Fukushima Daiichi –

nuclear disaster

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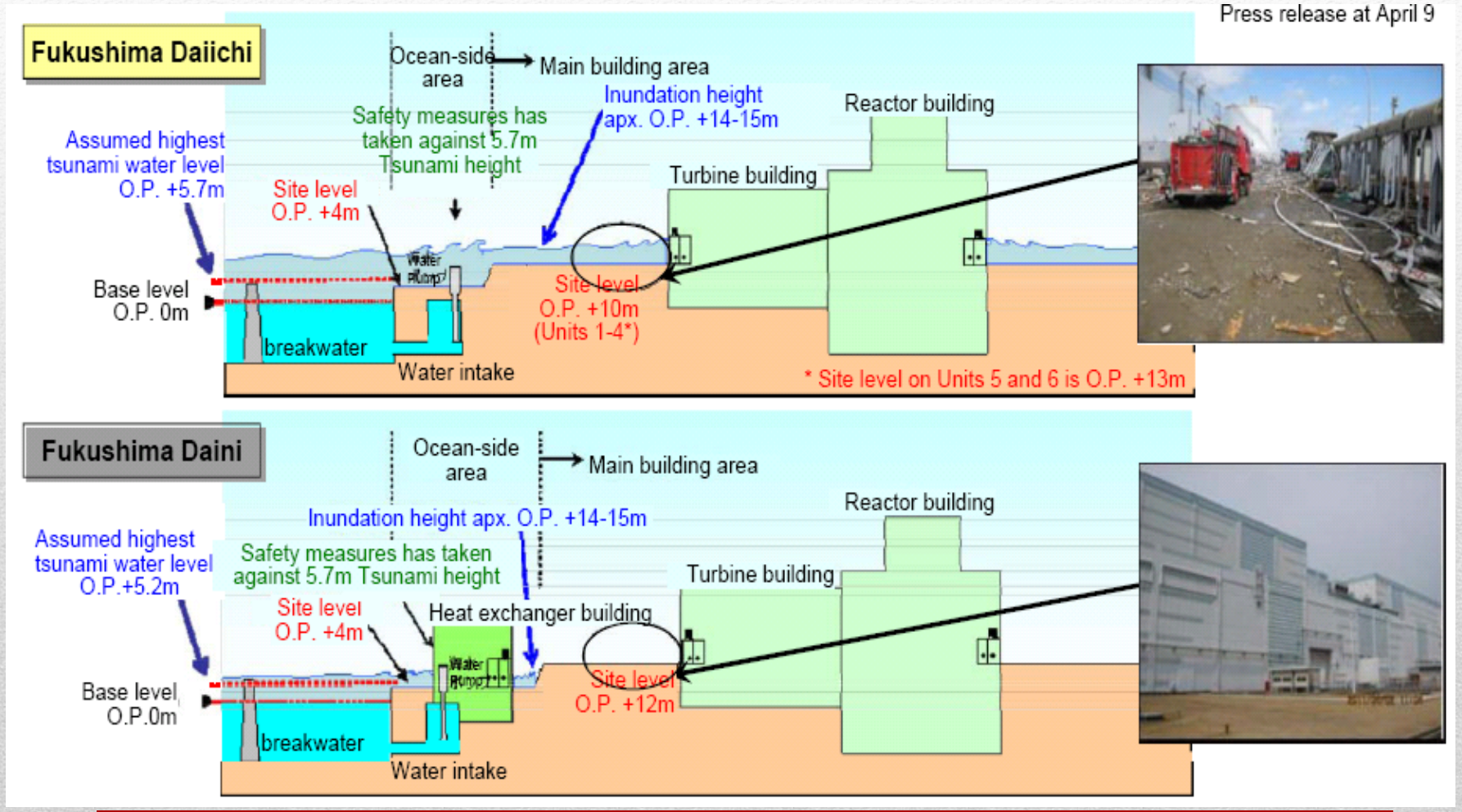
The eartquake:

- March 11,2011
- earthquake - magnitude 9.0
- tsunami waves - up to 40.5 metres
- nuclear power plants automatically shut down
- destroyed diesel backup power systems

