GE's ESBWR - Overview

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GE Nuclear Energy

NRC Meeting on Piping
March 9, 2005
Rockville, MD

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Purpose of Meeting

Reach agreement on method used for piping analyses at certification stage

Outline

Design overview

Piping analysis to support design certification

Environment fatigue on piping

Piping documentation to support DCD

What's different about ESBWR

ABWR	ESBWR
Recirculation System + support systems	Eliminated (Natural Circulation)
HPCF (High Pressure Core Flooder) (2 each)	Combined all ECCS into one Gravity Driven Cooling System (4 divisions)
LPFL (Low Pressure Core Flooder) (3 each)	
RCIC (Isolation/Hi-Pressure small break makeup)	Replaced with IC heat exchangers (isolation) and CRD makeup (small break makeup)
Residual Heat Removal (3 each) (shutdown cooling & containment cooling)	Non-safety shutdown cooling, combined with cleanup system; Passive Containment Cooling
Standby Liquid Control System–2 pumps	Replaced SLCS pumps with accumulators
Reactor Building Service Water (Safety Grade) And Plant Service Water (Safety Grade)	Made non-safety grade – optimized for Outage duration
Safety Grade Diesel Generators (3 each)	Eliminated – only 2 non-safety grade diesels

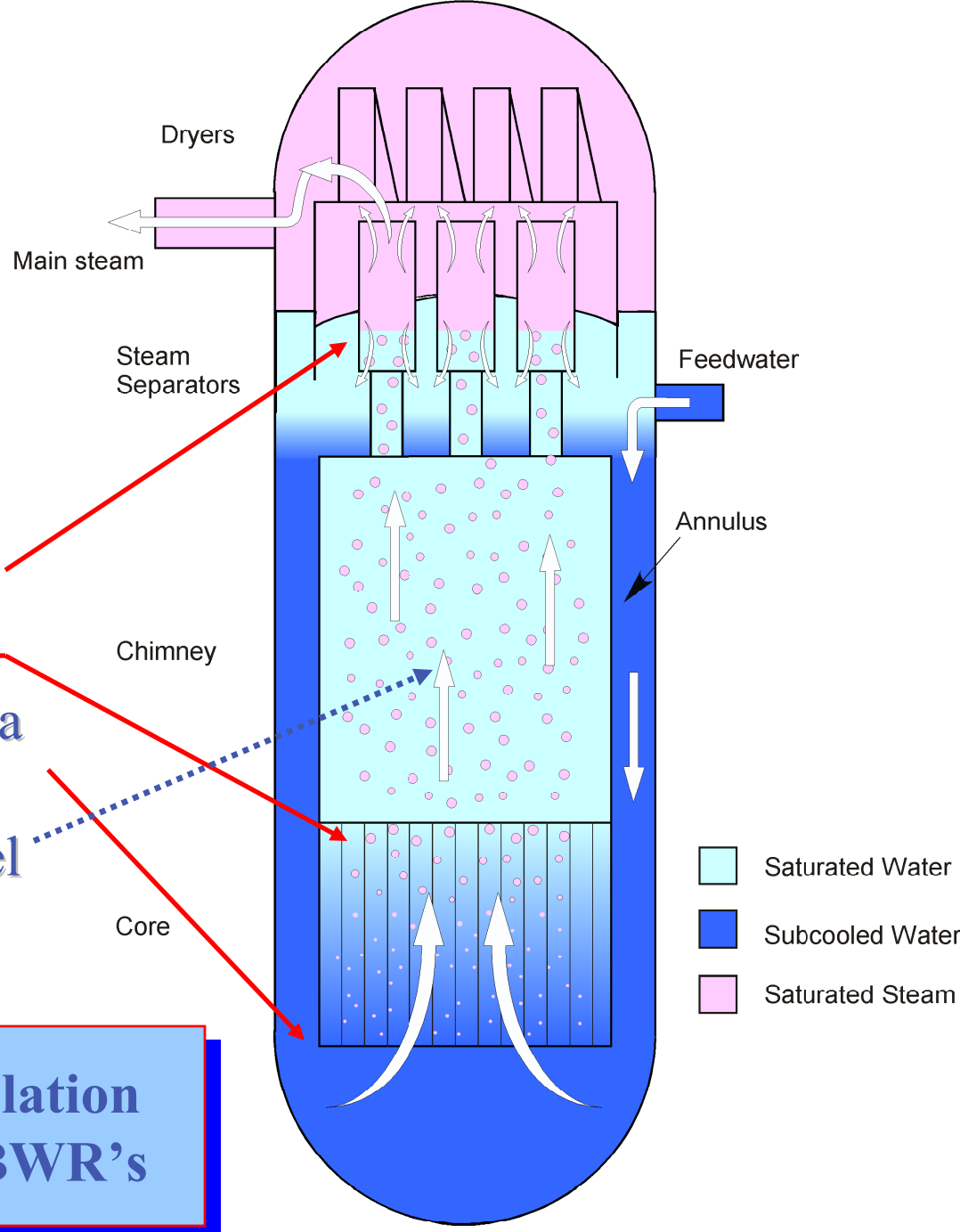
2 Major Differences – Natural Circulation and Passive Safety

Optimized Parameters for ESBWR still within Experience Base

Parameter	BWR/4-Mk I(Browns Ferry 3)	BWR/6-Mk III (Grand Gulf)	ABWR	ESBWR
Power (MWt/MWe)	3293/1098	3900/1360	3926/1350	4500/1550
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	1E-7
Safety Bldg Vol (m^3/MWe)	115	150	160	<100

