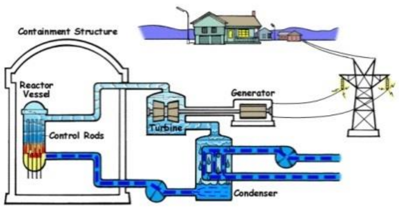
بسم الله الرحمن الرحيم

Thermal Power Stations II



Lecture (8)
on
Safety System of Nuclear Power Stations

By

Dr. Emad M. Saad

Mechanical Engineering Dept.
Faculty of Engineering
Fayoum University

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Faculty of Engineering
Mechanical Engineering Dept.

Safety Systems

Active Safety Systems

- Pressurizing System
- Emergency Boron Injection System
- Emergency Feed Water System
- Residual Heat Removal System
- Double Containment
- Spray System
- Emergency Power Supply System

Passive Safety Systems

- Emergency Core Cooling System (Passive Part)
- Passive Containment Heat Removal System
- Passive SG Heat Removal System
- Passive Hydrogen Removal System
- Passive Reactor Scram System
- Passive Corium Catcher

Passive Safety Systems Concept

- The passive safety systems require no signal inputs of "intelligence" or external power sources or forces to actuate or operate.
- The only forces that are needed to safely cool the reactor are: the natural rising of steam, condensation, and gravity flow to the reactor.
- Natural circulation cools the reactor core and transfers heat out of containment by the forces of nature rather than relying on mechanical pumps and forced cooling.

Passive Safety Systems Benefits & Advantages

1. No external power supply: no loss of power accident has to be considered.
2. No human factor, implying no inclusion of the operator error in the analysis.
3. Better impact on public acceptance, due to the presence of “natural forces”.
4. Less complex system than active and therefore economic competitiveness and reducing plant construction and O&M costs.
5. Provides more than 7 days of reactor cooling without AC electrical power or human action.
6. Only simple actions are needed to extend cooling well beyond an initial 7 days.

Passive Safety Systems Drawbacks & Disadvantages

1. Reliance on “low driving forces”, as a source of uncertainty, and therefore need for uncertainties modeling.
2. Licensing requirement (open issue), since the reliability has to be incorporated within the licensing process of the reactor. For instance the PRA’s should be reviewed to determine the level of uncertainty included in the models.
3. Need for operational tests, so that dependence upon human factor can not be neglected.
4. Time response: the promptness of the system intervention is relevant to the safety function accomplishment. It appears that the inception of the passive system operation, as the natural circulation, is conditional upon the actuation of some active components (as the return valve opening) and the onset of the conditions/mechanisms for natural circulation start-up

Passive Safety Systems Drawbacks & Disadvantages

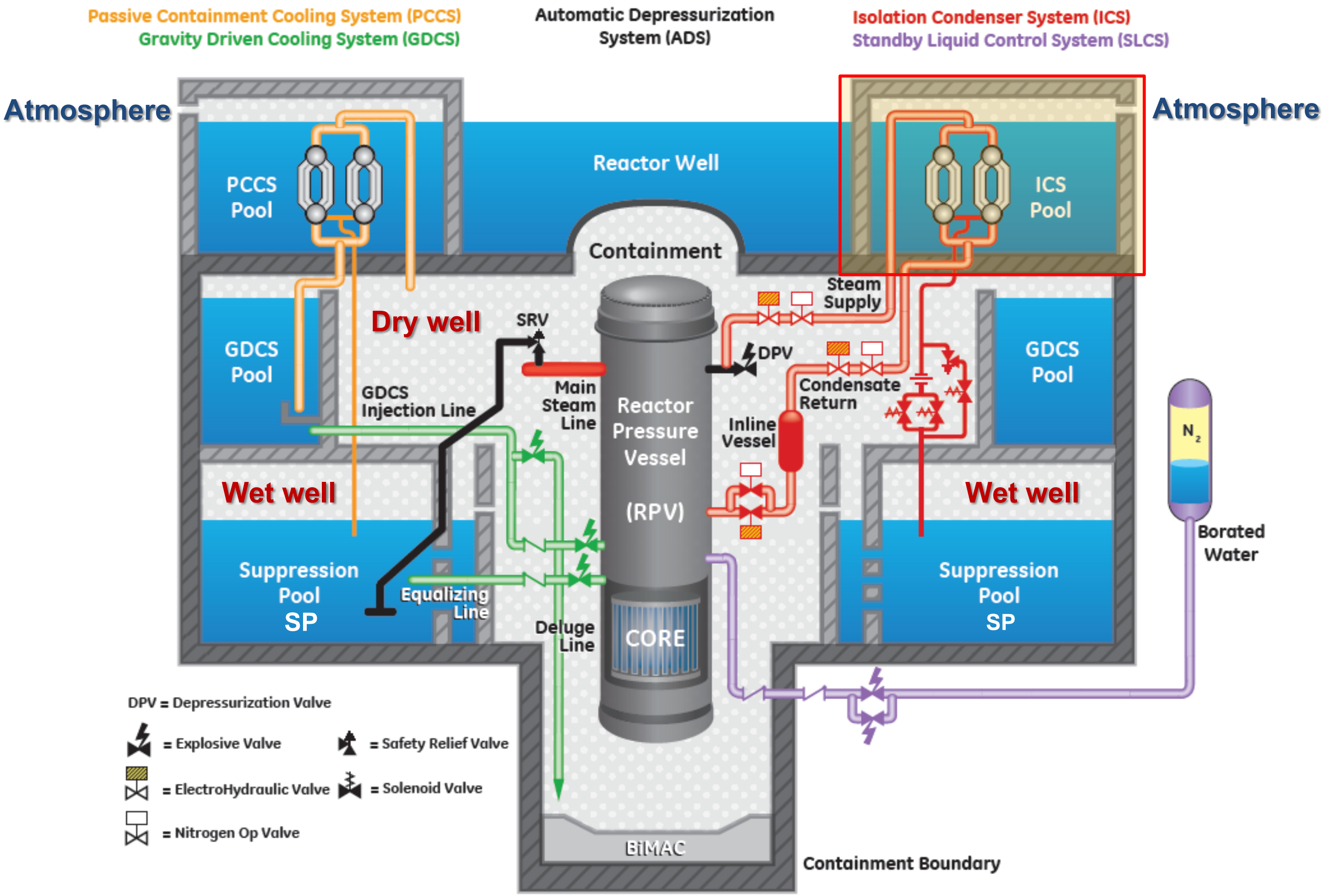
5. Reliability and performance assessment in any case. Quantification of their functional reliability from normal power operation to transients including accidental conditions needs to be evaluated. Functional failure can happen if the boundary conditions deviate from the specified value on which the performance of the system depends.
6. Ageing of passive systems must be considered for longer plant life; for example corrosion and deposits on heat exchanger surfaces could impair their function.
7. Economics of advanced reactors with passive systems, although claimed to be cheaper, must be estimated especially for construction and decommissioning.

