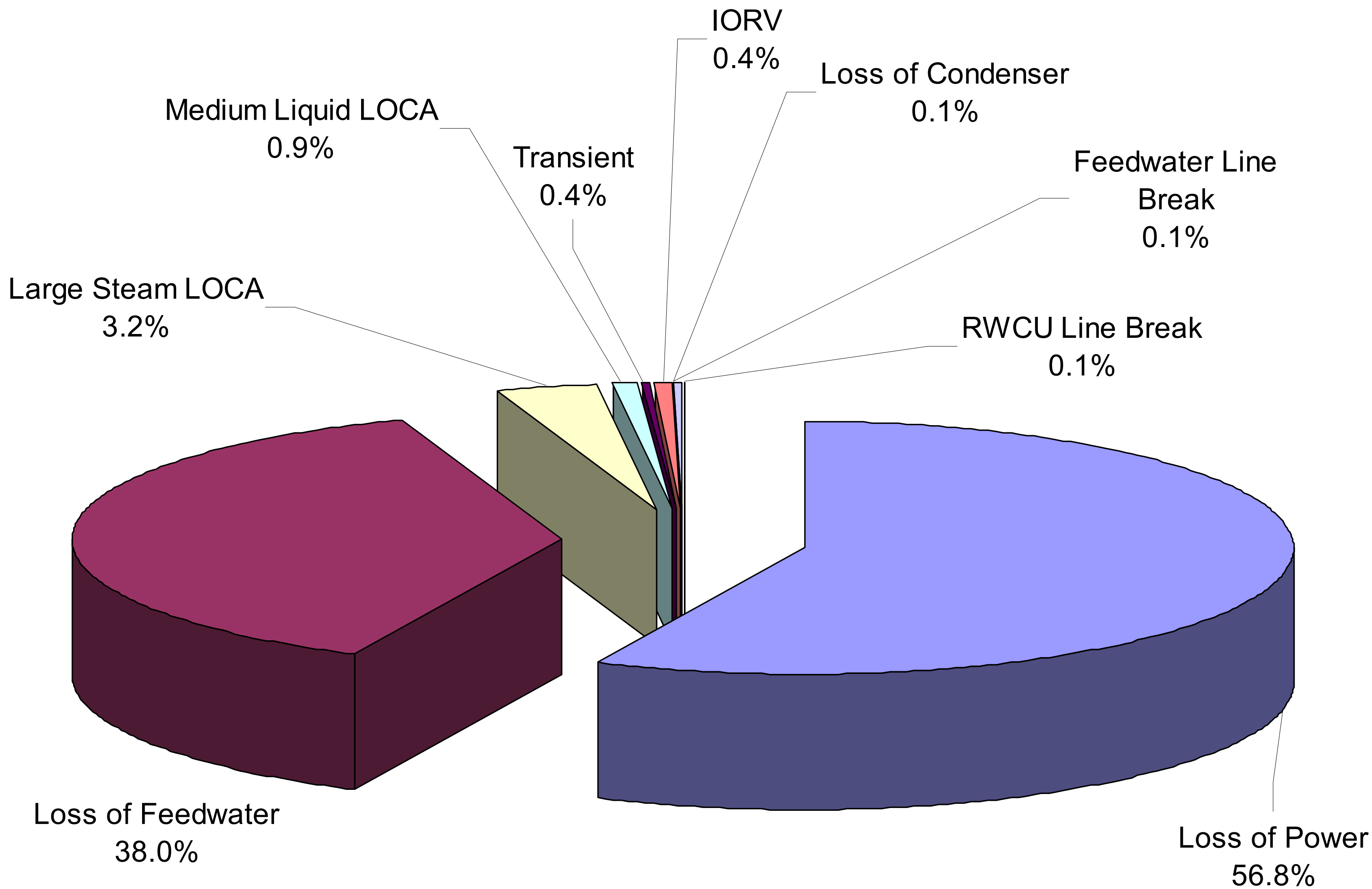