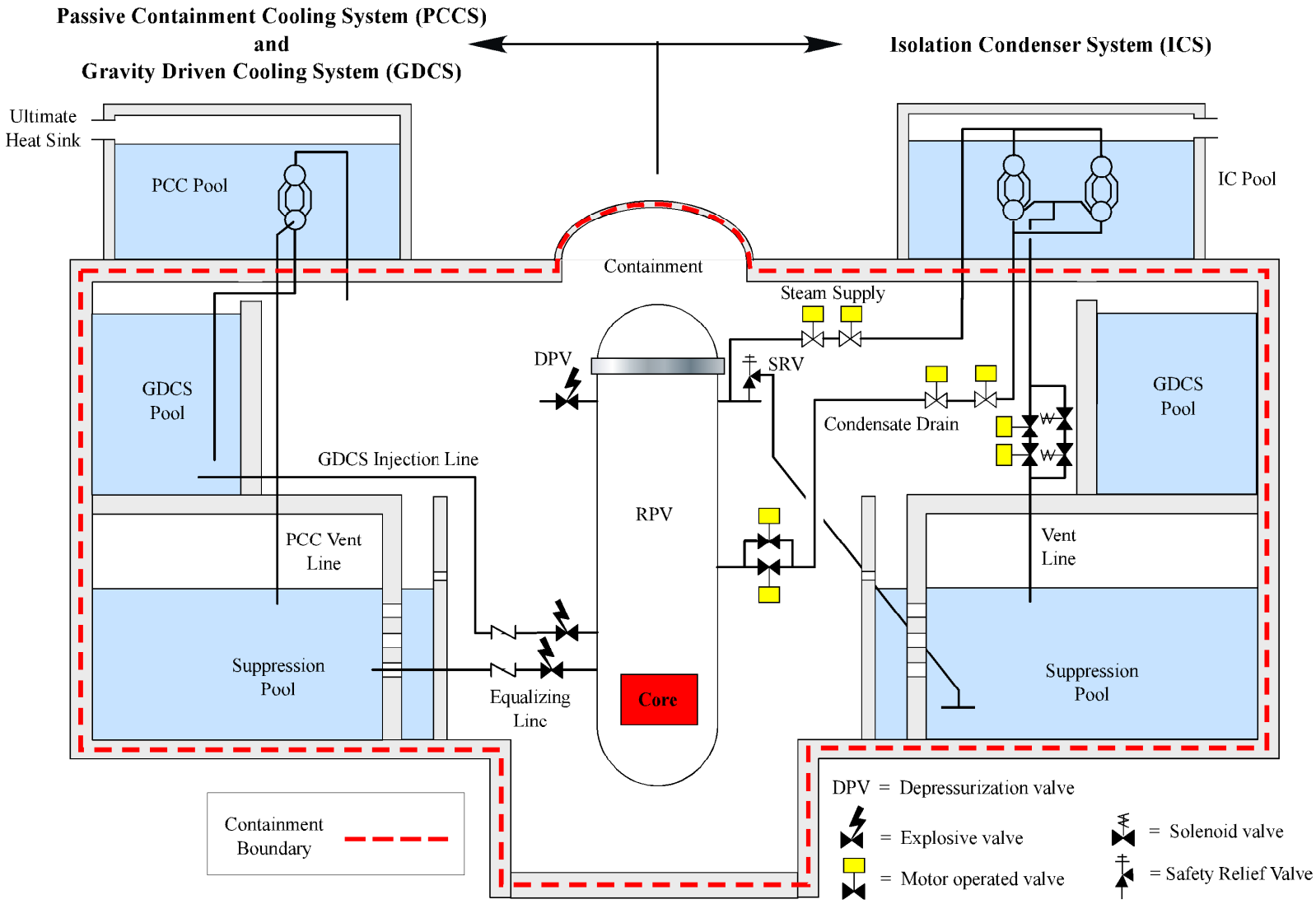
Improved core damage frequency & reduced systems & buildings

- Reduced flow restrictions
  - improved separators
  - shorter core
  - increase downcomer area
- Higher driving head
  - chimney and taller vessel