Passive Safety System

1. Isolation Condenser System (ICS)

- Passive closed-loop cooling system that transfers decay heat to the atmosphere.
- Water cooling the fuel turns into steam, rises to four isolation condenser heat exchangers, condenses into water, and then returns to cool the reactor again.
- Allows for near-immediate plant restart after operation.

Passive Safety System



Passive Safety System

1. Isolation Condenser System (ICS)

During a Loss of Coolant Accident (LOCA), the reactor shuts down and the Reactor Pressure Vessel (RPV) is isolated by closing the main steam line isolation valves. The ICS removes decay heat after any reactor isolation. In other words, the ICS passively removes sensible and core decay heat from the reactor when the normal heat removal system is unavailable. Decay heat removal limits further increases in steam pressure and keeps the RPV pressure below the safety set point.

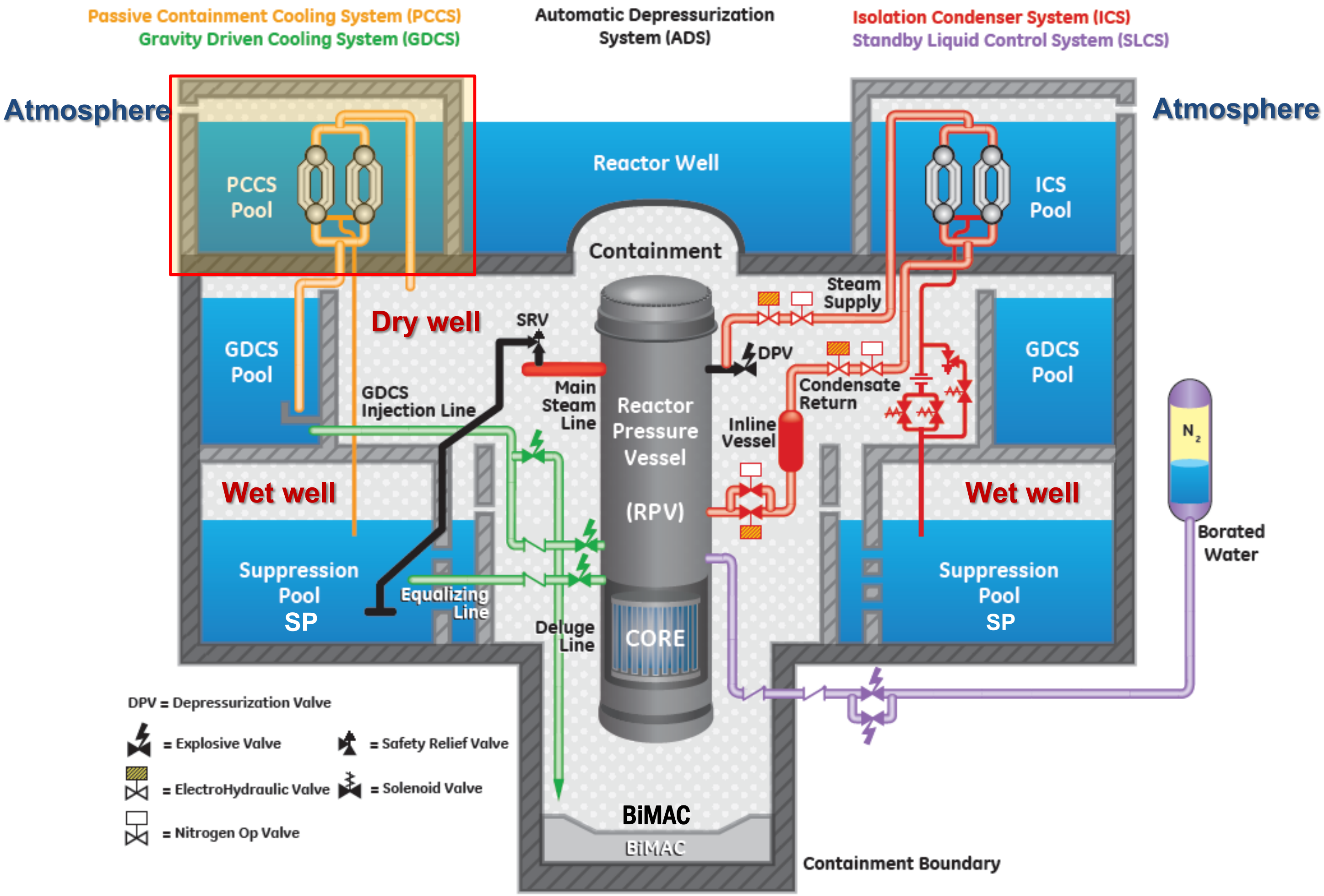
The ICS consists of four independent loops, each containing two heat exchanger modules that condense steam inside the tube and transfers heat by heating/evaporating water in the IC pool, which is vented to the atmosphere. This transferring mechanism from IC tubes to the surrounding IC pool water is accomplished by natural convection, and no forced circulation equipment is required. The ICS is initiated automatically by any of the following signals: high reactor pressure, main steam line isolation valve (MSIV) closure, or an RPV water level signal. To operate the ICS, the IC condensate return valve is opened whereupon the standing condensate drains into the reactor and the steam water interface in the IC tube bundle moves downward below the lower headers.