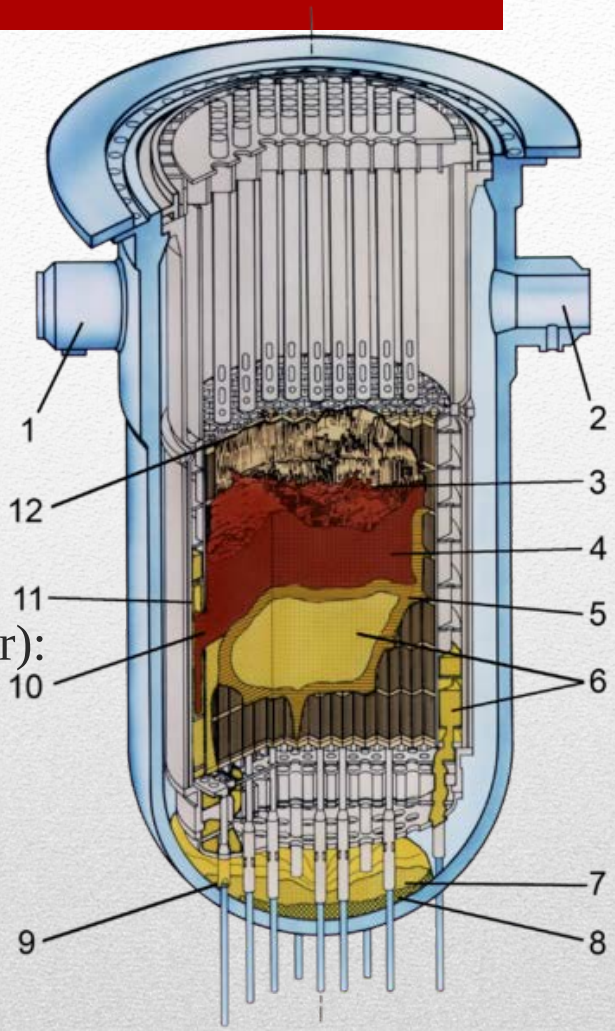
Tsunami


Press release at April 9
Fukushima Daiichi
Ocean-side area
Main building area
Inundation height apx. O.P. +14-15m
Safety measures has taken against 5.7m Tsunami height
Assumed highest tsunami water level O.P. +5.7m
Site level O.P. +4m
Reactor building
Turbine building
Base level O.P. 0m
Site level O.P. +10m (Units 1-4*)
breakwater
Water intake
* Site level on Units 5 and 6 is O.P. +13m
Fukushima Daini
Ocean-side area
Main building area
Inundation height apx. O.P. +14-15m
Reactor building
Assumed highest tsunami water level O.P.+5.2m
Safety measures has taken against 5.7m Tsunami height
Turbine building
Site level O.P. +4m
Heat exchanger building
Base level O.P.0m
Site level O.P. +12m
breakwater
Water intake

Cooling systems

- every reactor unit has emergency cooling system
- after the earthquake : HPCI (high pressure cooling injections)
- passive cooling systems - designed to work without electricity (steam from reactor)
- Unit #1 : 0h – ICC(isolation core cooling) failed
- Unit#2 : 70h – RCIC(reactor core isolation cooling)
- Unit#3: 40h – RCIC/HPCI

Core melting



Energy balance:

1) Decay heat 10-20 MWh/h
2) Over 1500 K – fast reaction Zirconium - water (50 ton Zr):