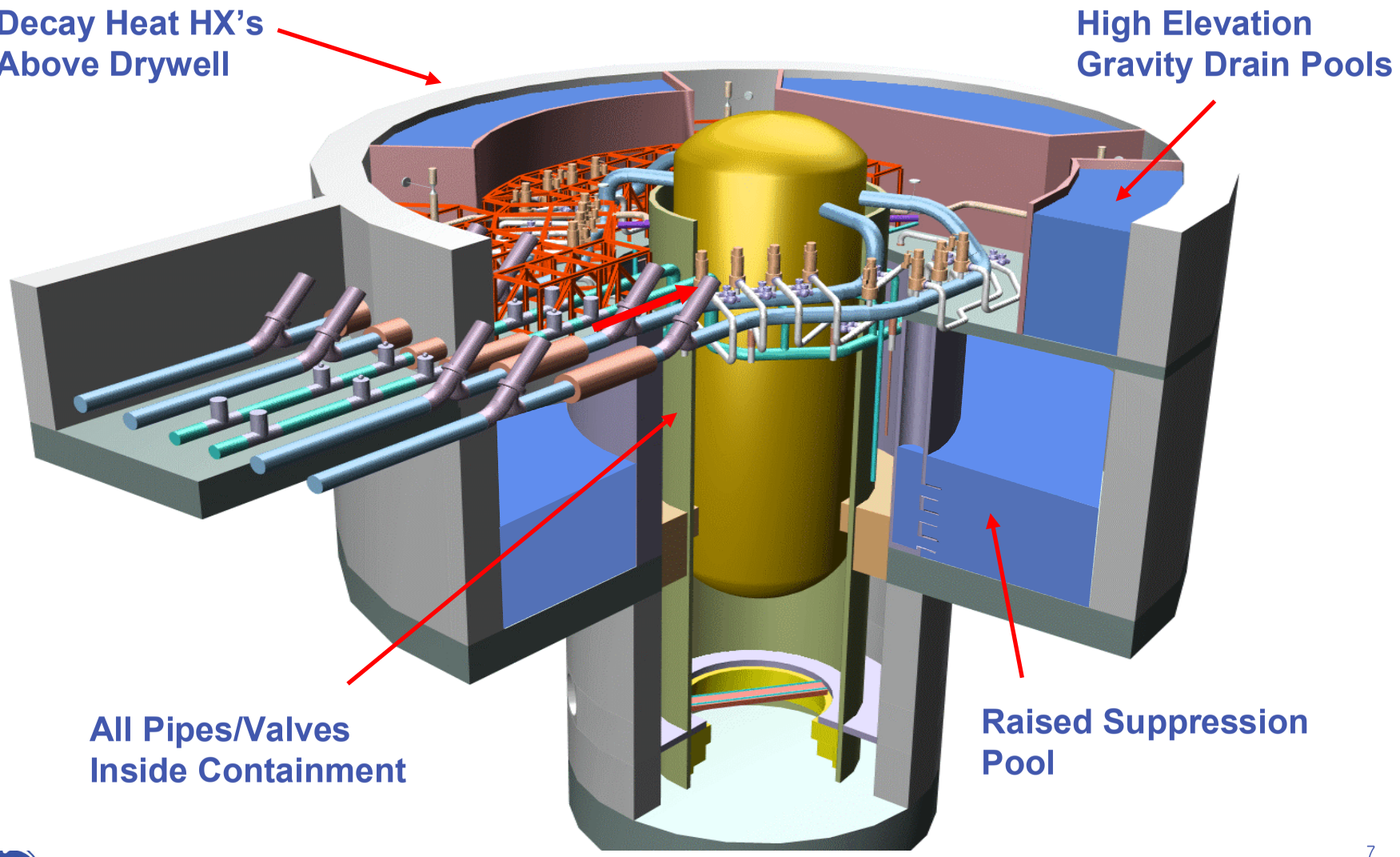


Enhanced Natural Circulation Compared to Standard BWR's

Passive Safety …



Passive Safety Systems Within Containment Envelope



Contents – Design Summary

Reactivity Control Systems

Isolation Events

Loss of Coolant – ECCS

Loss of Coolant – Decay Heat Removal

Defense-in-Depth Systems

Control Rod Drive (CRD)

Primary reactivity control mechanism

> Scram function is hydraulic with backup insertion by motor

Drives - Uses Fine Motion Control Rod Drive (FMCRD) versus Locking Piston CRD (LPCRD) for BWR/6 and earlier

> FMCRD developed for the ABWR

> Based on years of European reactor experience and extensive test and development program

> Actual operating experience at Kashiwazaki 6 and 7 (~5 years each)

Control Rod Drive System

Safety function – provide rapid control rod insertion (scram) and safe shutdown so that no fuel damage results from any abnormal operating condition

- Hydraulic scram provided by nitrogen-charged accumulator

Non-safety functions

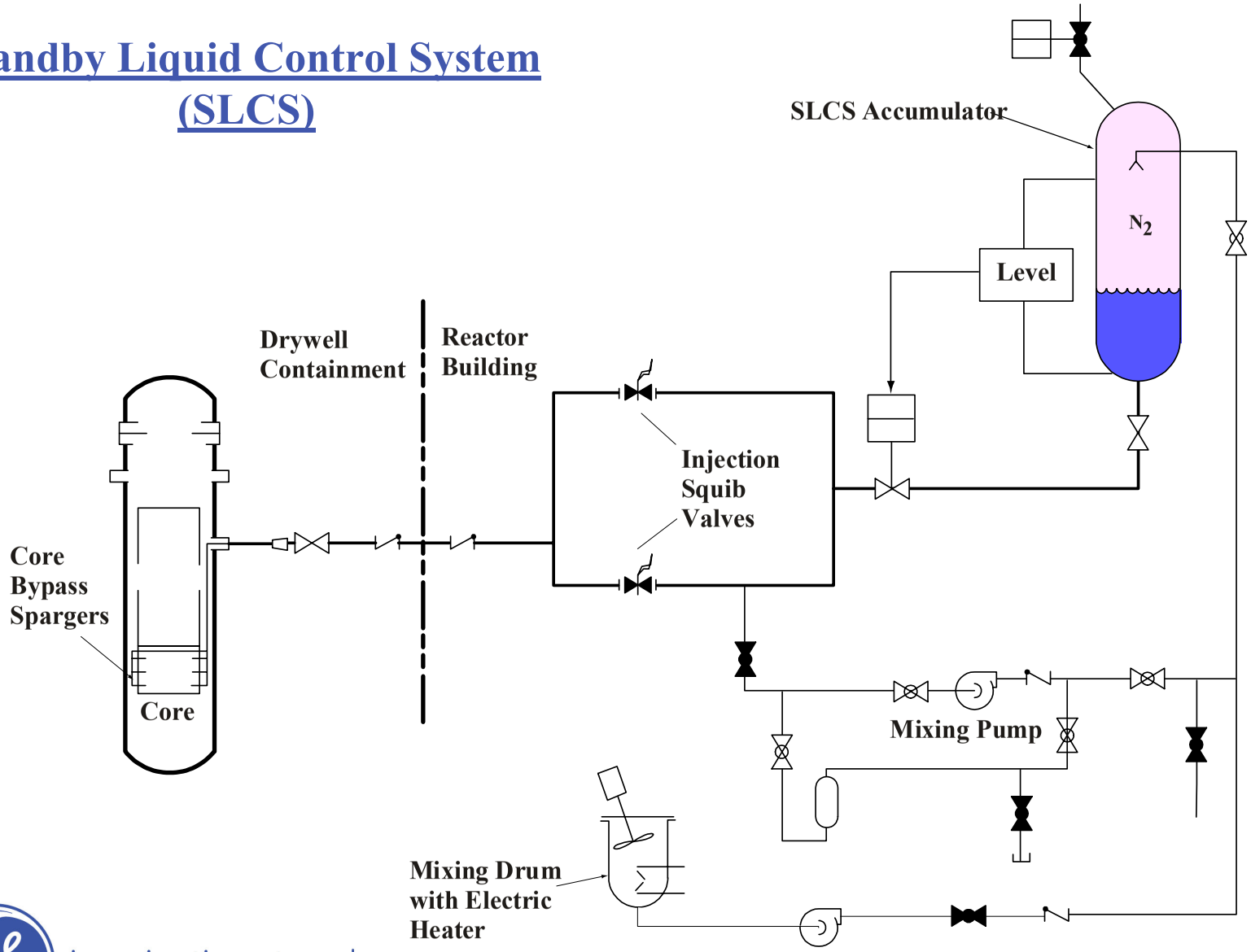
- Provide high pressure reactor inventory makeup (direct vessel injection) during plant transient events in which reactor water level drops to Level 2
- Provide purge water to FMCRD and cleanup pumps

