
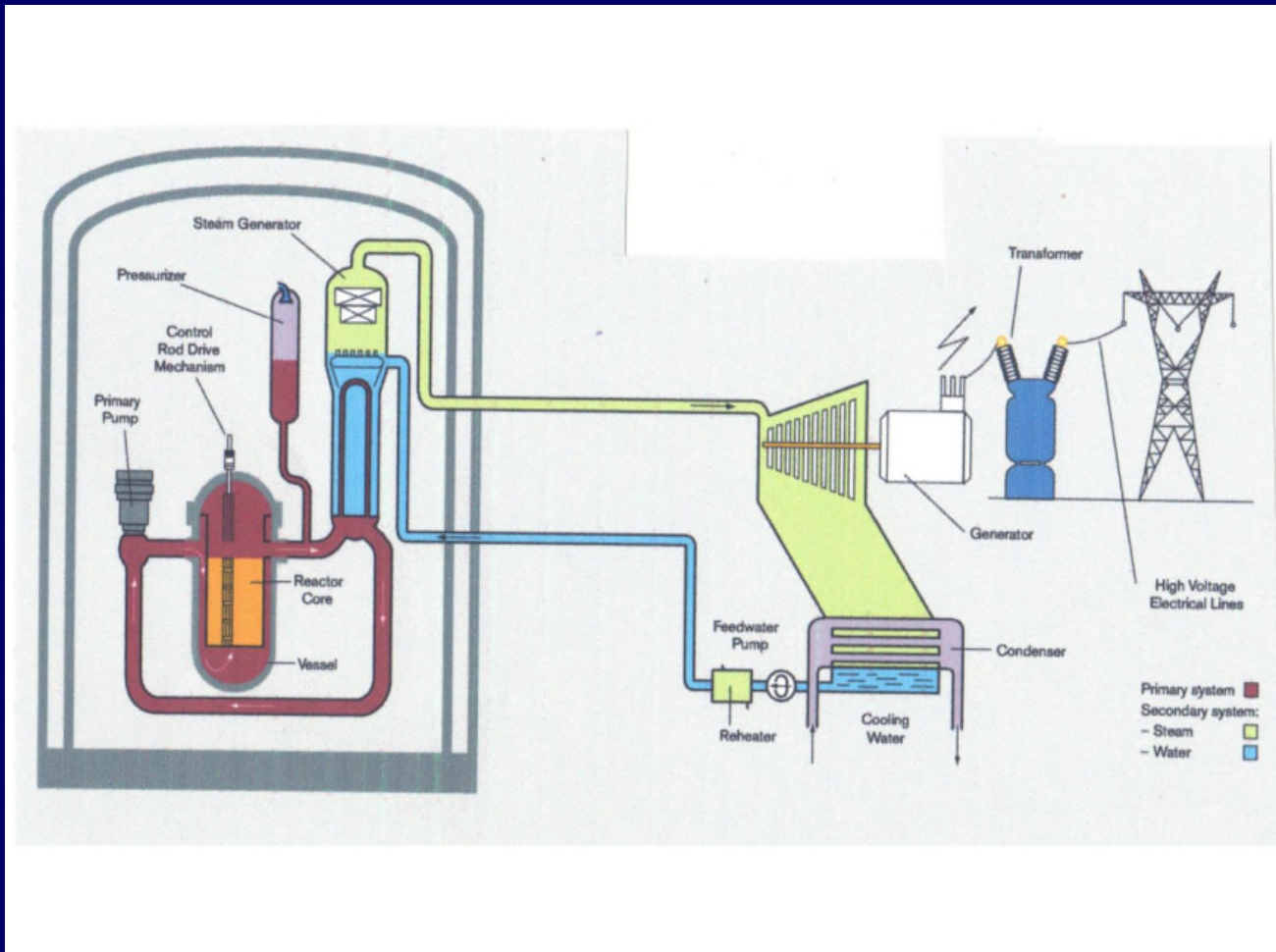




ECCCSs

- Emergency core cooling systems
 - Designed to prevent core meltdown
 - Crucial when Sizewell B inquiry passed
 - Provided for EPR emergency cooling
 - Not applied at TMI 2, operators fooled
 - Started, but failed by Fukushima SBO
 - Needed when component fails
 - Concept is to inject water into RV after part depressurised to cool core
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EPR



John Busby



Reactor vessel (RV)

- Contains core and control rods
 - EPR RV has 8 inlet/outlet connections to 4 steam generators and a pressuriser
 - EPR Pressure/Temperature 15.5 Mpa/328°C
 - PWRs have steam generators (SGs); BWRs have none.
 - EPR has 89 CRDM mechanisms mounted on RV head to drive 89 control rods
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Core meltdowns

- TMI 2 - Partial core meltdown
- No available feed pumps; stuck relief valve; operators failed to apply ECCS
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- Fukushima 1, 2 and 3 had full meltdowns in station blackout (SBO)
- Cooling water failed after start; cores melted through RV's bottoms
- Control rods applied; but decay heat enough to melt cores




TMI 2

- Reserve feed pumps down for maintenance; working pumps failed
 - RV pressure rose, opened relief valve which stuck open; led to depressurisation
 - HP hot water flashed to steam/water mix
 - Steam/water mix level rose; operators thought core covered; partial melt of core.
 - H₂ explosion retained by containment
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Fukushima

- Fukushima Daiichi; 6 BWRs 3 working
 - Control rods driven up from bottom in earthquake; reactors shut down
 - Emergency cooling stops with SBO; steam turbine pumps stopped when batteries ran down; service auxiliaries, controls and lighting failed.
 - Decay heat raised pressure in RVs; when relieved caused H₂ explosion; service floor gone, full core melting
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Hydrogen generation

- RV contains water at high pressure and temperature
 - Venting turns water into steam
 - Heat transfer from fuel cans to water water/steam mix pool
 - Fuel cans heat up – ion exchange zirconium/steam -> hydrogen
 - Hydrogen leaves RV into containment
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Hydrogen explodes

- Can surface 1000°C – 2000°C
- Generated hydrogen leaves at more than auto-ignition temperature of 585°C
- Explosive H₂/air mix 18.3% - 59%
- Once the mix is between limits it explodes
- TMI 2 containment held; will EPR's
- Fukushima 1 and 3 service floors destroyed.

Why the EPR ECCSs can't work

- RV pressure needs to fall by half for emergency cooling water to enter; accumulator and pump pressure just 8 MPa; RV has to be depressurised below this.
- The depressurisation leads immediately to flashing, coolant volume expands preventing emergency water entering
- Venting flashes hot water to steam, can surface heats, hydrogen generated, explodes in air
- Steam/H₂ leaving stops water ingress
- Uncooled core melts, if full melt it goes through bottom of RV to corum catcher



EPR design

- Double concrete containment plus corium catcher
 - Massive civil engineering
 - Unaffordably expensive construction needed to cater for an ECCS that can't work
 - Radioactivity contained, but EPR lost
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