$Zr + 2H_2O \rightarrow ZrO_2 + 2H_2$ + ~20 MWh/10 ton Zr

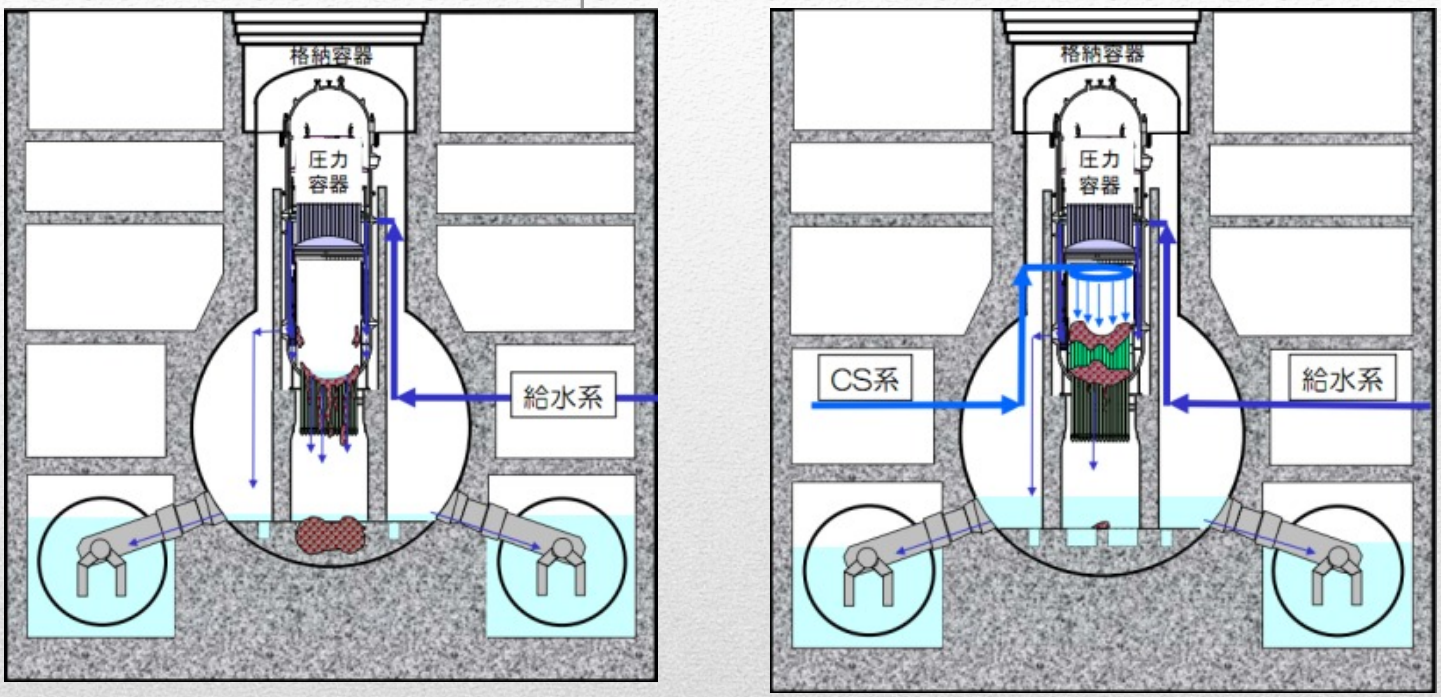
3) Combustion H_2 ~20 MWh/10 ton Zr

-1) Evaporation H_2O ~5 MWh/10 ton (3 h ~ 100 ton)
water ~100-200 ton, unknown leaking
-2) heating and melting of the fuel and other parts of reactor
~20 MWh/100 ton UO_2

Core melting

- about 1500°C
- fuel rod cladding melts, releasing radioactive isotopes (Cs,I, …) into damaged containment building
- radiation escapes into enviroment
- some of the fuel remains inside of the vessel, some had been leaking through the holes at the bottom