Reactivity Control - Backup

Standby Liquid Control System (SLCS)

- Meets alternate shutdown control requirements
  - Also meets ATWS requirements (10CFR50.62)
- Accumulator driven boron injection system
  - Two divisions
- Nitrogen pressurized accumulators
- Headers located in vessel annulus, penetrating shroud
  - Injection into bypass region of core

Standby Liquid Control System (SLCS)



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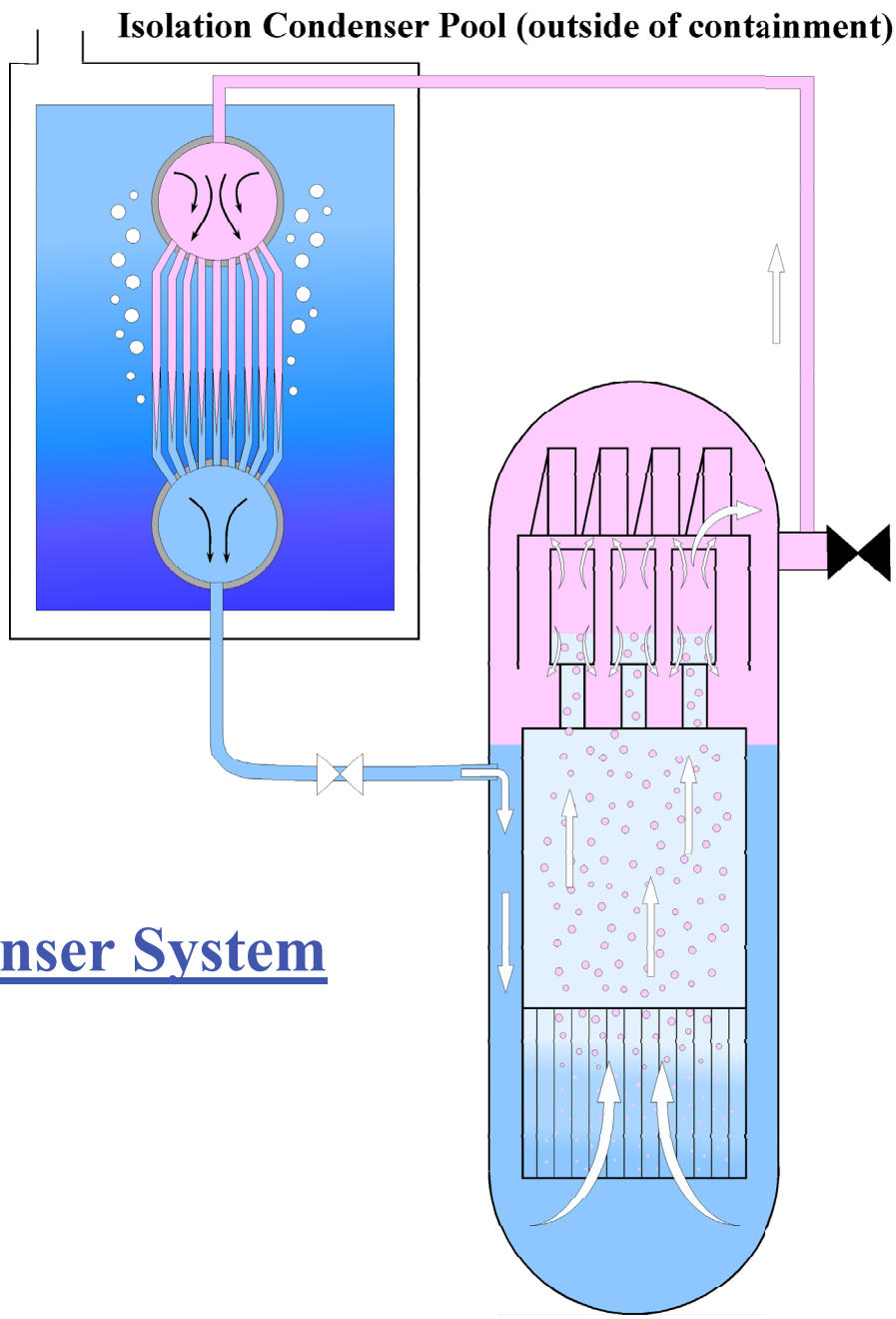
Isolation Condenser System