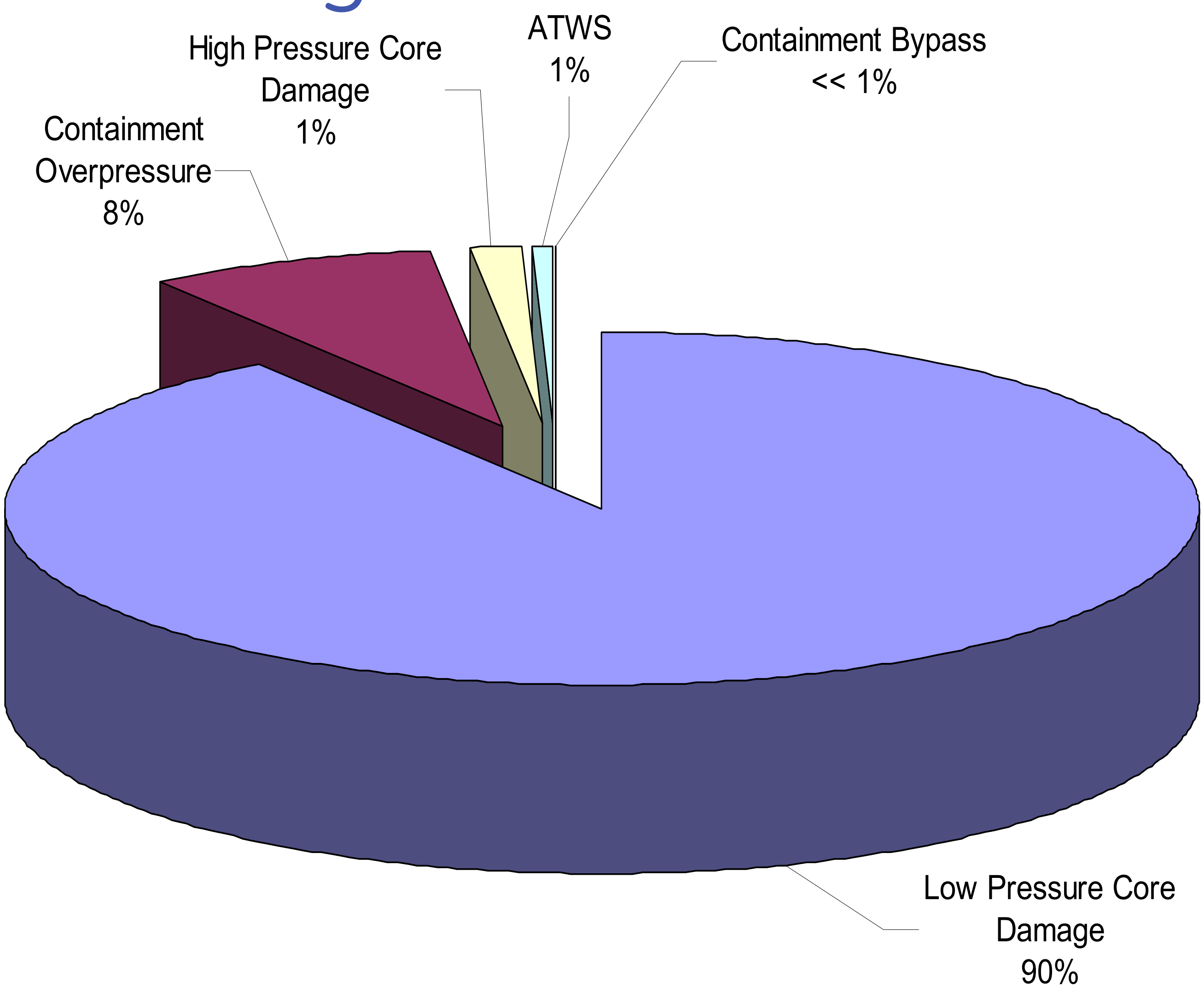
Breakdown By Initiating Event