Passive Safety System

2. Passive Containment Cooling System (PCCS)

- Passively transfers decay heat out of containment in the unlikely event of a pipe break inside containment or depressurization of the reactor by ADS.
- Steam inside containment rises into the six PCCS heat exchangers where it is condensed into water which returns to the GDCS pools for reuse.

Passive Safety System



Passive Safety System

2. Passive Containment Cooling System (PCCS)

The PCCS is a passive system which removes the decay heat released to the containment and maintains the containment within its pressure limits for design basis accidents. The PCC heat exchangers receive a steam-gas mixture from the Dry Well (DW), condense the steam and return the condensate to the RPV via the Gravity Driven Cooling System GDCS pools. The non-condensable gas is vented to the Wet Well (WW) gas space through a vent line submerged in the Suppression Pool (SP). The venting of the non-condensable gas is driven by the differential pressure between the DW and WW. The PCCS condenser, which is open to the containment, receives a steam-gas mixture supply directly from the DW. Therefore, the PCCS operation requires no sensing, control, logic or power actuated devices for operation. The PCCS consists of six PCCS condensers. Each PCCS condenser is made of two identical modules. The condenser condenses steam on the tube side and transfers heat to the water in the IC/PCC pool. The evaporated steam in the IC/PCC pool is vented to the atmosphere. PCCS condensers are located in the large open IC/PCC pool, which are designed to allow full use of the collective water inventory.

