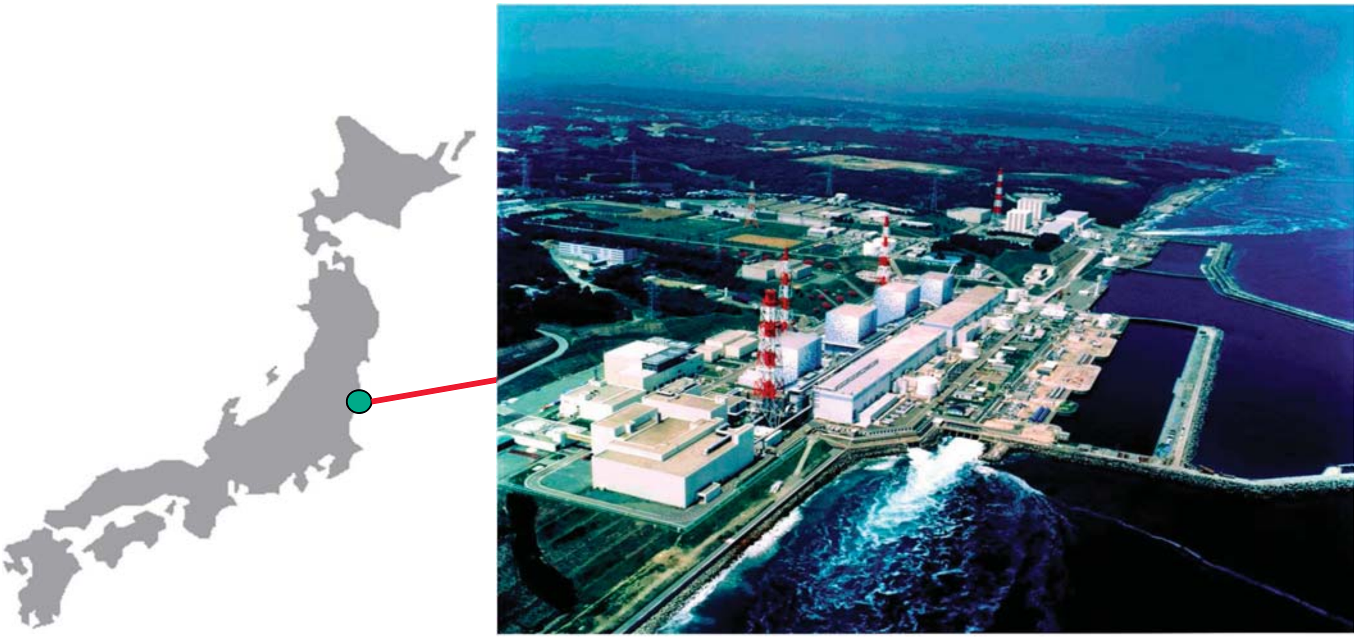
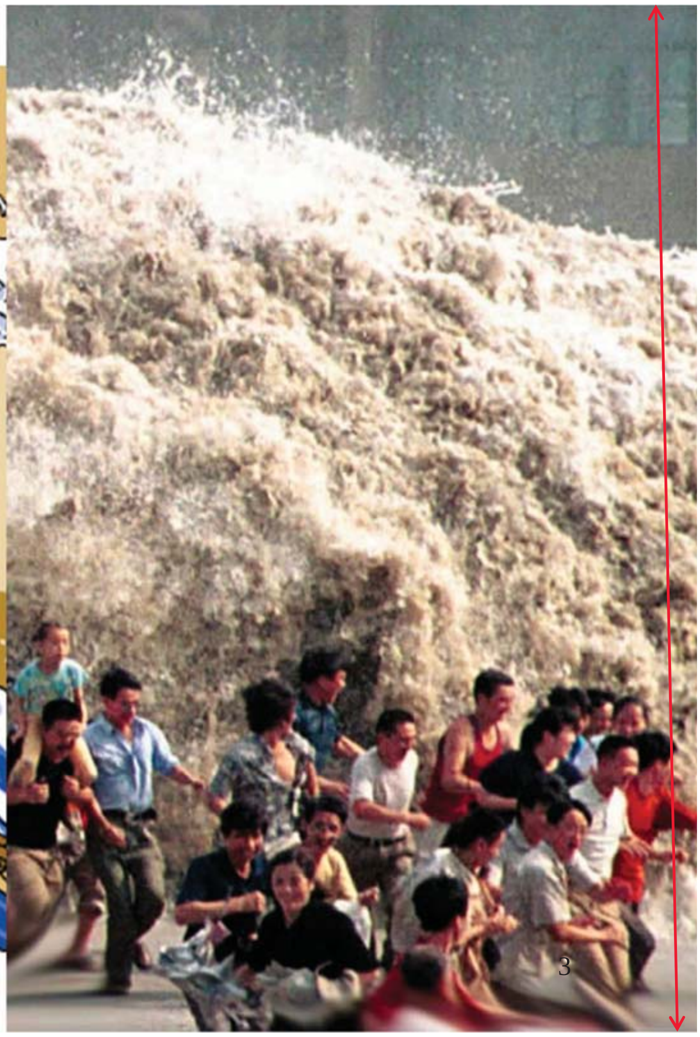
Fukushima Daiichi NPP



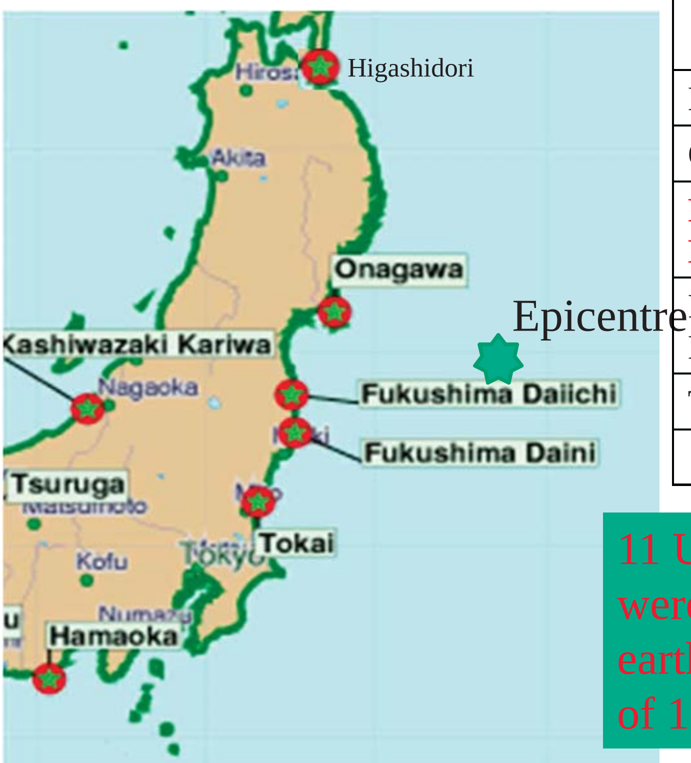
April 21 2011, Ki Sig Kang

Tsunami Phenomenon



3

Earthquake and affected NPPs



	Automatic Shutdown	Inspection Outage
Higashidori	-	Unit 1
Onagawa	Units 1-3	-
Fukushima Daiichi	**Units 1-3**	**Units 4-6**
Fukushima Daini	Unis 1-4	-
Tokai Daini	(only 1 unit)	-
	11 Units	4 Units

11 Units (BWRs) under operation were successfully shutdown after the earthquake occurred at 14:46 (06:46) of 11 March 2011