Melted core



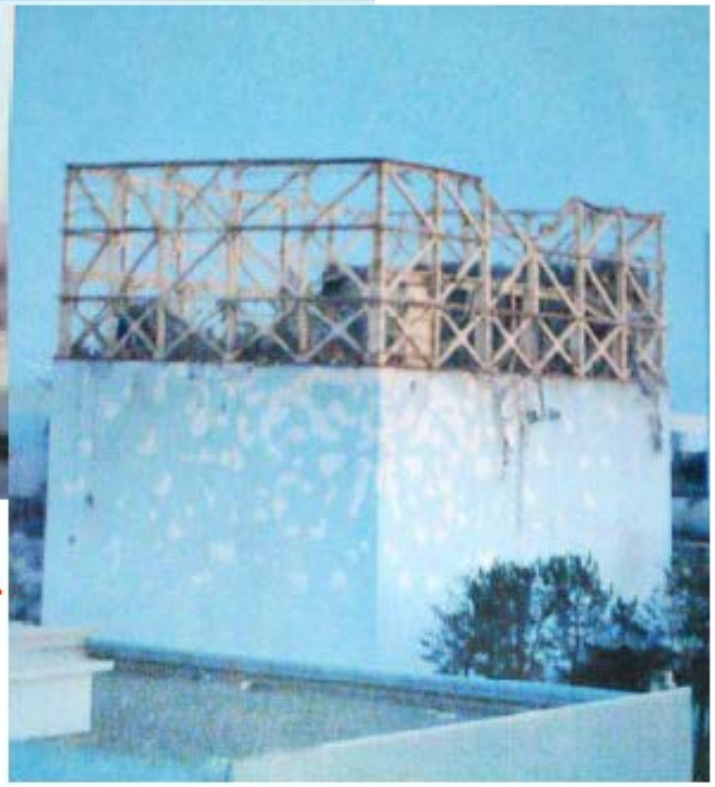
In reactor unit#1 70% of the fuel had been damaged(left)

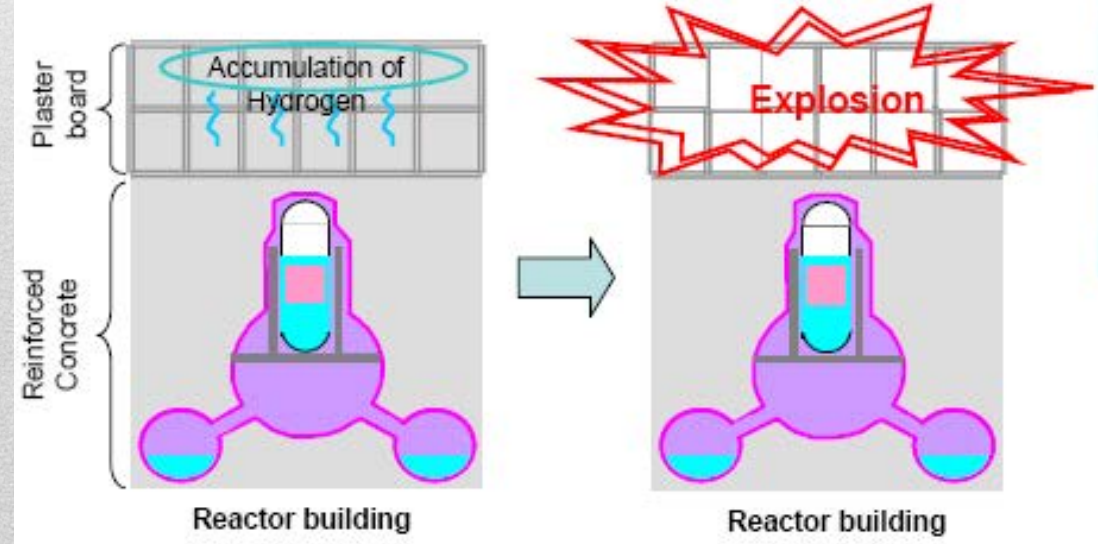
in units#2 & #3 30-35% (right).

Hydrogen explosion

- Unit#1, Unit#3 and Unit#4
- for explosion to occur the reactor must be damaged
- exposed fuel rods (Zr) reacts with steam, producing hydrogen
- high concentration of hydrogen – a spark triggers the explosion