Passive Safety System

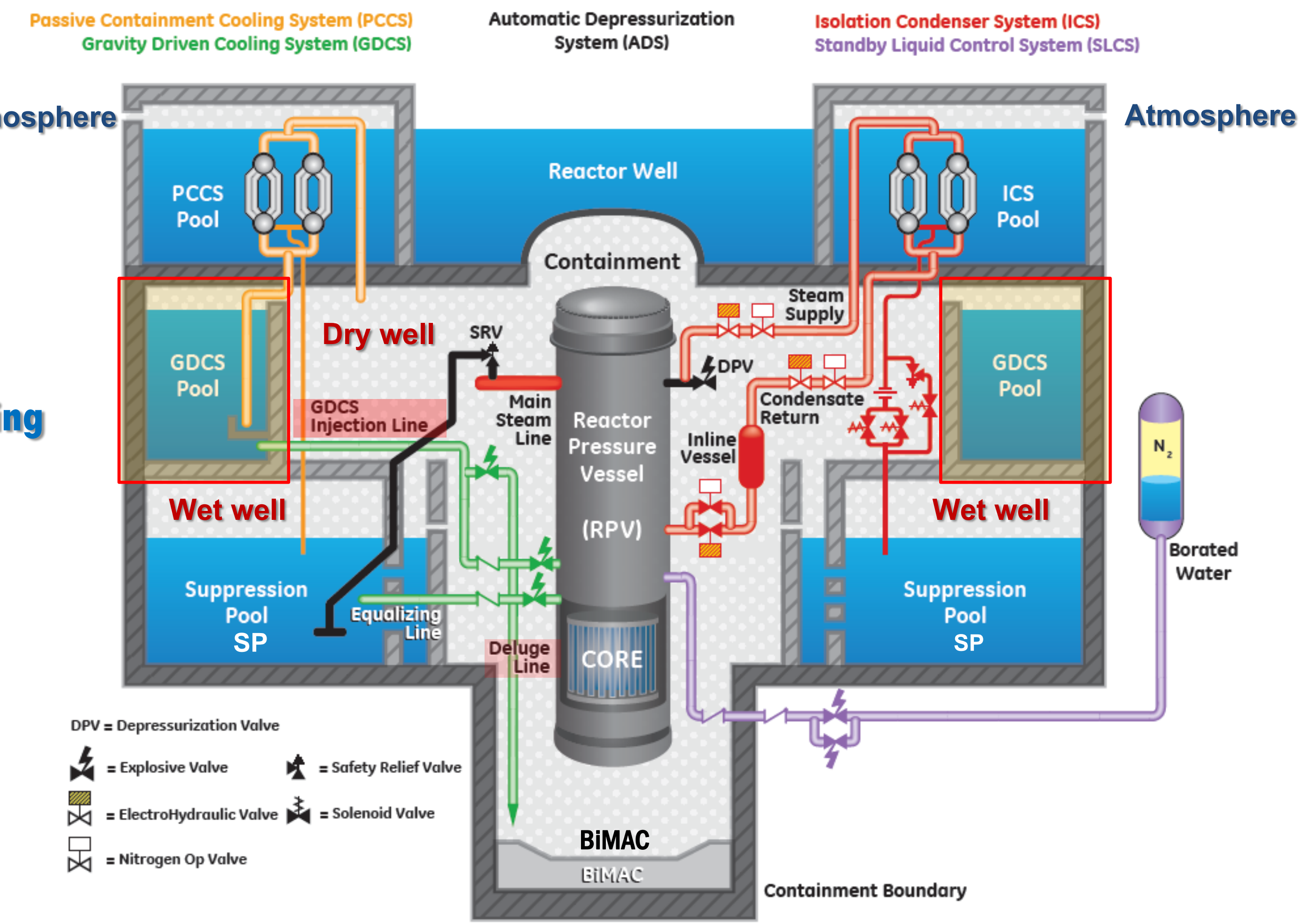
3. Gravity Driven Cooling System (GDCS)

- Passively injects cooling water into the reactor in the unlikely event of a loss of coolant accident .

4. Automatic Depressurization System (ADS)

- Depressurizes the reactor (and keeps it depressurized) to allow GDCS injection or other low pressure refill.