4

Fukushima Daiichi NPP

Unit	Output（MW）	Start Operation	Manufacturers
No.1	460, BWR-3, 400 FA (68T, UO2)	1971／3	GE
No.2	784, BWR-4, 548 FA (94T, UO2)	1974／7	GE／Toshiba
No.3	784, BWR-4, 548 FA (95T, MOX)	1976／3	Toshiba
No.4	784, BWR-4, 548 FA (94T, UO2)	1978／10	Hitachi
No.5	784	1978／4	Toshiba
No.6	1100	1979／10	GE／Toshiba
Total	4696		

13 Emergency Diesel Generators, each unit has 2 DG, but No.6 has three DG(one- air cooled)

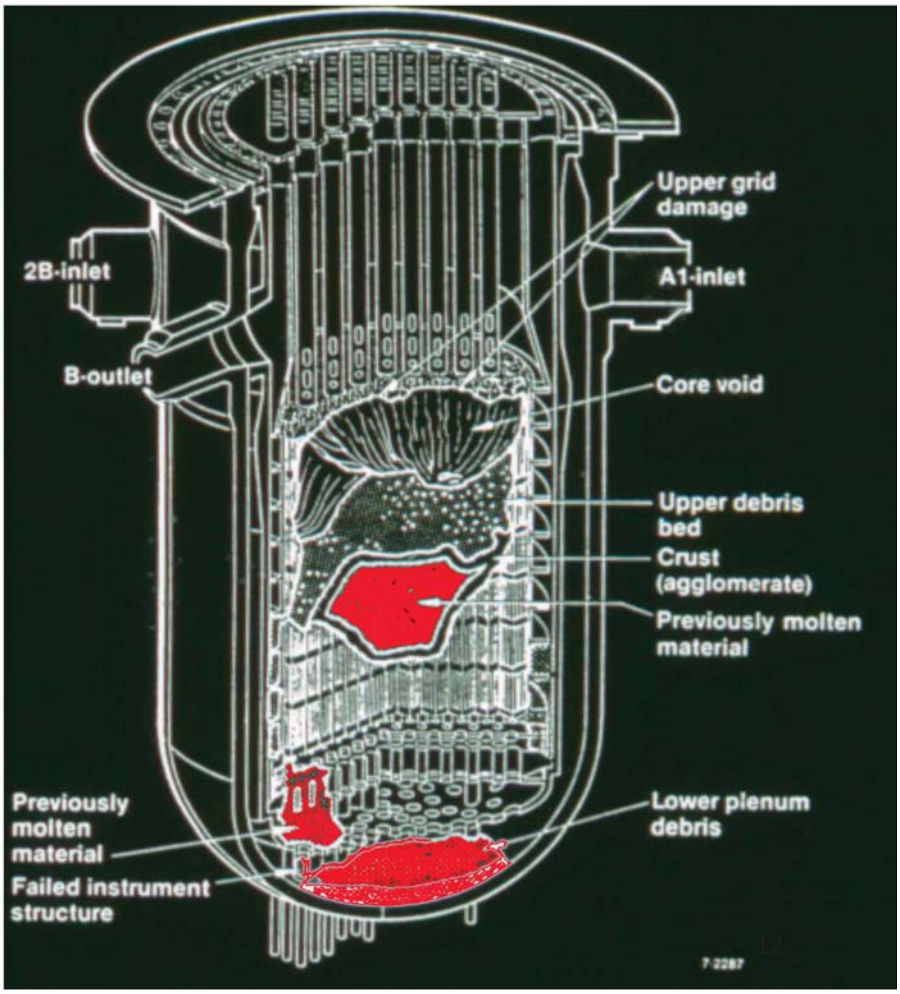