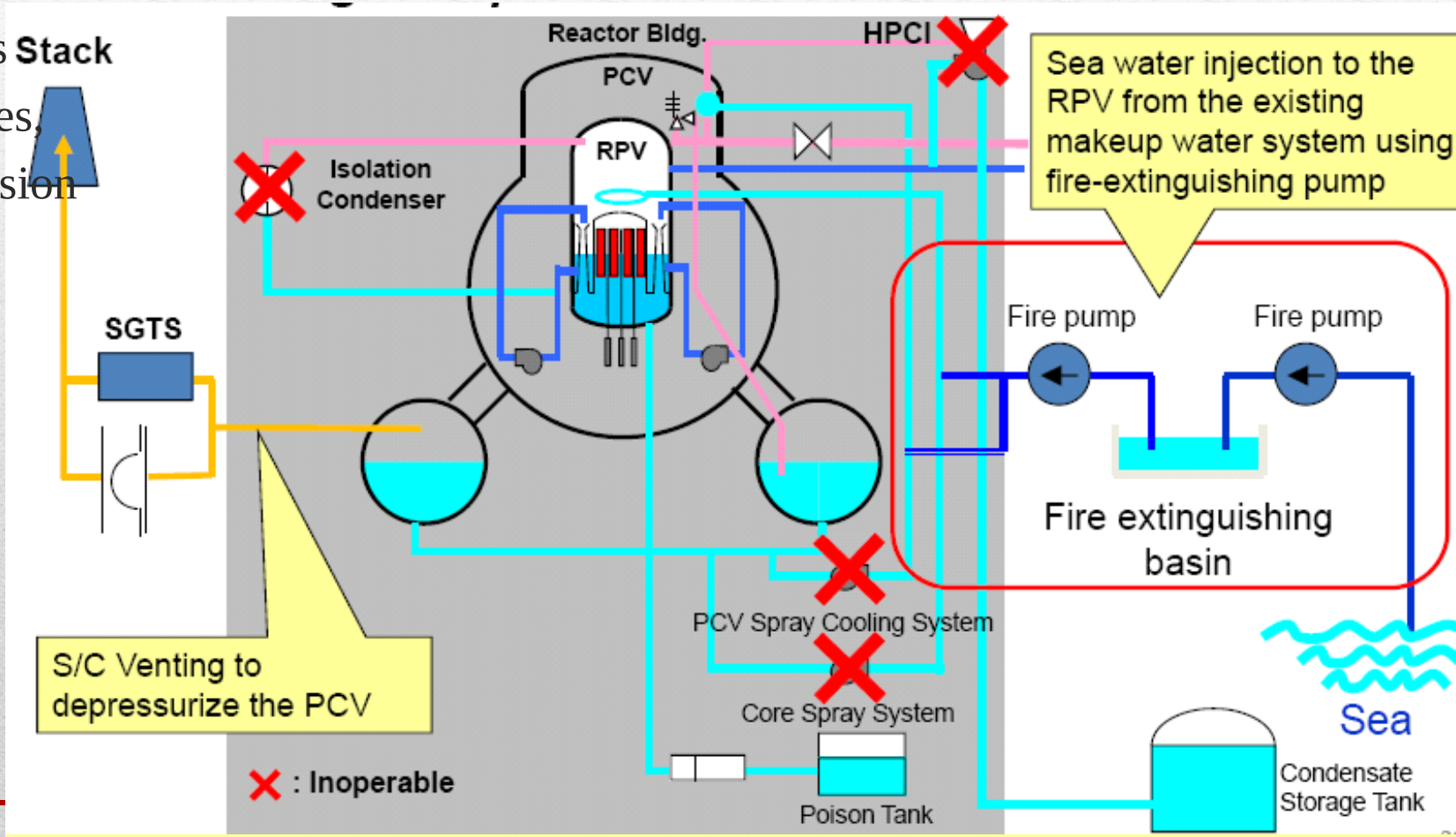
Hydrogen explosion in the operation floor





Cooling

- Seawater injected with fire trucks
- 10 houres to fill the reactor and 10 days to cool it down
- adding boric accid as a neutron absorber
- salt clogs cooling pipes, cousing erosion



Spent fuel pools

First few weeks:

Cooling with external water cannons (#1 & #4) – 2 weeks sea water, later fresh water