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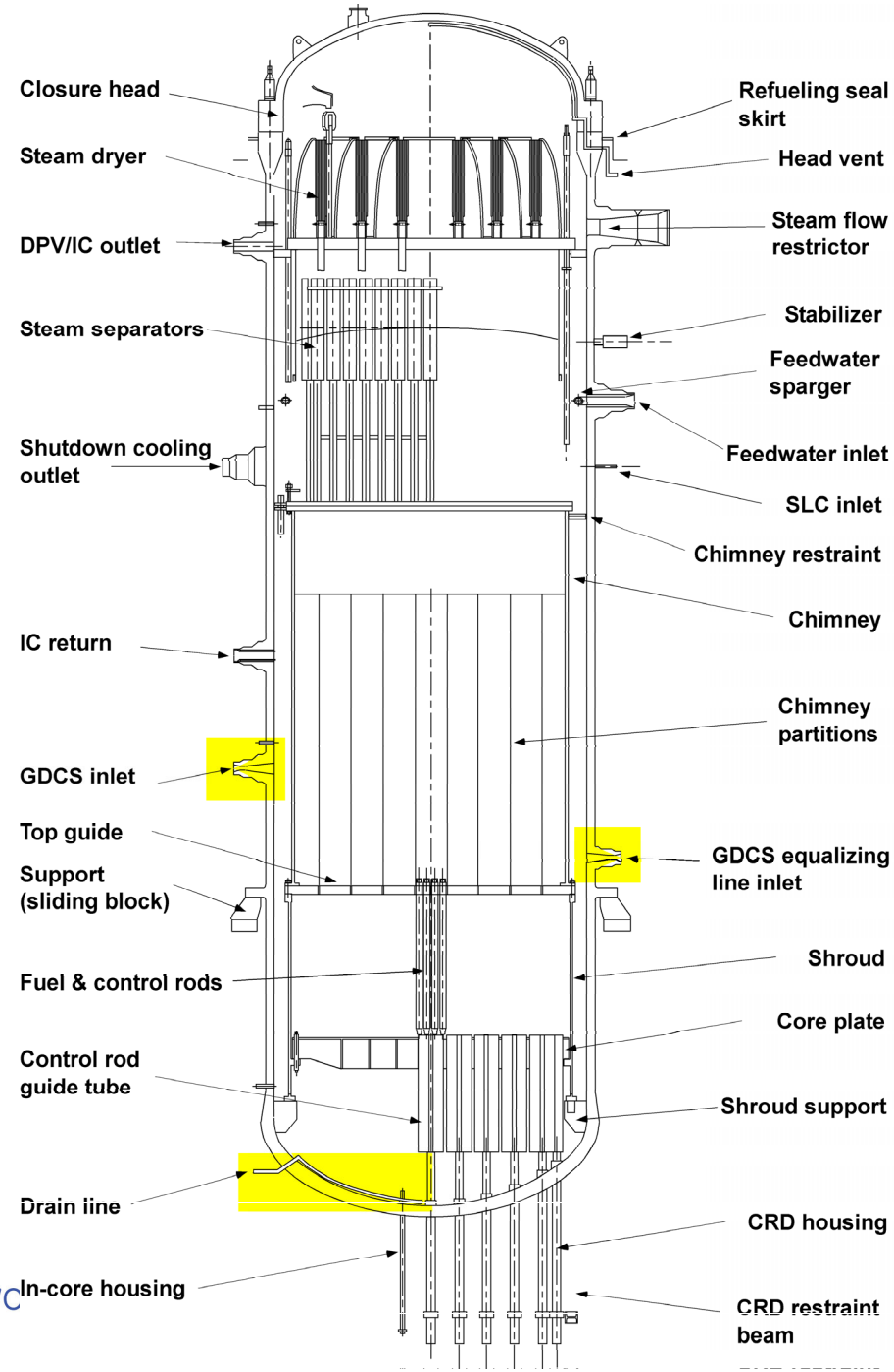
ESBWR Reactor Pressure Vessel And Internals