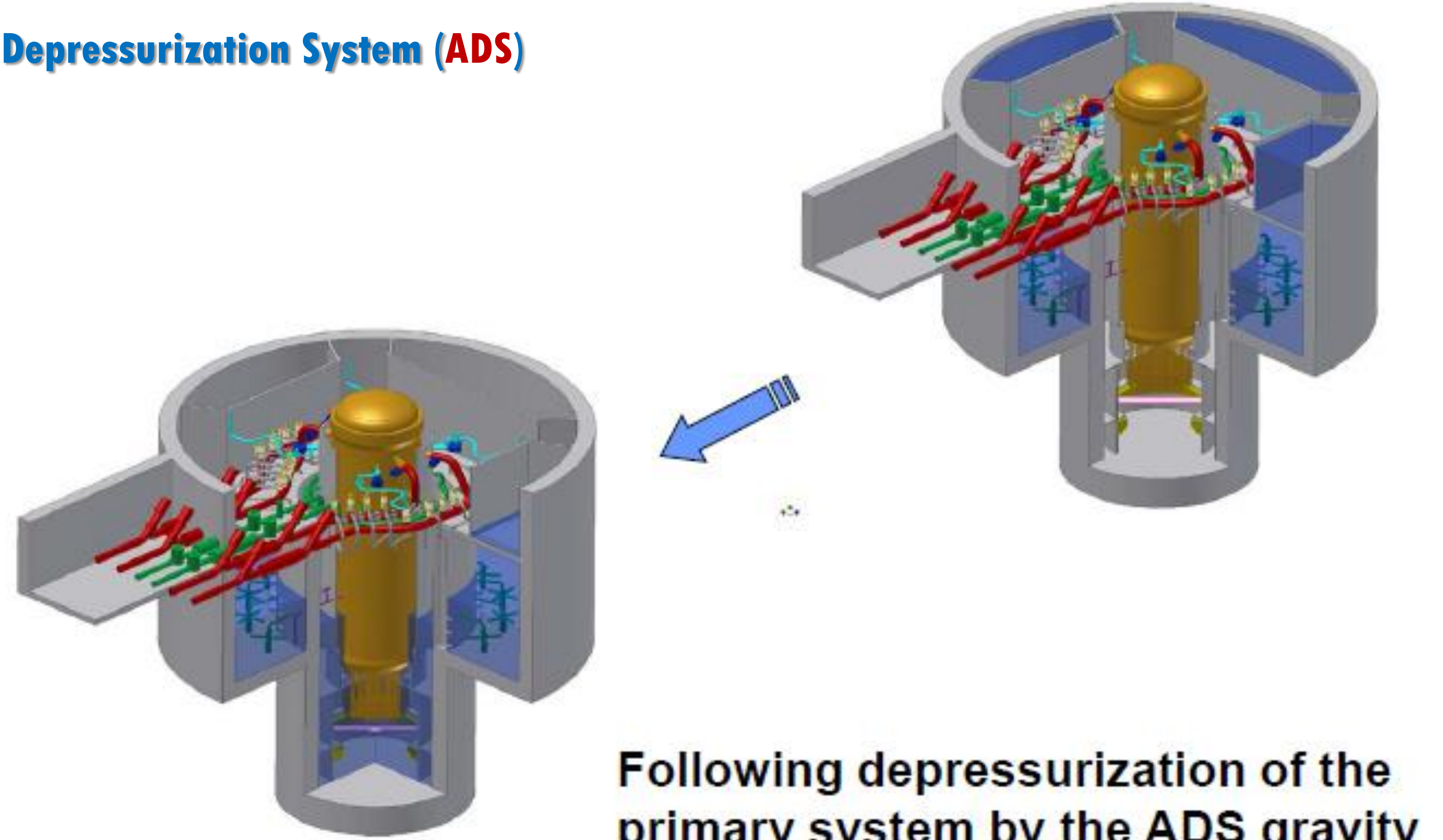
Passive Safety System



3. Gravity Driven Cooling System (GDCS)

Passive Safety System

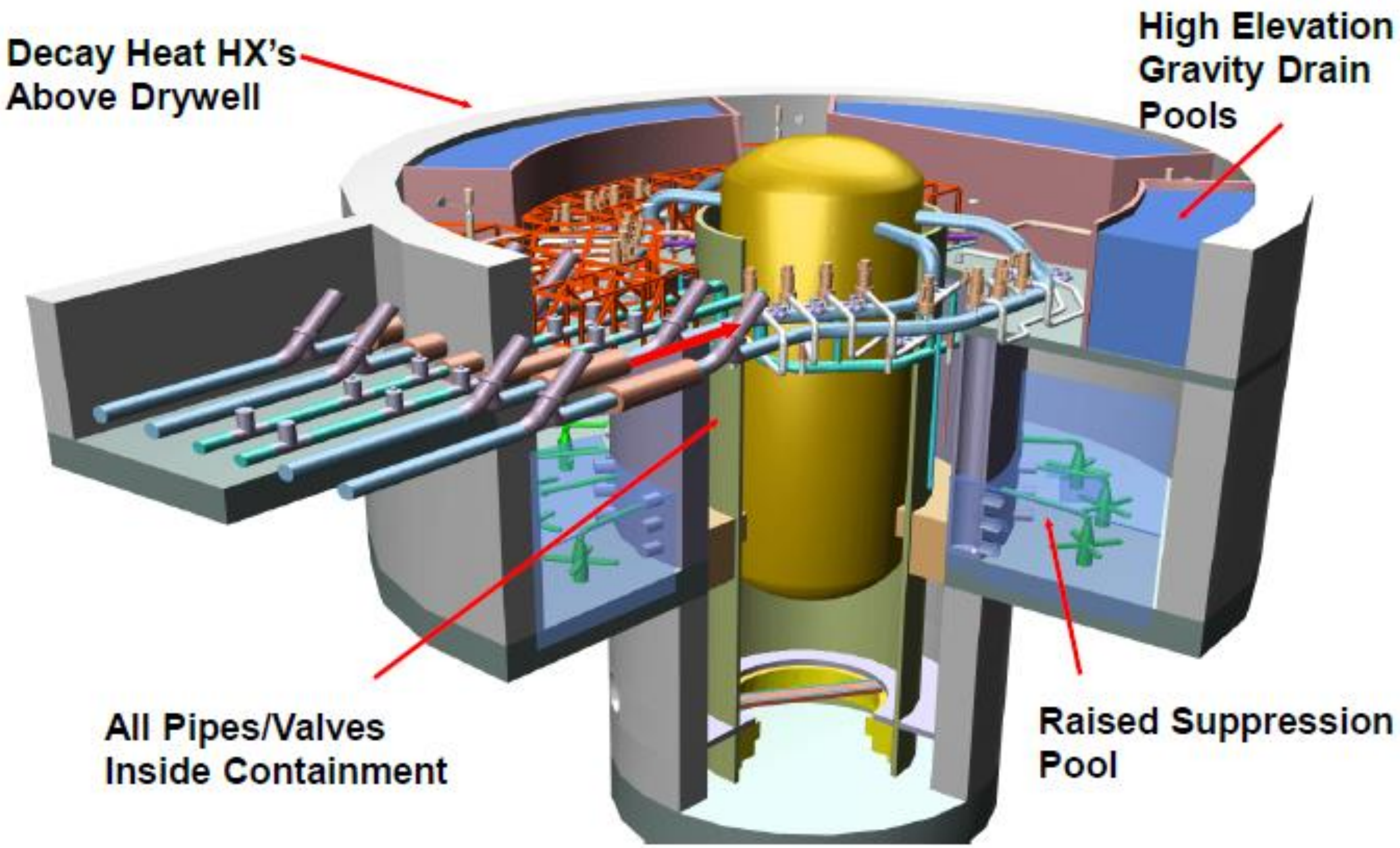
4. Automatic Depressurization System (ADS)