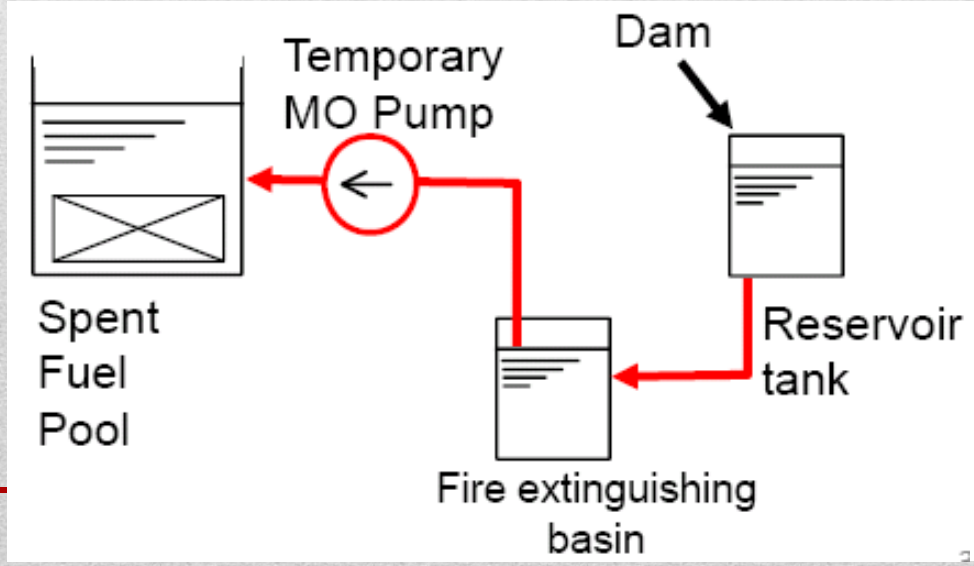
Structural integrrity of pool #4 was questionable – explosion(H2 from unit#3)

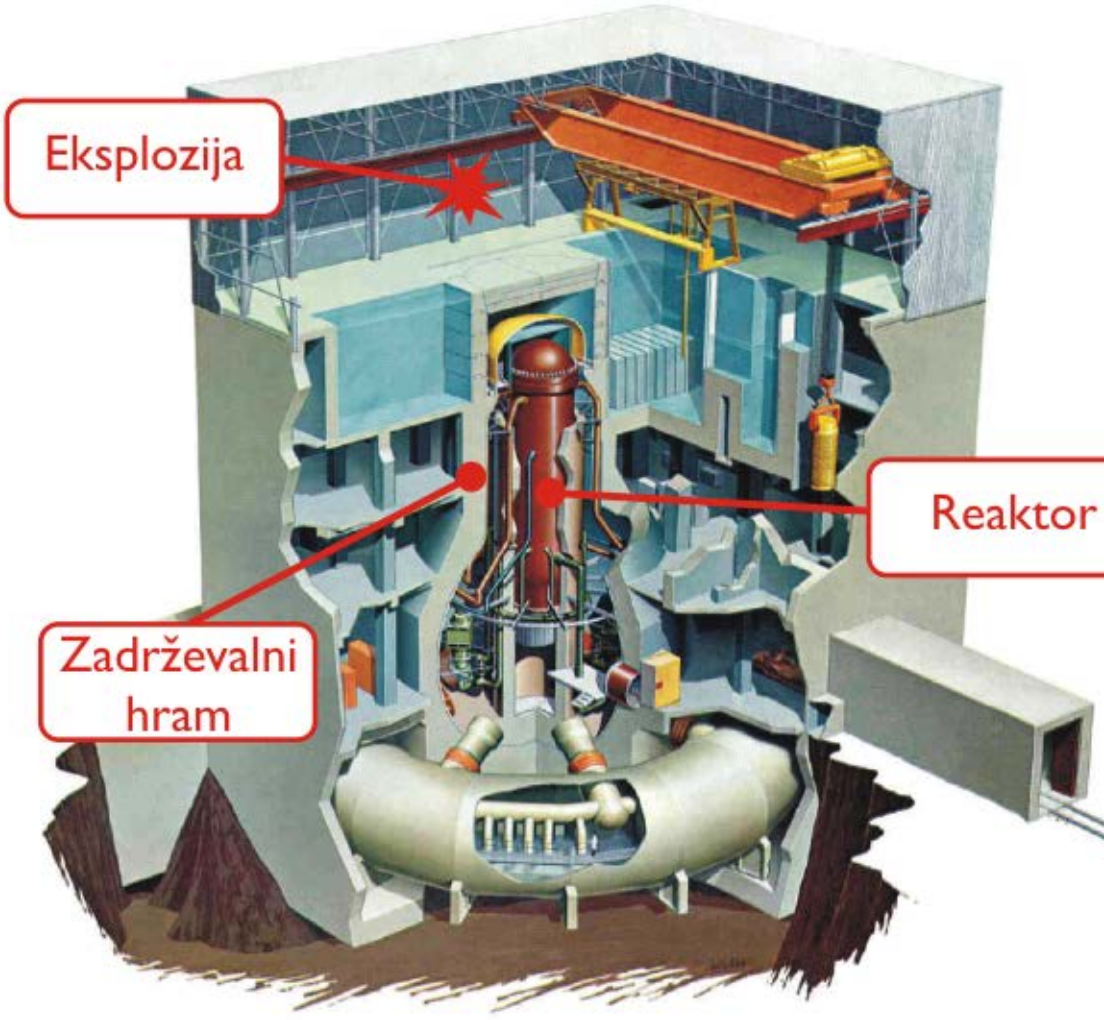
Pools #2 and #3 – standard cooling system (8.5.2011)