Breakdown By Accident Class



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Attributes of ESBWR Risk

Redundancy and Diversity!!

At Least 3 I&C Systems Need to Fail for Core Damage

Top Cutsets Involve

- CCF of Batteries
- CCF of Squib Valves

Loss of All Electric Power (AC & DC) Itself Does Not Cause Core Damage

Containment Failure Does Not Lead to Core Damage within 72 Hours

Containment Can Be Flooded Above Core Using Passive Systems

Attributes Affecting Risk (continued)

High Containment Ultimate Strength

- High confidence pressure 1.2 MPaG
- Most scenarios well below 0.9 MPaG

Ex-Vessel Explosion

- Does not occur if water in lower drywell less than 0.7 m. This is the likely case.
- Containment survives EVE pressure pulse
- Consideration for localized failures included

Attributes Affecting Risk (continued)

Direct Containment Heating

- Containment survives initial pressurization
- Long term high temperatures do not fail liner or penetrations
- Lower to upper drywell configuration minimizes relocation of core debris
- Containment spray added as defense-in-depth

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Attributes Affecting Risk (continued)

Basemat Melt Penetration

> Precluded by BiMAC (see next slide)
> Diverse actuation
> Cools debris from above, below, and on sides

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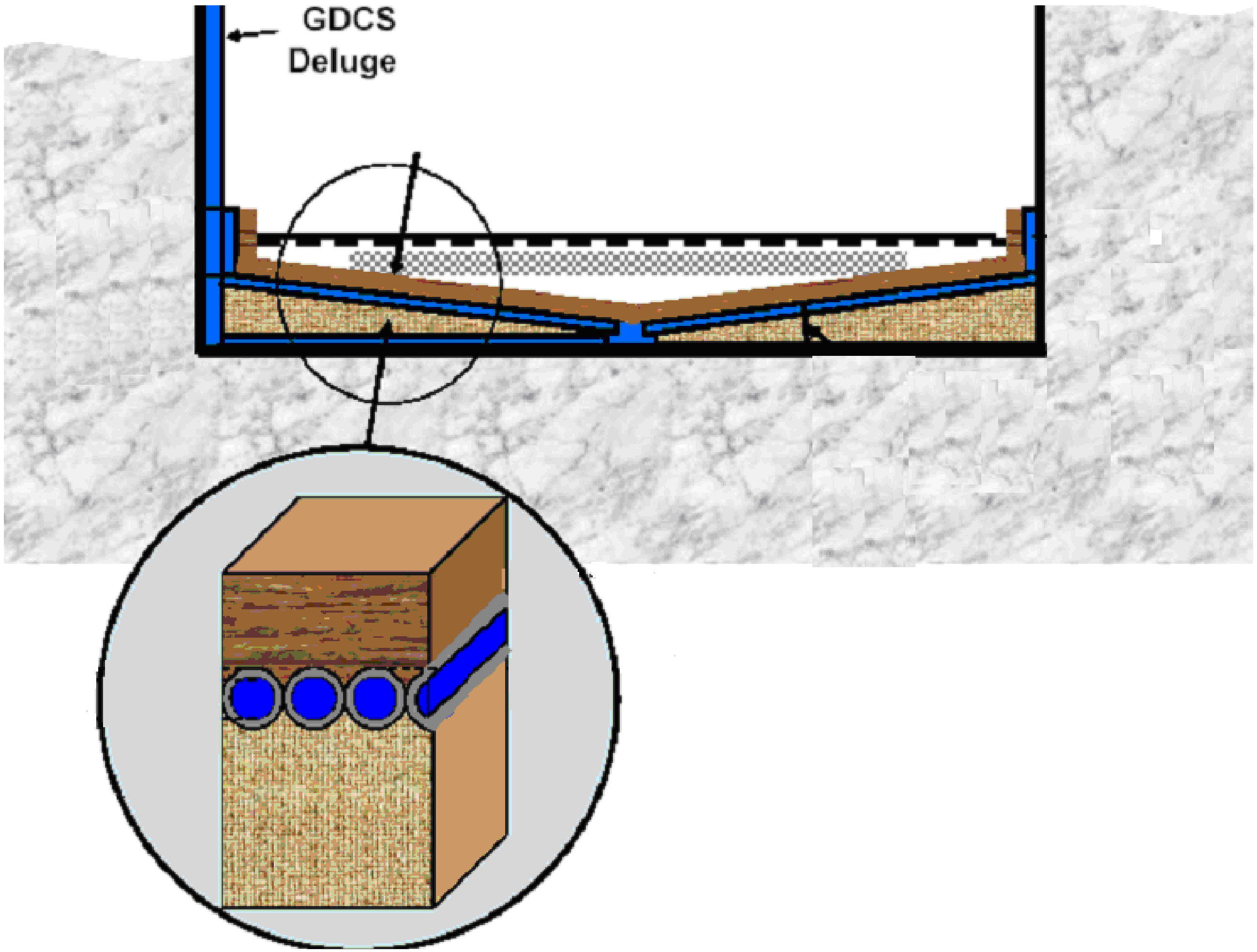
Basemat Internal Melt Arrest and Coolability (BiMAC)



Regulatory Treatment of Non-Safety Systems

One System Identified

- Fire water refill of IC/PCC pools

Sensitivity Analysis Provides Basis

- Calculated CDF using only safety-related and special treatment systems
- CDF = 4.0×10^{-5}
- LRF = 2.6×10^{-7}

Other Sensitivities

Case	Core Damage Frequency (yr^{-1})	Large Release Frequency (yr^{-1})
Base	3.2×10^{-8}	8×10^{-10}
Safety + RTNSS	4.0×10^{-5}	2.6×10^{-7}
No Operator Credit	1.9×10^{-6}	4.0×10^{-7}
Squib Failure x 5	1.4×10^{-7}	2.4×10^{-9}
Squib Failure x 10	2.8×10^{-7}	4.2×10^{-9}
Truncation @ 10^{-14}	3.4×10^{-8}	9×10^{-10}

Conclusions

PRA Report Provides a Comprehensive Assessment of ESBWR Mitigation Capabilities

Incorporating Risk Insights During Design Drives Reliability

ESBWR Satisfies Risk Goals With Significant Margin