Following depressurization of the primary system by the ADS gravity driven flow keeps core covered

Passive Safety System

4. Automatic Depressurization System (ADS)



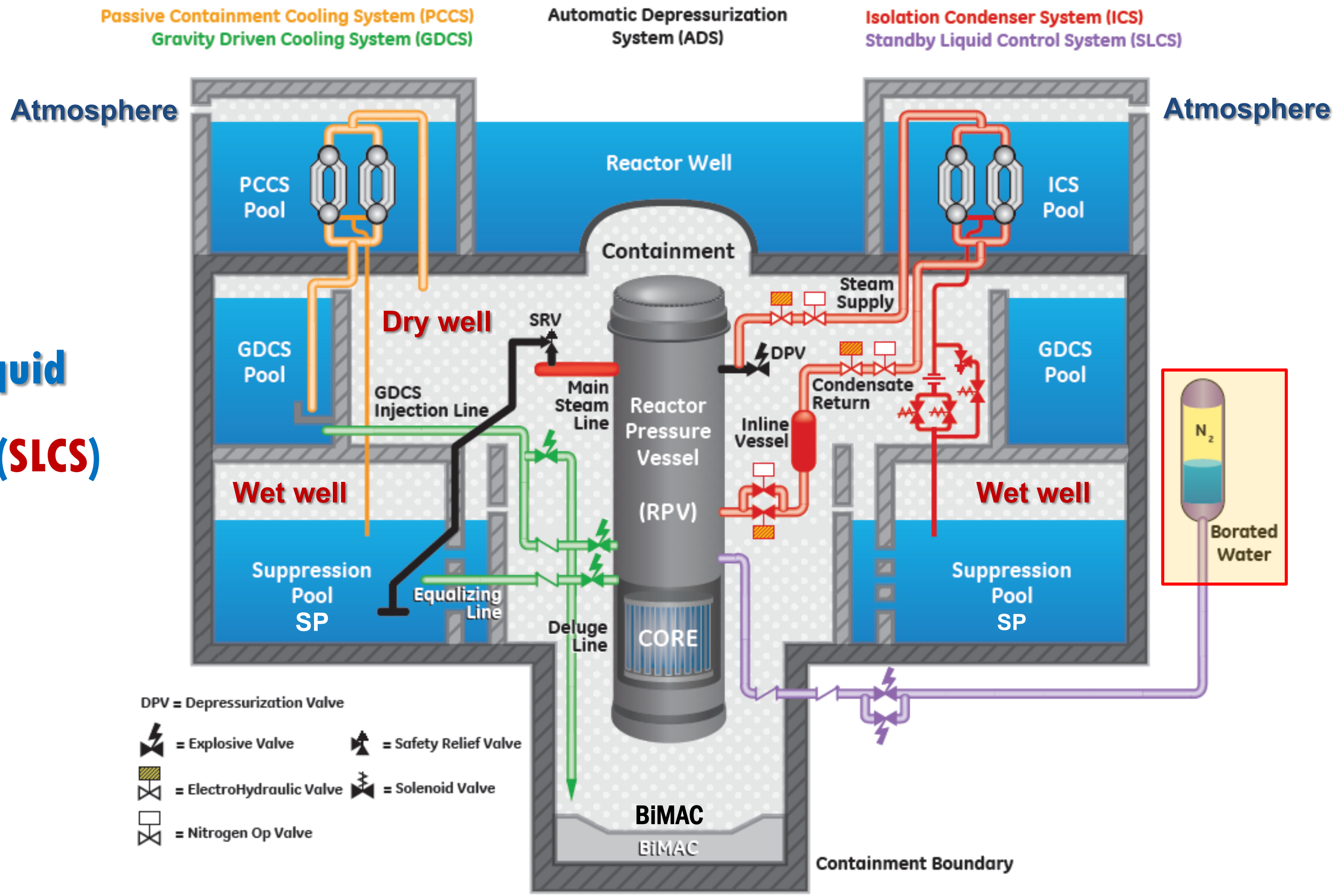
Passive Safety System

5. Standby Liquid Control System (SLCS)

- Passive backup shutdown capability via nitrogen-driven boron injection into the reactor.
- The SLCS consists of a tank containing borated water as a neutron absorber, protected by explosively-opened valves and redundant battery-operated pumps or nitrogen-driven accumulator, allowing the injection of the borated water into the reactor against any pressure within; the borated water can and will shut down a reactor gone out of control.