2 inch restricted nozzle size

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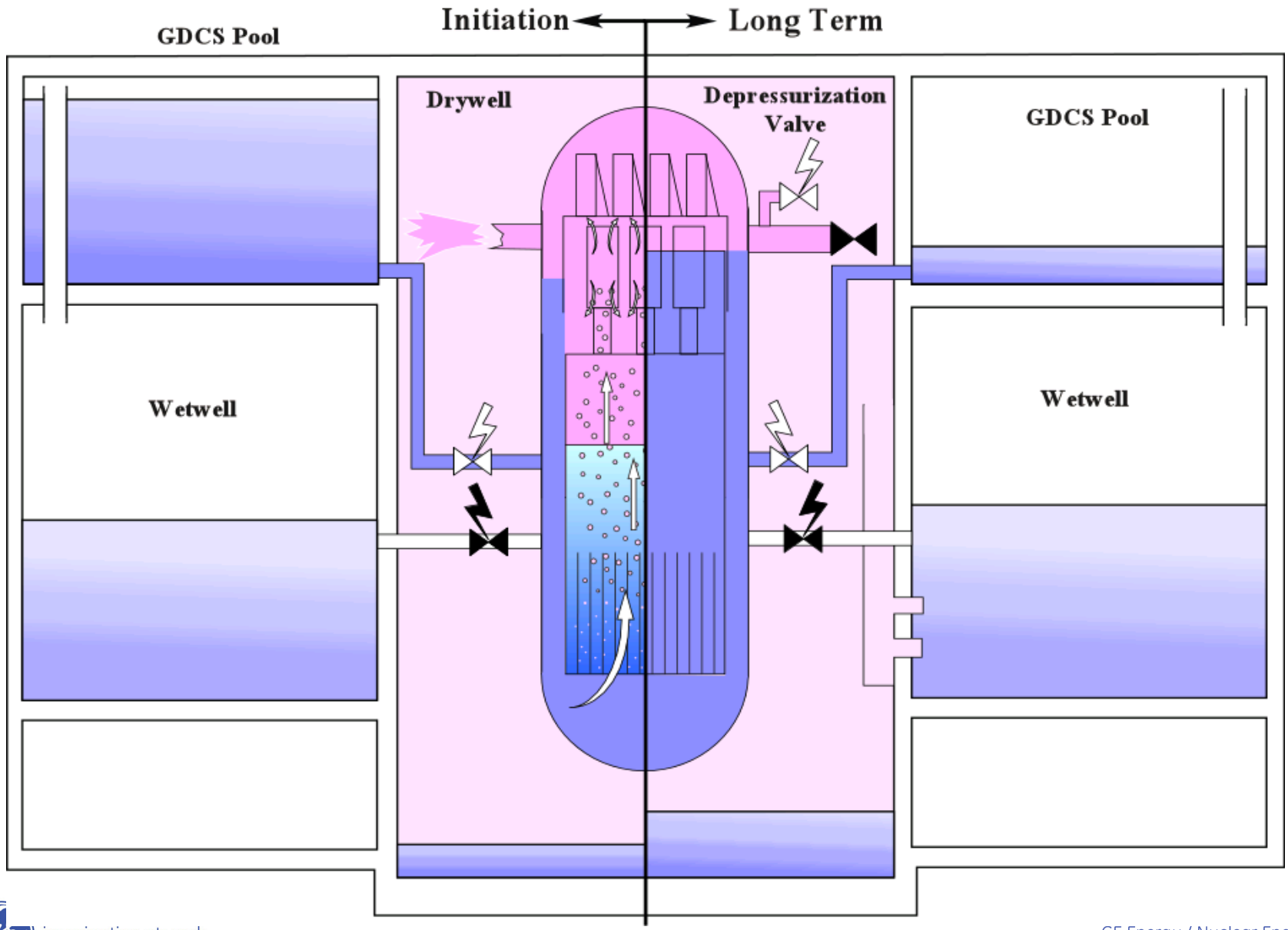
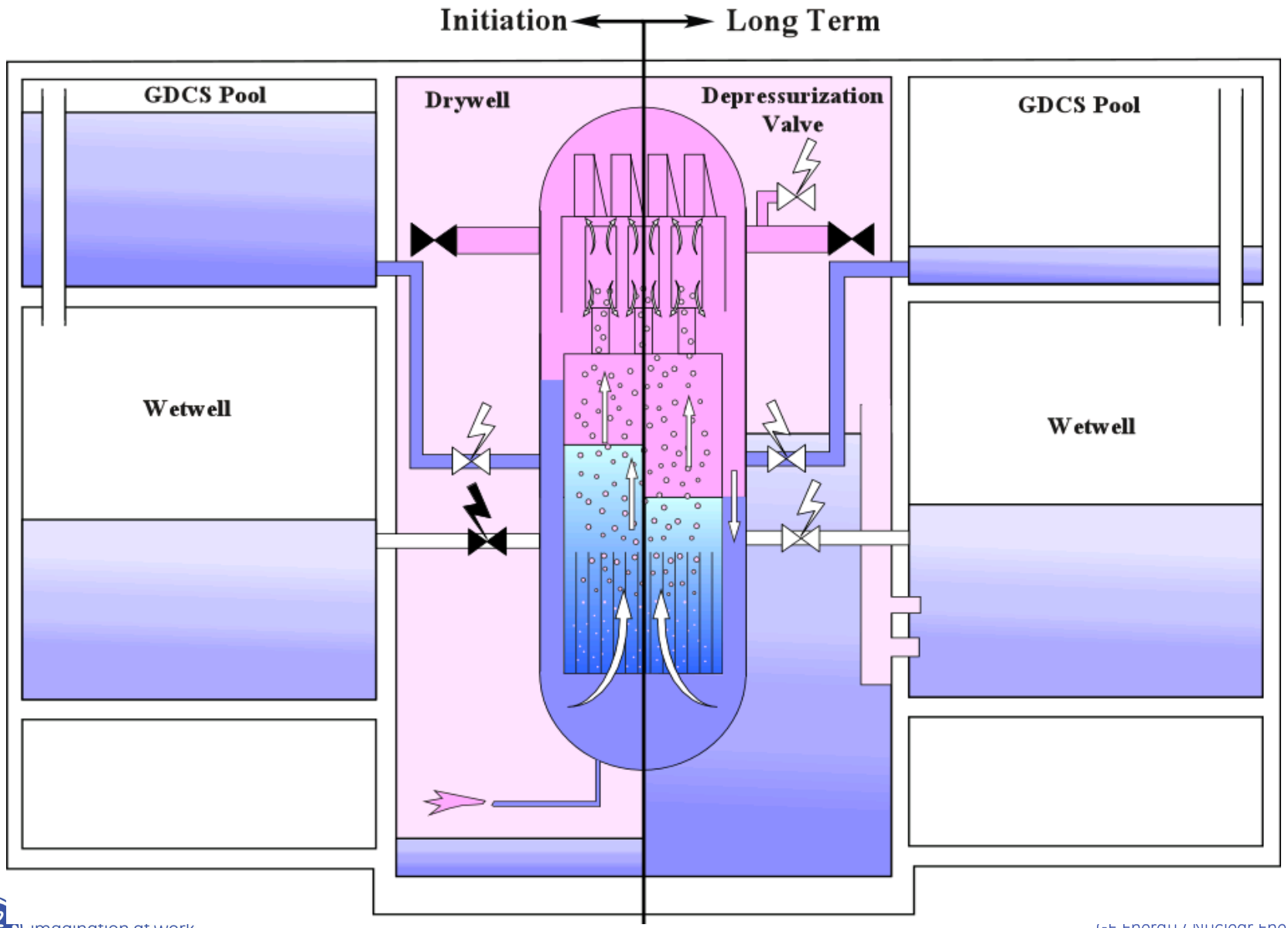
Gravity Driven Cooling System (GDCS) - Main Steam Line Break