Fukushima 1 Npp unit 1 ~ 4

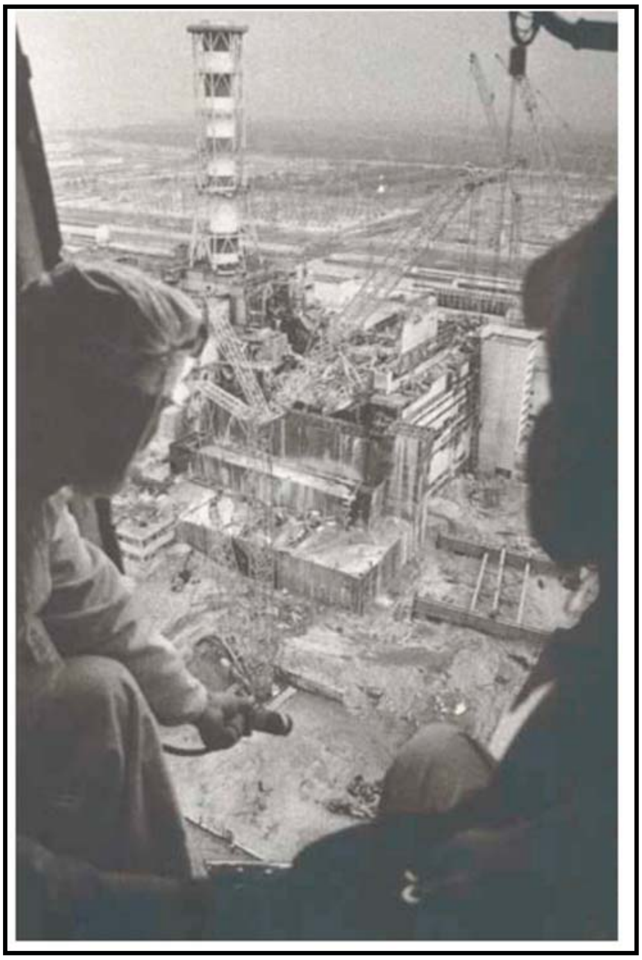
Dai Ini NPS before Tsunami

Dai Ini NPS after Tsunami

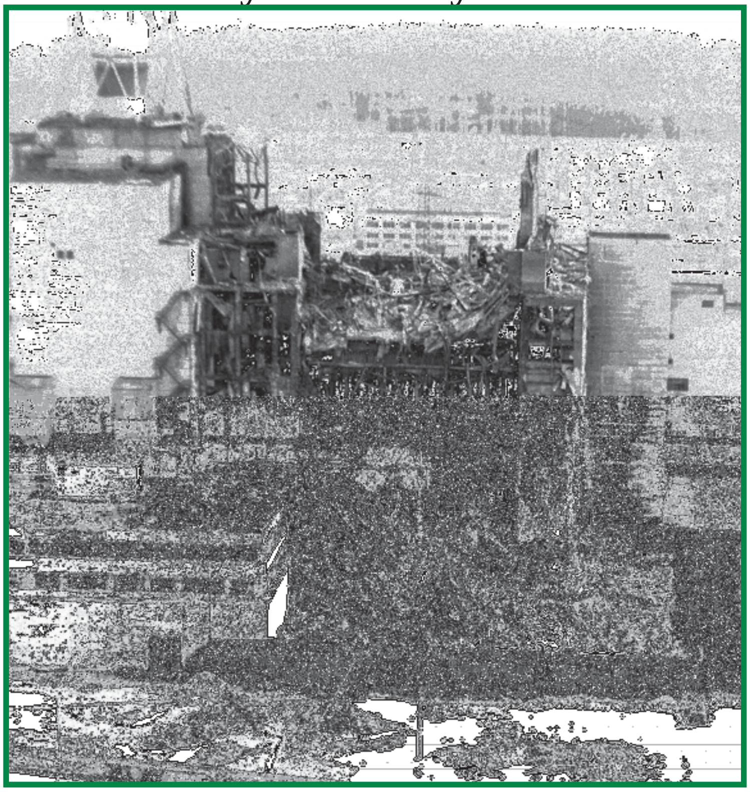
March 28 1979

1987
End State
Configuration

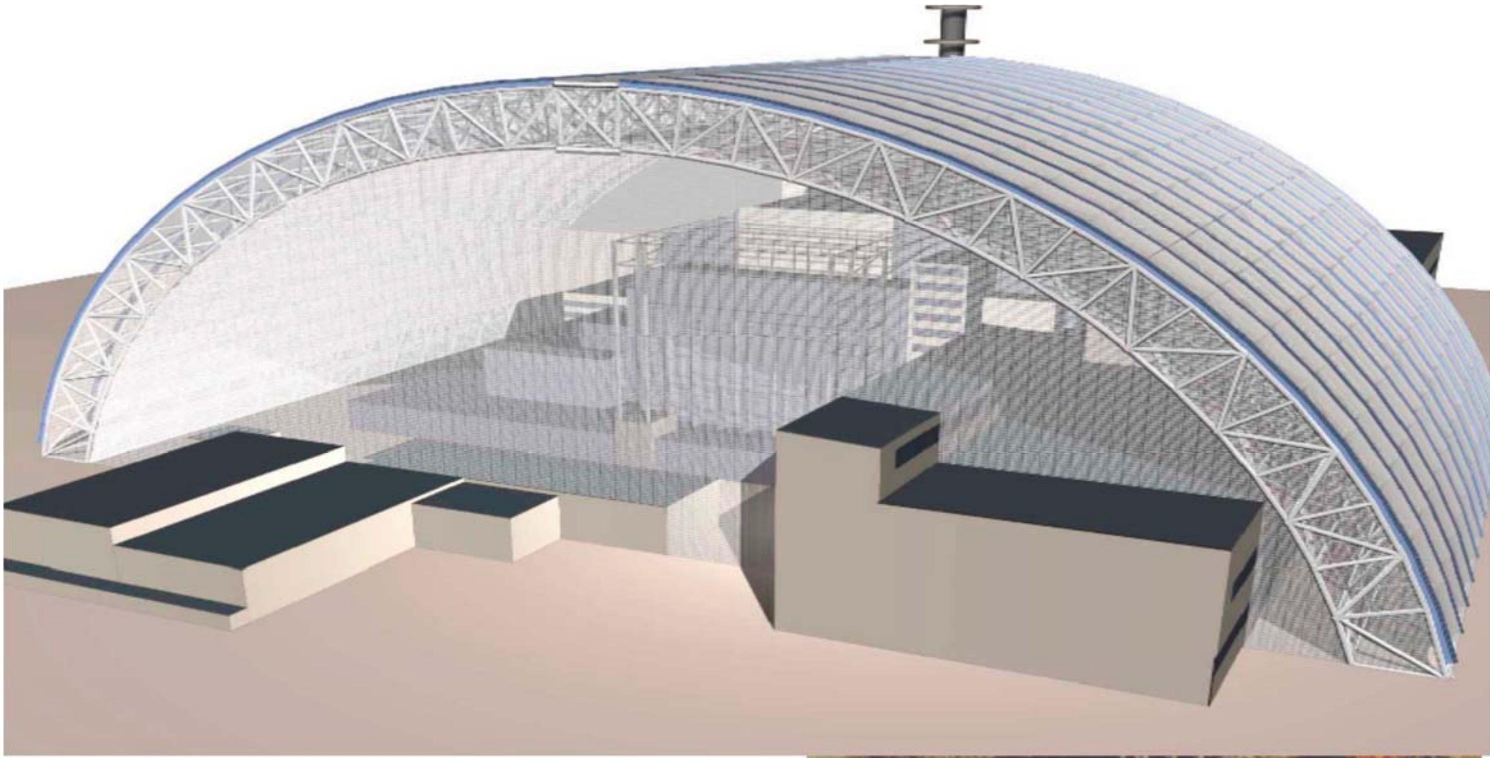




April 26 1987
Chernobyl 4 Destroyed

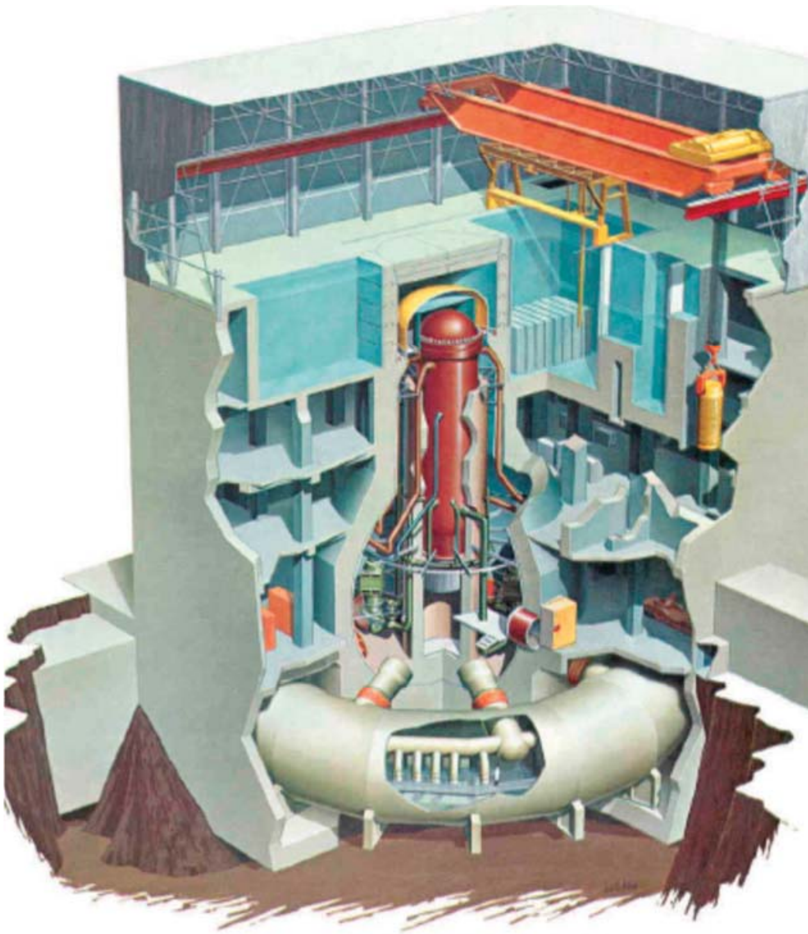


Molten Fuel – Elephant Foot



A lot of equipment will be placed inside the “Arch”, i.e. lifting cranes, mechanisms and other industrial facilities..