Pools of unit #5 and #6 and main pool : cooling systems were working normaly all the time

Temperatures : 30-40 ^{0}C

Source: Asahi.com

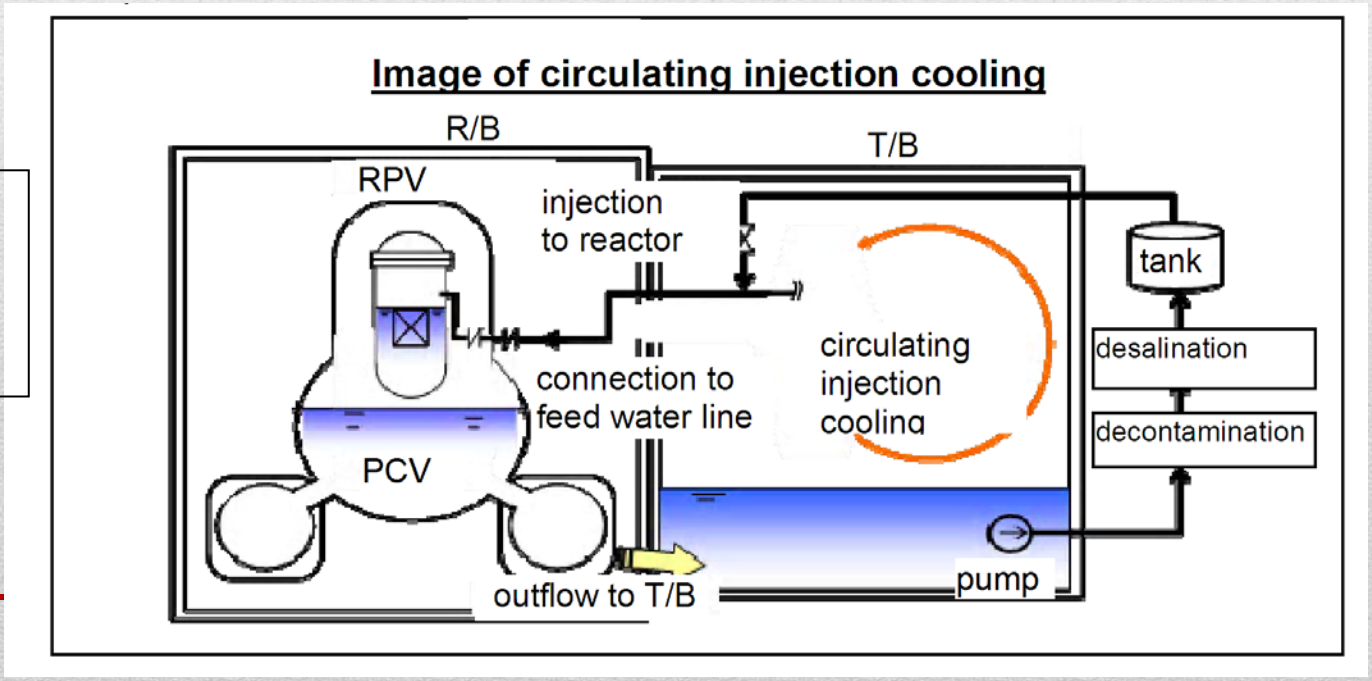



Eksplozija
Reaktor
Zadrževalni hram

After six months…

- reactors 1,2,3 – injecting water into reactor vessel (3.5, 3.5, 8 m^3/h)
  T_{vessel}: ~90-120 °C; p~1 bar (TEPCO 2.9.2011)
- damaged infrastrukture
- leaking of radioactive water
- decontamination of water

First 2-3 months water had not been “recycled“ -> ~110000 ton highly radioactive water.