Passive Safety System

5. Standby Liquid Control System (SLCS)



Passive Safety System

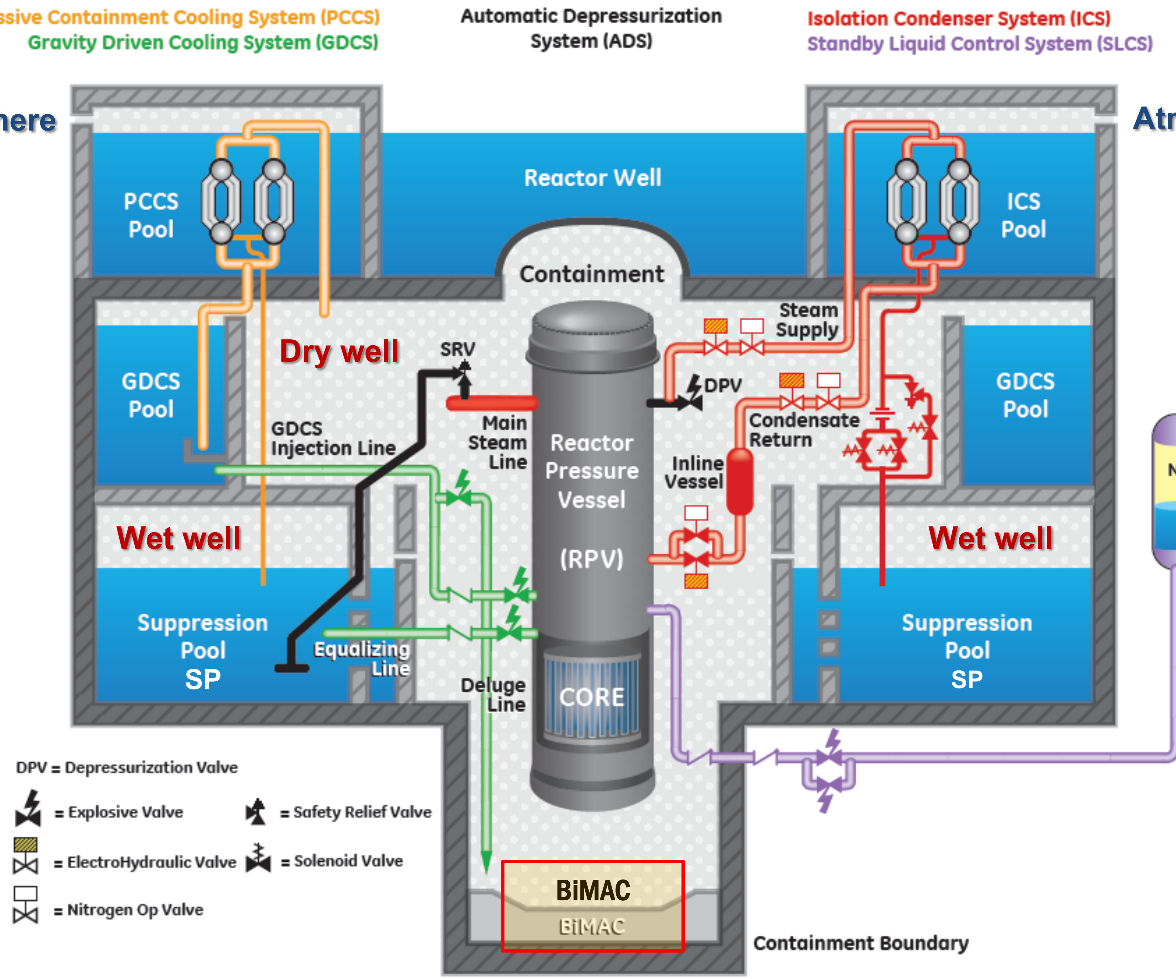
6. Core Melt Cooling (BiMAC)

- A backup in the very unlikely event that the ICS, ADS, and GDCS systems are unable to function.
- Quenches any high temperature corium by utilizing concrete protected inclined pipes filled with water from the GDCS pools. Steam transfers the decay heat into the PCCS heat exchangers where it is condensed, returns to the GDCS pools, and subsequently back into the BiMAC