BWR information

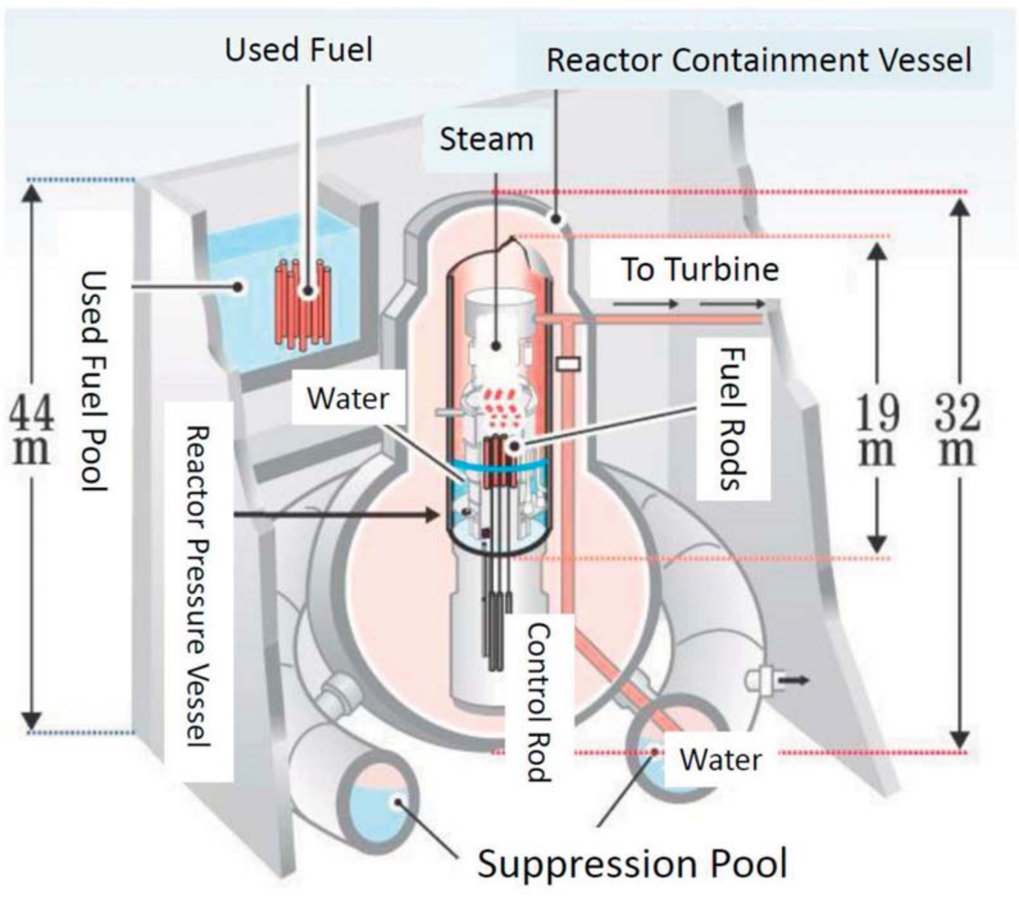


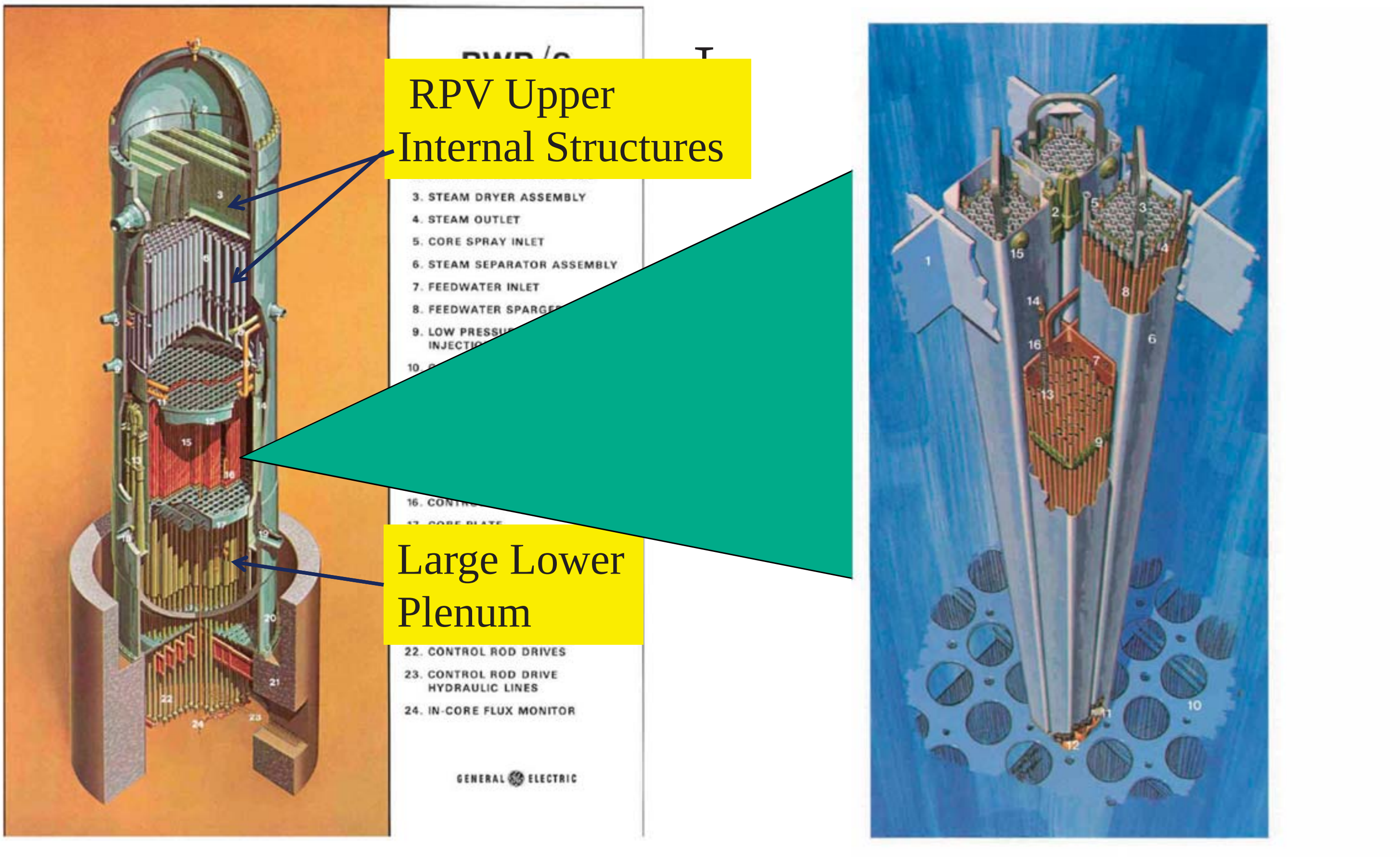
DRYWELL TORUS

Mark 1 Containment
Fukushima Daiichi #1

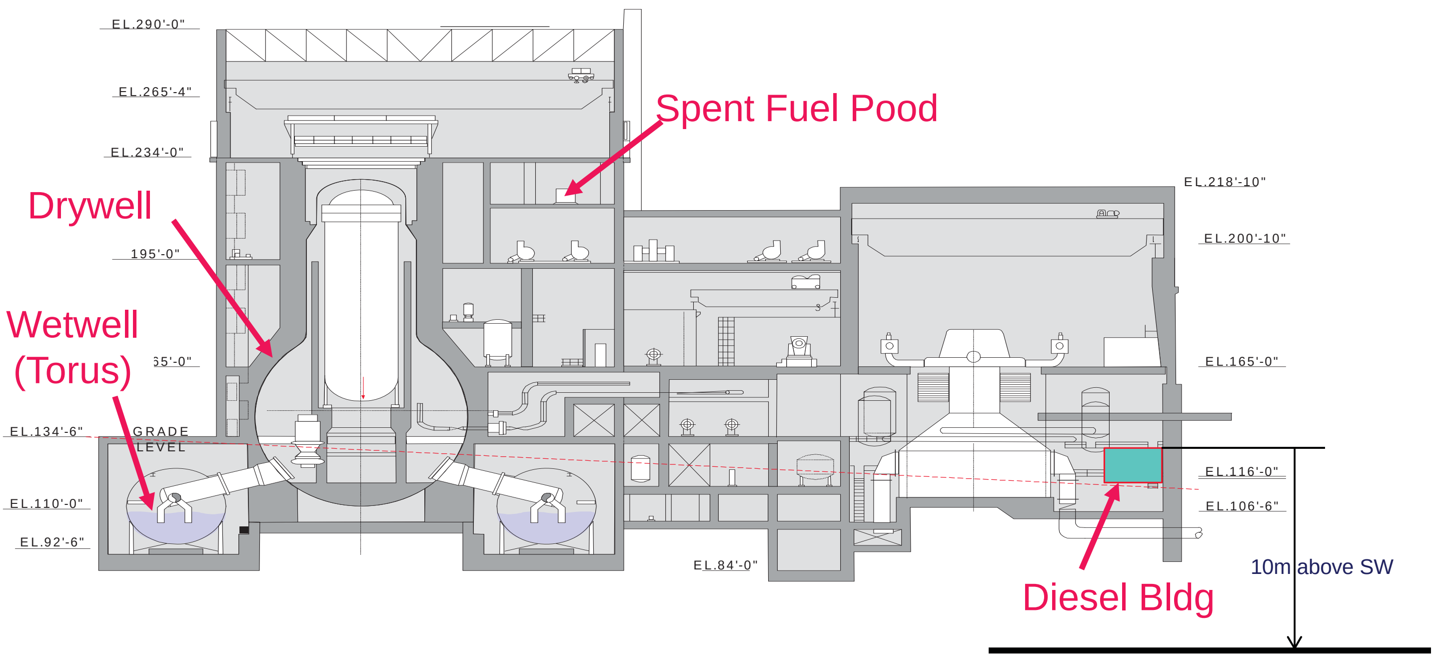
RPV : 19.7 m
RPV In-dia: 4.8 M
RPV Thick: 16 Cm
Fuel : UO2
Refuelling : 13 M
FA : 400
FA length : 3.66 m
Operation Press. : 70.7 bar
Operation Temp : 285 oC