How a nuclear plant meltdown could unfold

An explosion at an earthquake-hit nuclear plant in Japan has sparked fears of a radiation leak and nuclear meltdown. A meltdown occurs when failure of the cooling system leads to fuel rods overheating and melting

Boiling Water Reactor, BWR: Water, heated by splitting of uranium atoms, turns to steam and drives turbine-generator to make electricity. Steam condenses back to water and is pumped back into the reactor to continue cycle. **There are multiple barriers to prevent release of radiation**

1 Metal cladding: Encases uranium fuel rods in reactor core

2 Reactor pressure vessel

3 Containment building

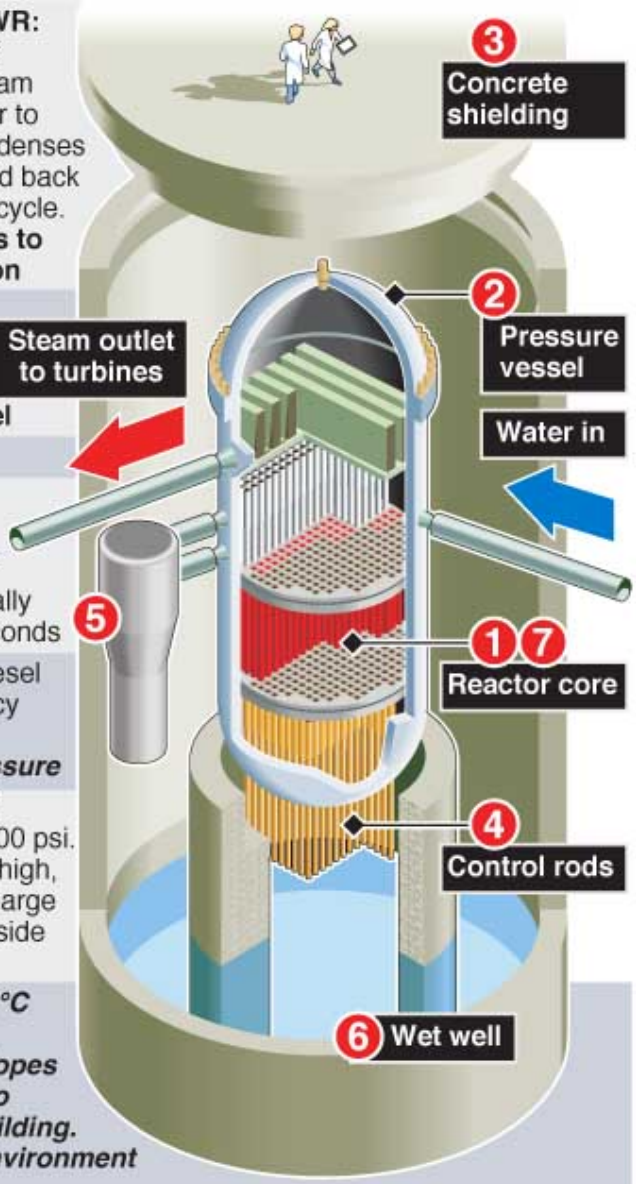
Reactor scram: During earthquake, reactor automatically shuts down

4 Control rods: Hydraulically driven into core within 7 seconds

5 Emergency cooling: Diesel generators power emergency cooling. ***Failure produces more heat, increases pressure***

6 Wet well: Pressure relief systems active at about 1,100 psi. If reactor pressure gets too high, relief valves open and discharge steam to water filled pool inside containment

7 Meltdown: Above 1,200°C fuel rod cladding melts, releasing radioactive isotopes of caesium and iodine into damaged containment building. Radiation escapes into environment



Sources: General Electric, wire agencies

Viri:

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