Gravity Driven Cooling System (GDCS) - Small Pipe Break, Vessel Bottom



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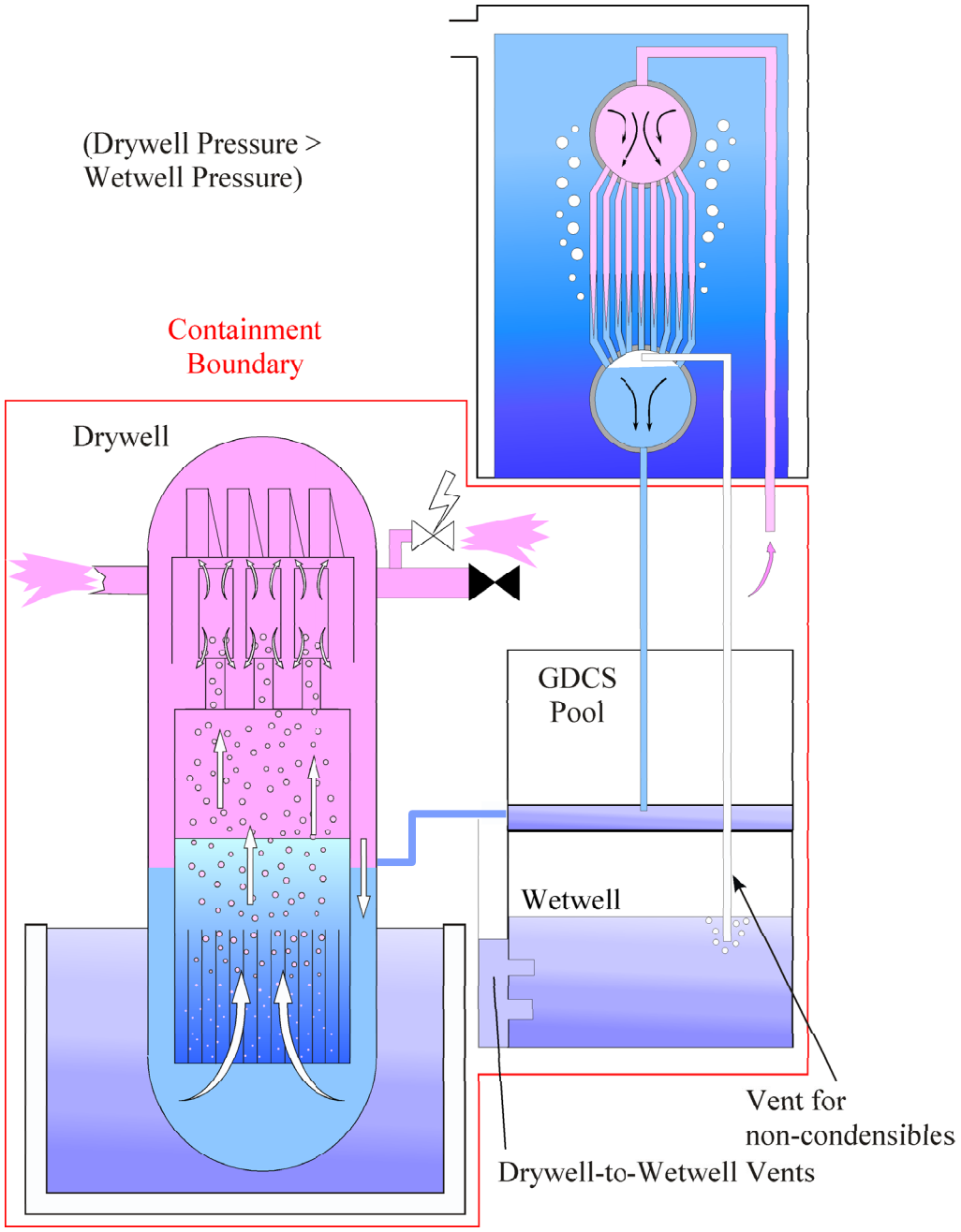
Passive Containment Cooling