Thermal Power : 1380 MWt
Elec. Power : 460 Mwe
Turbine : 1500 RPM
Cont. Pressure : 4.3 bar
Total vol : 3410 M3
HP sys Press : 19 bar
SPF capacity : 900 FA

Const : 1967 7.25
COD : 1971.03.26



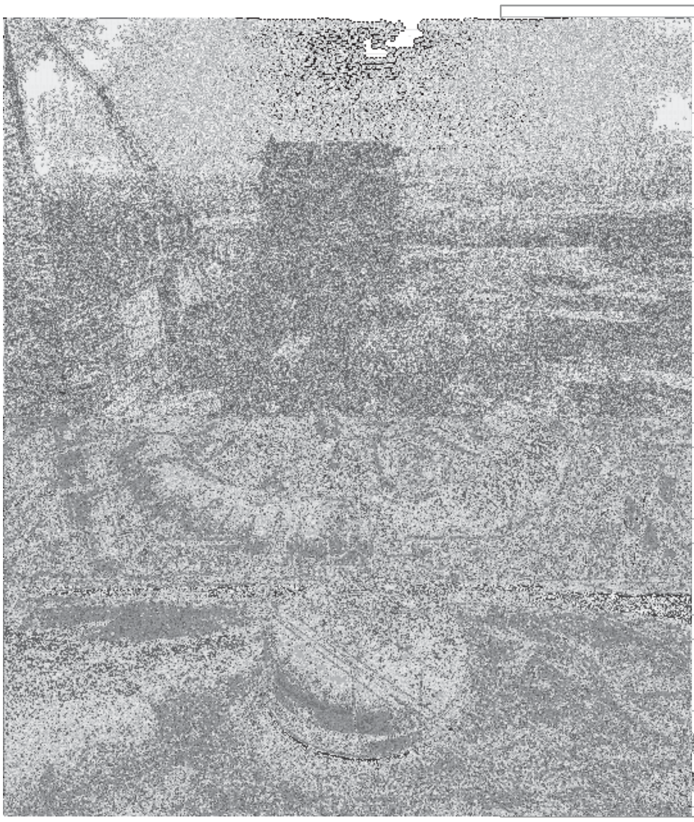


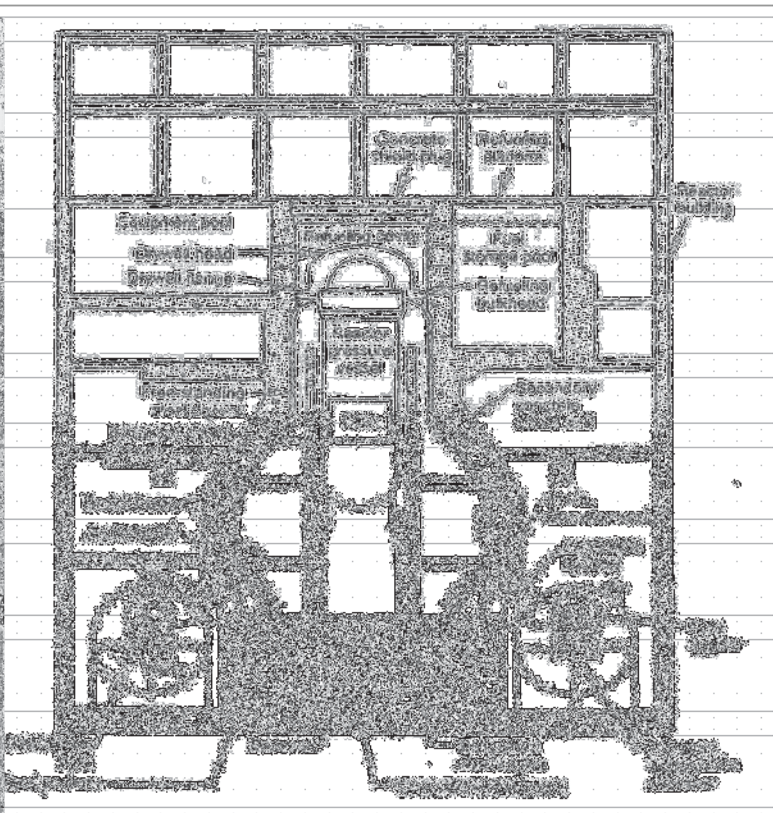
BWR Design Features – small primary containment housed in large building