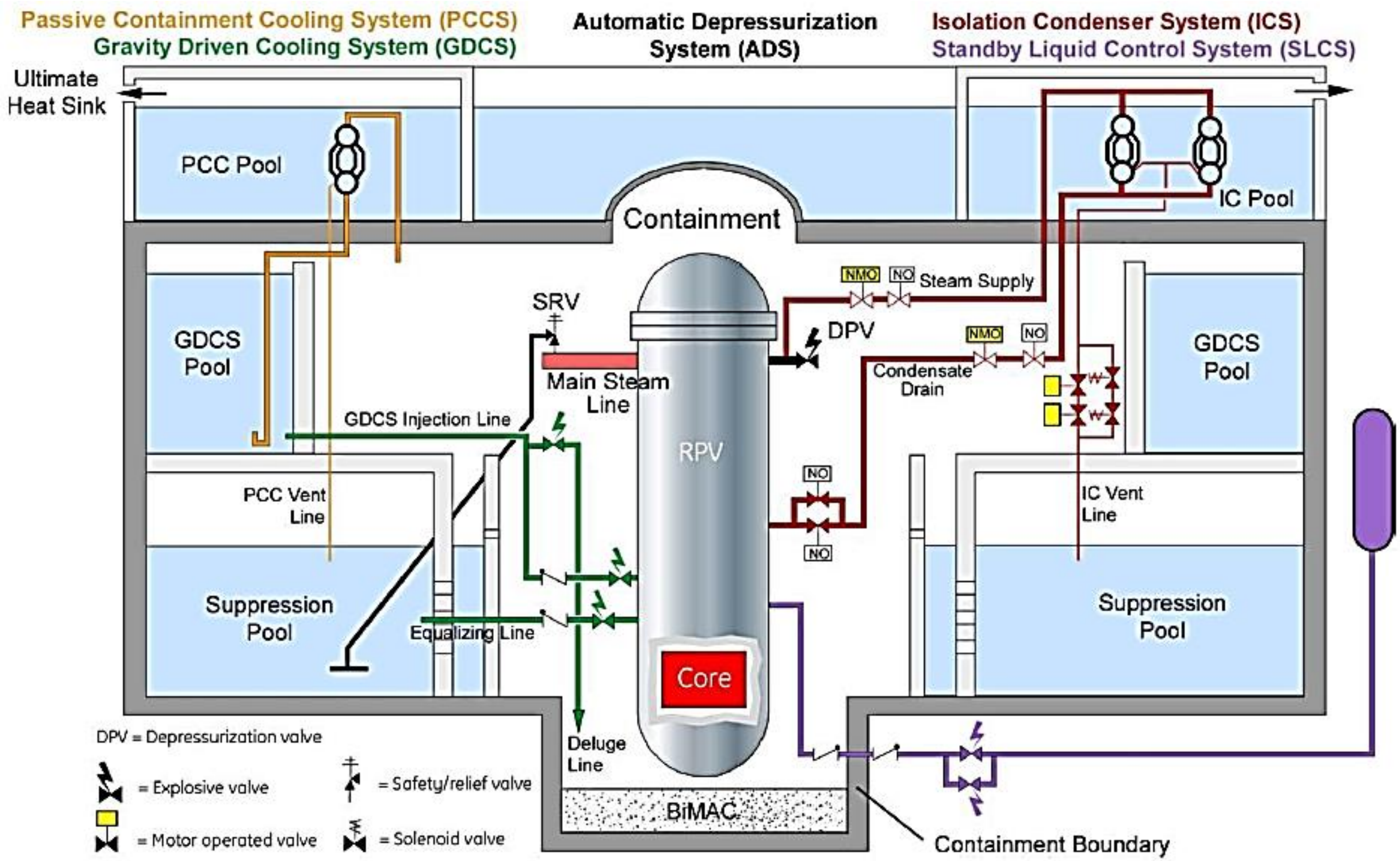
Passive Safety System

6. Core Melt Cooling

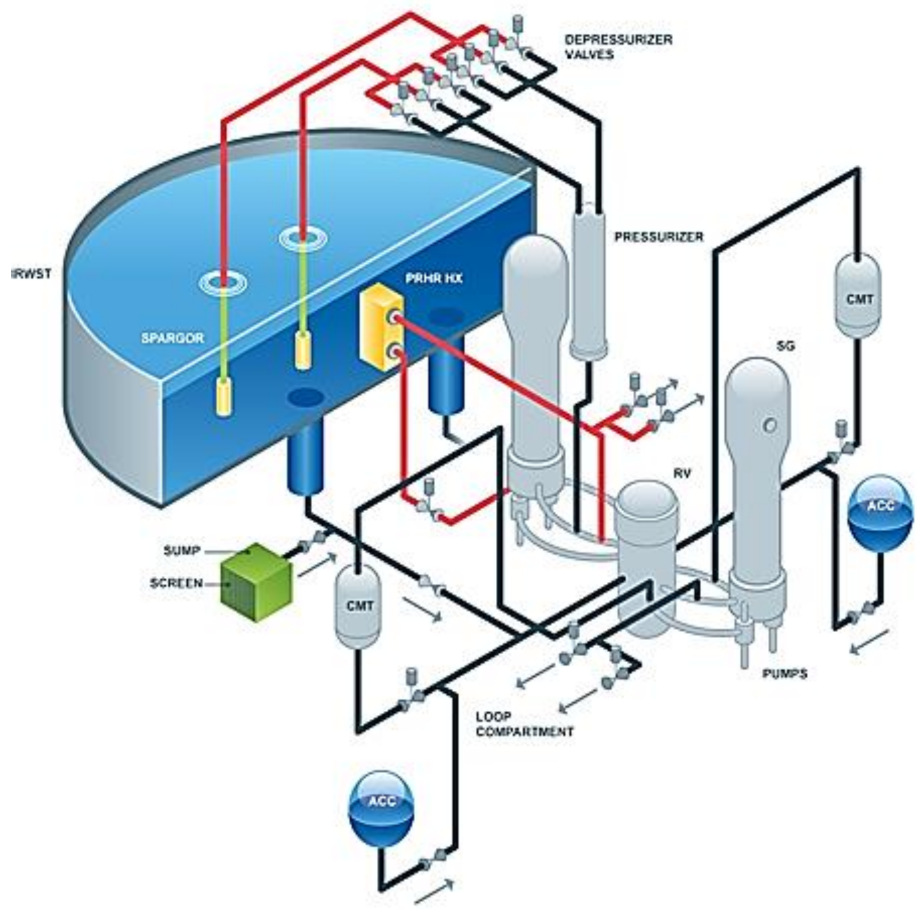
(BiMAC)



Passive Safety System



Passive Safety System



Thank you