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Defense-in-Depth

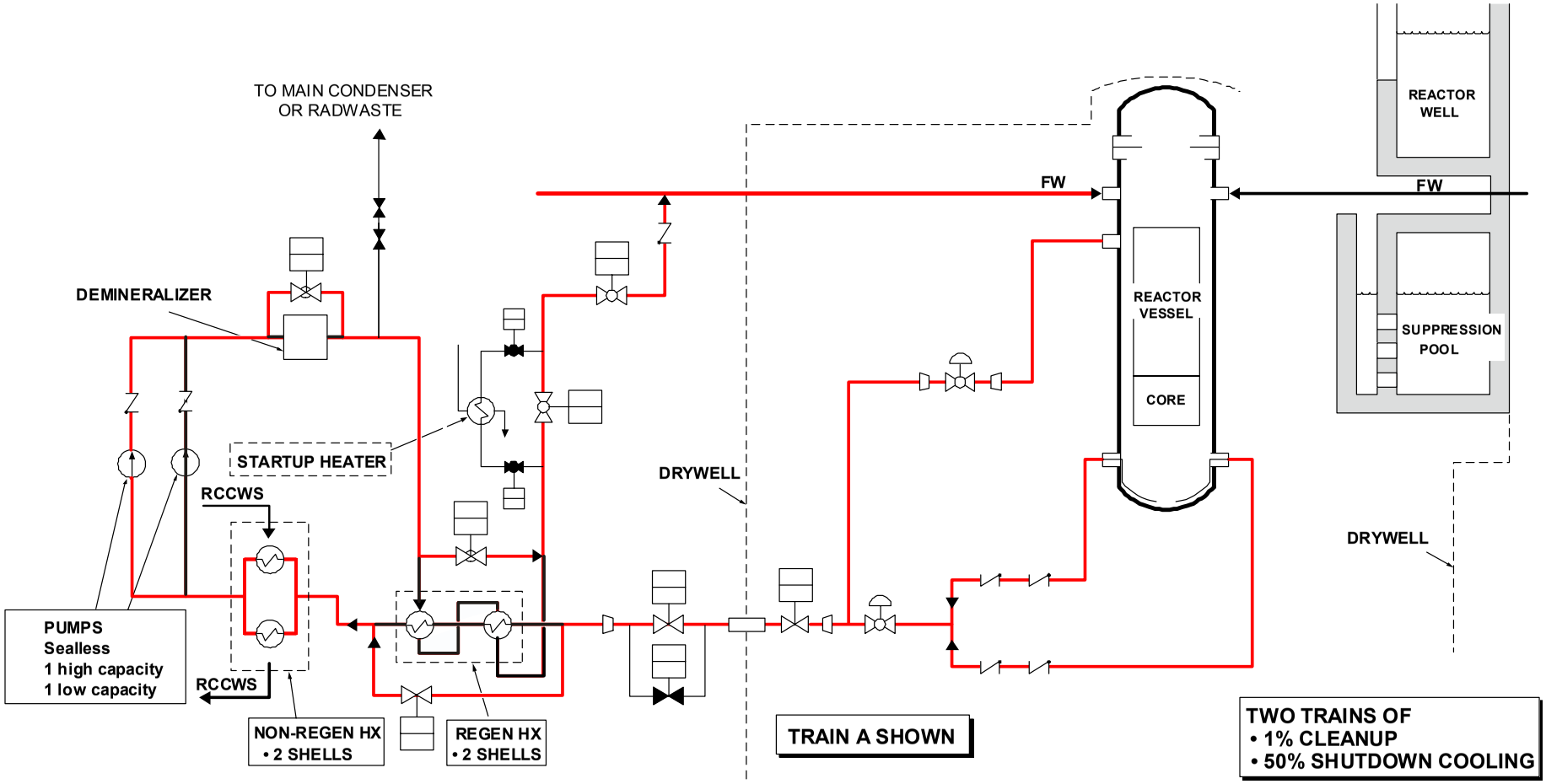
Inventory Control - Backup

- > Motor driven feedwater pumps (4) – high pressure
- > CRD system pumps (2) – high pressure
- > Low pressure coolant injection, via FAPCS – low pressure
- > Fire protection system – low pressure
- > Externally - connected water source

Decay Heat Removal - Backup

- > Main condenser – high pressure
- > Shutdown cooling system – high pressure
- > Suppression pool cooling – low pressure
- > Fire protection system – low pressure

Reactor Water Cleanup / Shutdown Cooling System (both systems combined for ESBWR)



Unique full pressure shutdown cooling system

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Design Philosophy for decay heat removal

Remove Decay Heat From Vessel

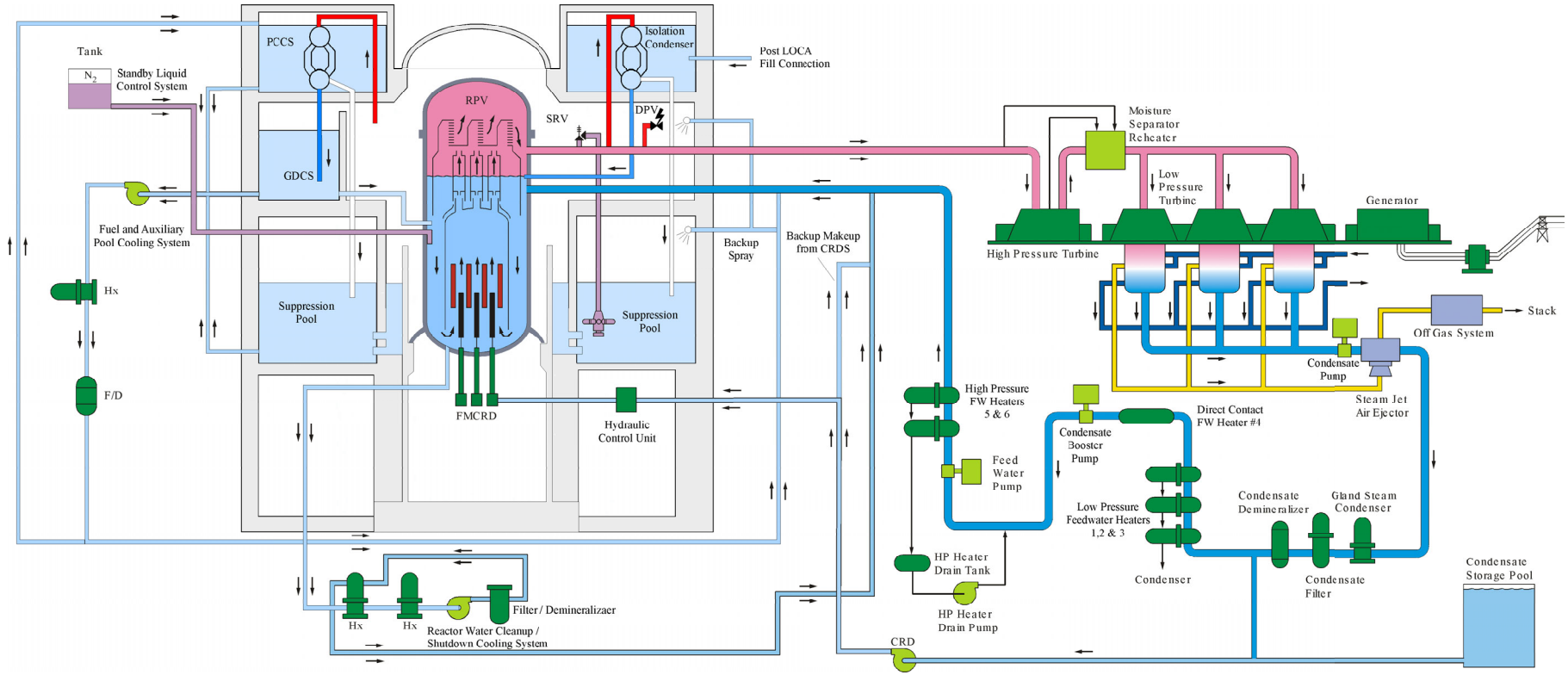
- **Main Condenser**
- **Normal shutdown cooling system – a full pressure system**
- **Isolation condensers**
- **Remove vessel heat through relief valve opening**

If Needed, Remove Heat From Drywell

- **Passive containment cooling (PCC) Hx (safety-grade)**
  - Always available and drywell/wetwell pressure difference drives the flow through the heat exchangers
  - Condensed steam returns to drywell/vessel, non-condensables collect in the wetwell airspace
  - No operator action needed for 72 hours
- **Suppression pool cooling (non-safety)**

Several Diverse Means of Decay Heat Removal

Simplification …



Plant Design Reduces Operator Challenges – Direct Cycle With Major Simplifications