Upper part of Reactor Vessel - Service Floor

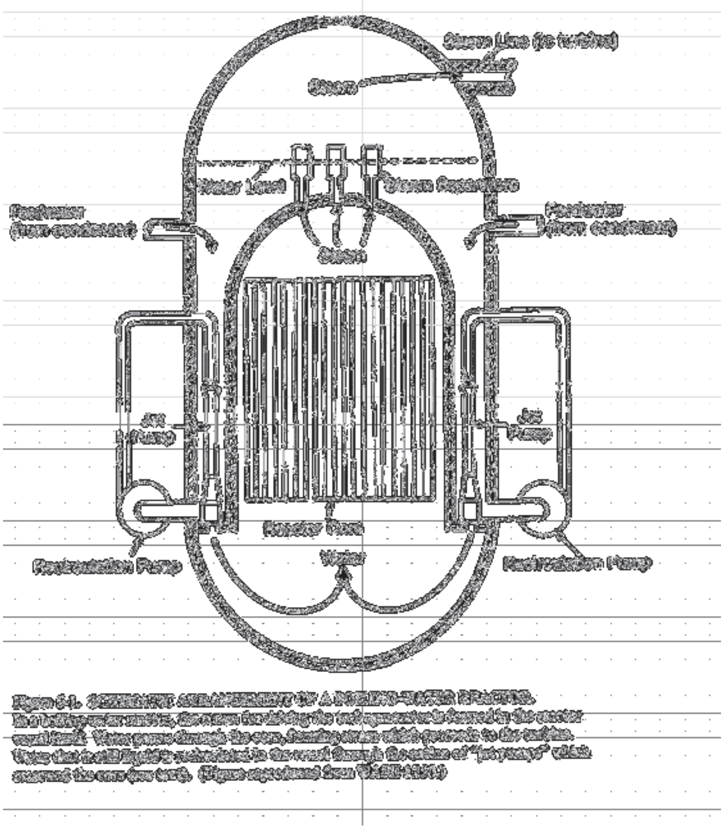
BWR Mark I Containment



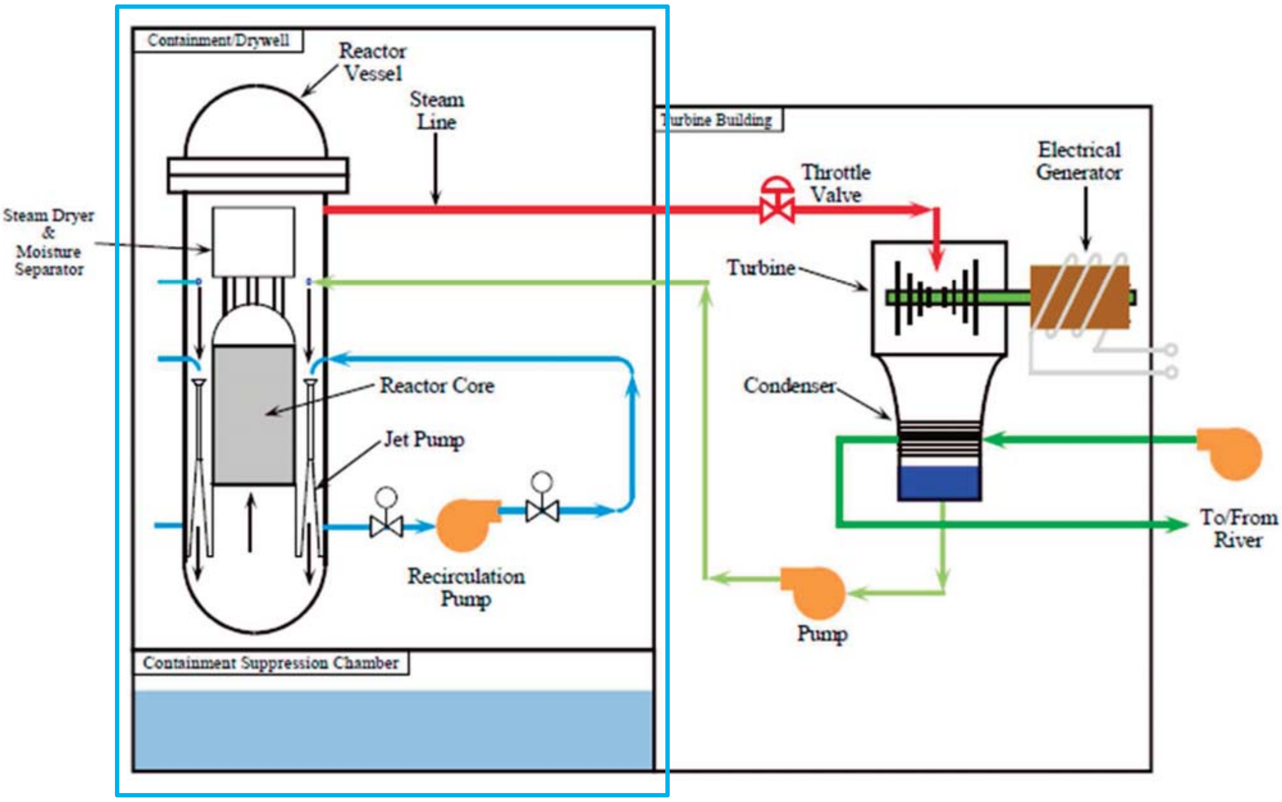


Reactor Vessel Assembly

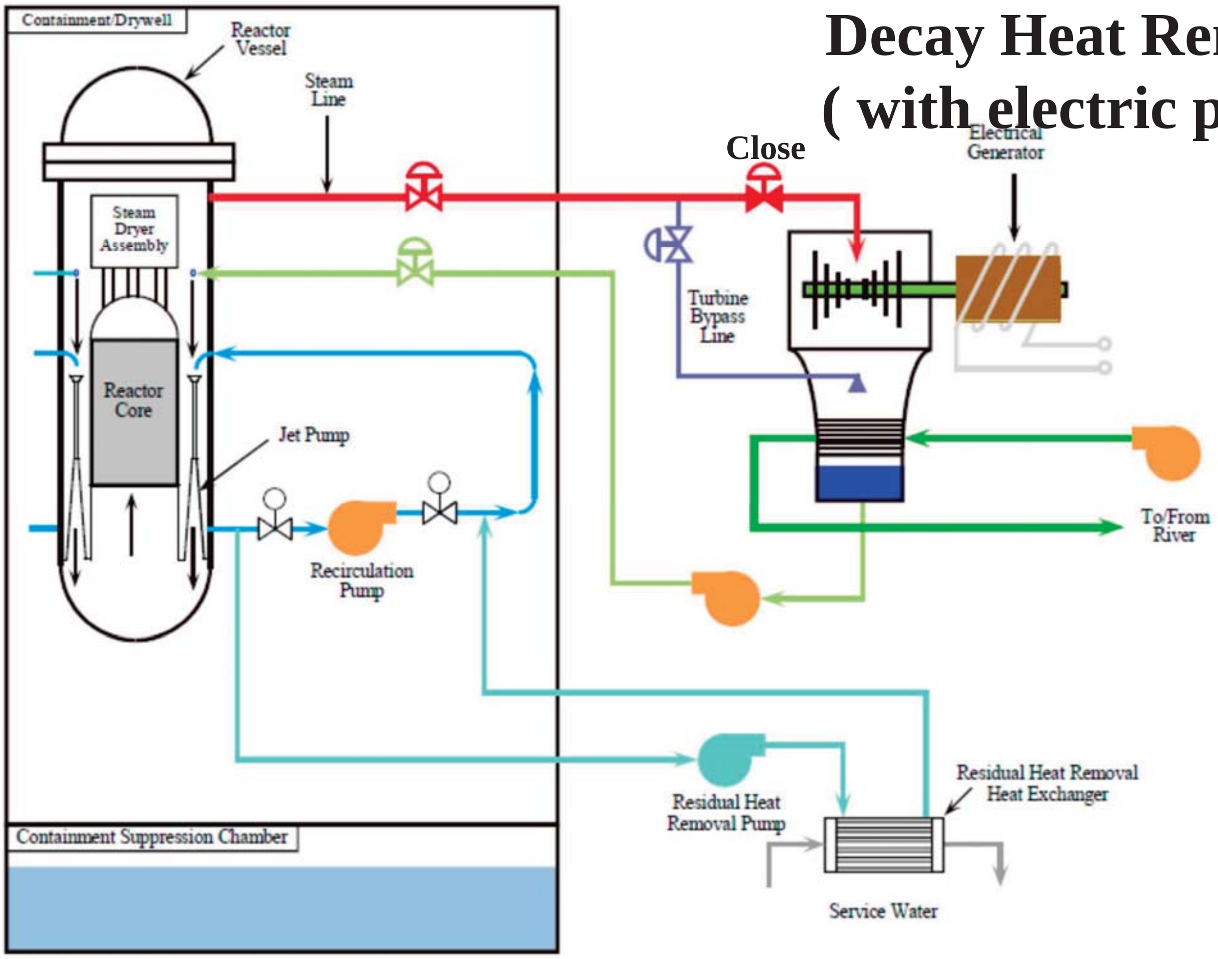
- Vessel
- Fuel Assembly and Control Rods
- Recirculation Jet Pump Assembly
- Core Support Structure
- Steam separator (dryer)
- Core Shroud



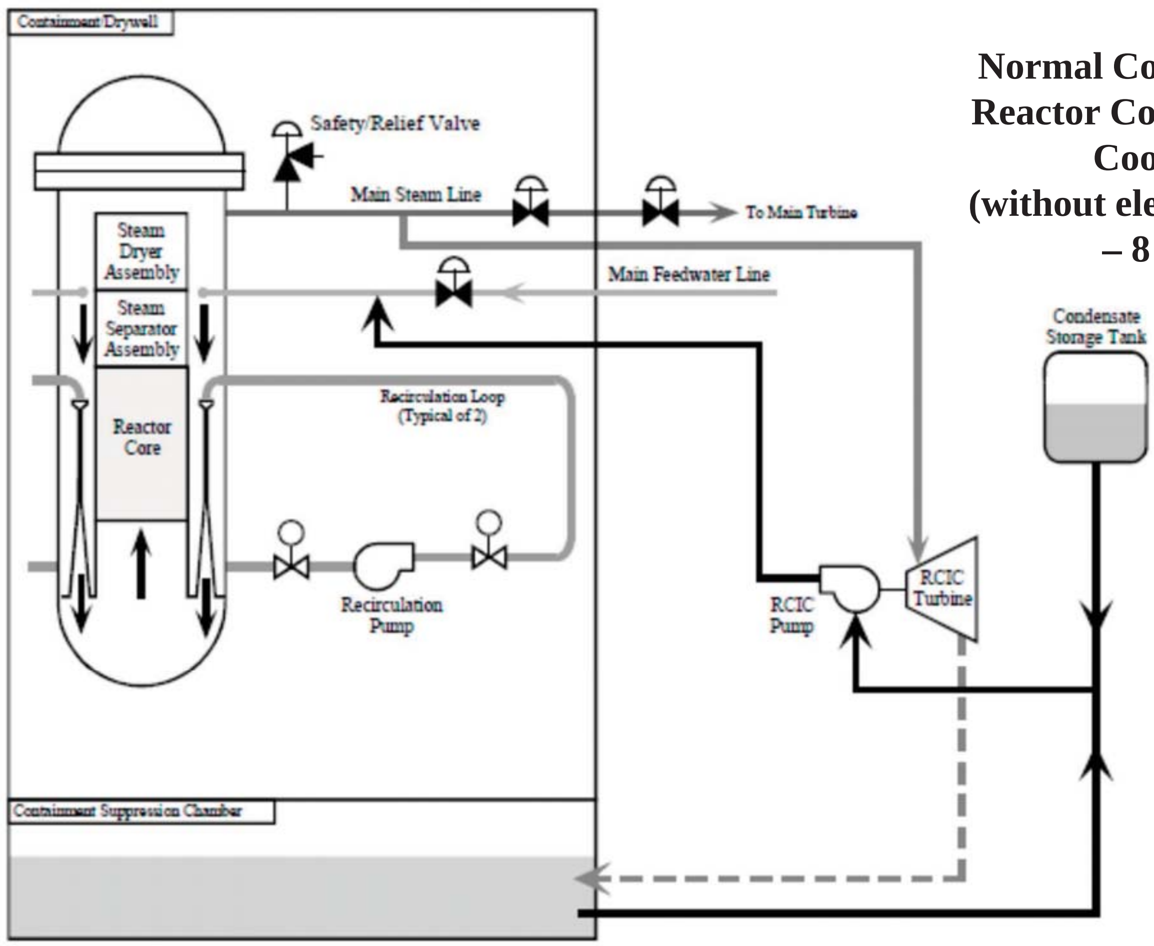
Normal Operation



Decay Heat Removal (with electric power)

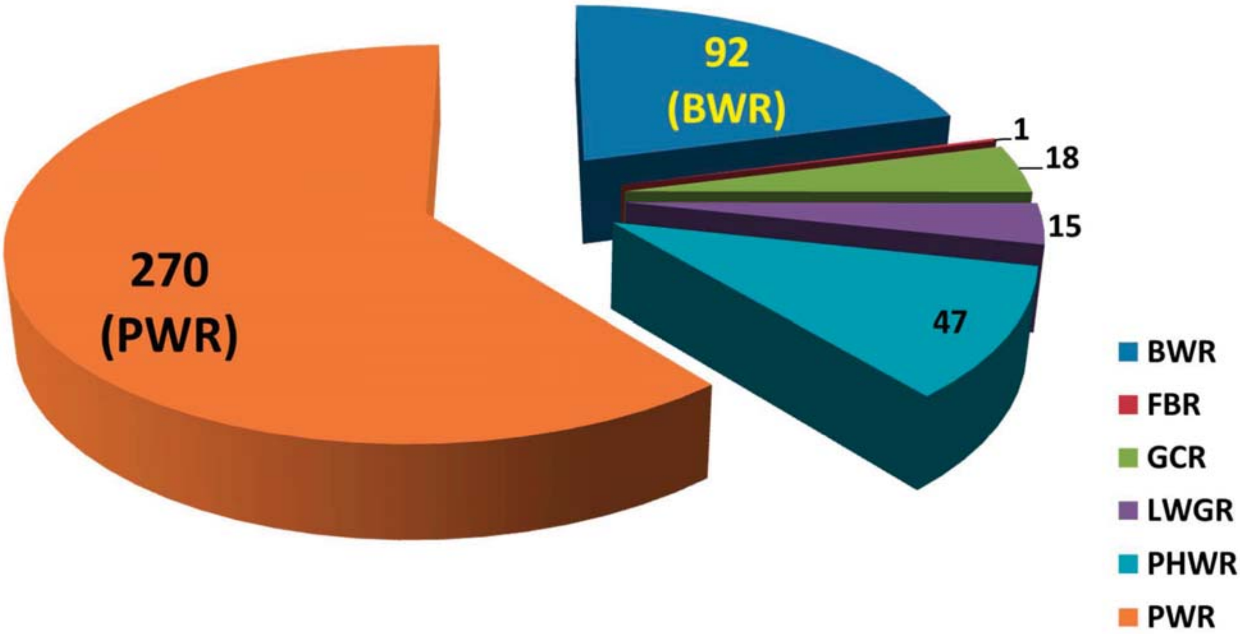


Normal Cooling using Reactor Core Isolation Cooling (without electric power – 8 hr)



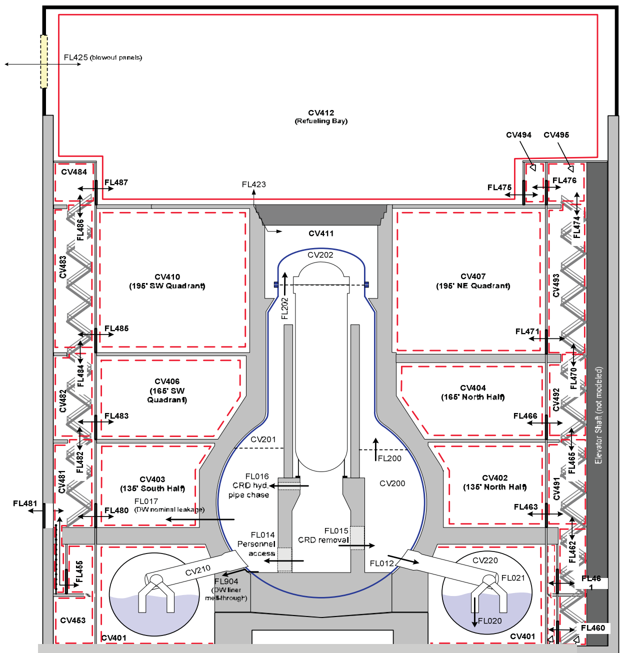
Number of Npp Units : 443

(as of Dec 2010)



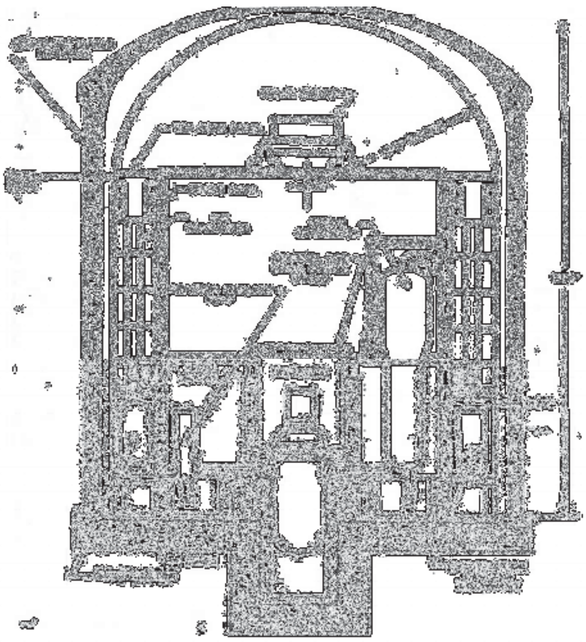
Reactor Building Arrangement

BWR Mark 1



Reinforced concrete reactor building

PWR PCCV*



* Pre-stressed Concrete Containment Vessel

Comparison of Design Features

Parameters	PWR	BWR
Steam Production	Secondary System Steam Generator	Directly in the System
Pressure	Varies, 15.5 Mpa Controlled by Pressurizer	Constant, 7.2 Mpa
Produced steam	Goes through steam generators then to turbine; nonradioactive	Goes through separators and steam dryers then to turbine; radioactive
Zircaloy mass of Fuel assembly	Relatively Small	Relatively Large Larger quantities of H_2 generated
Containment Building	Large Volume for non-condensible gas retention,	Small Volume, Minimal capacity for non-condensible gas retention,
Gen III, Gen III+ reactors	AP-1000, EPR, VVER-1200, APR-1400, APWR	ABWR, ESBWR

Engineering Review of Accident Sequences

Verification of the design Tsunami

Consideration of Tide

The Design Tsunami

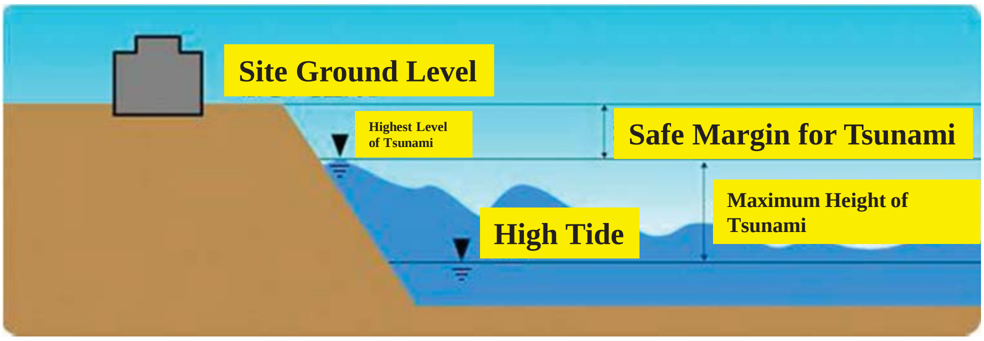
- Maximum water ascent
- Maximum water decent

Tidal Conditions

Tsunami Evaluation Method for Nuclear Power Stations in Japan, SAKAI Toshiaki- TEPCO

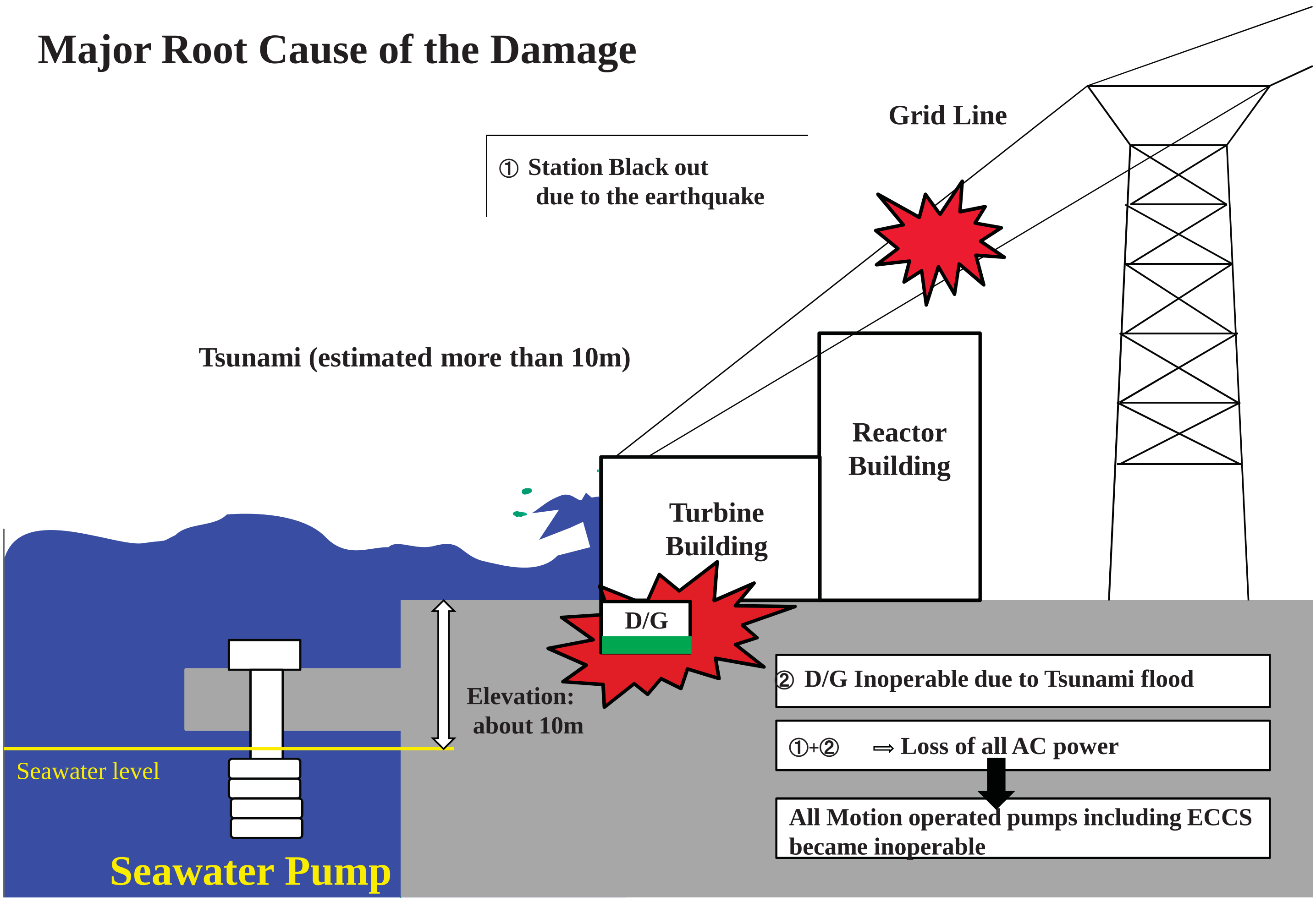
Design High Water Level = 10 M

= Maximum water ascent + Mean of high tides + Safe Margin

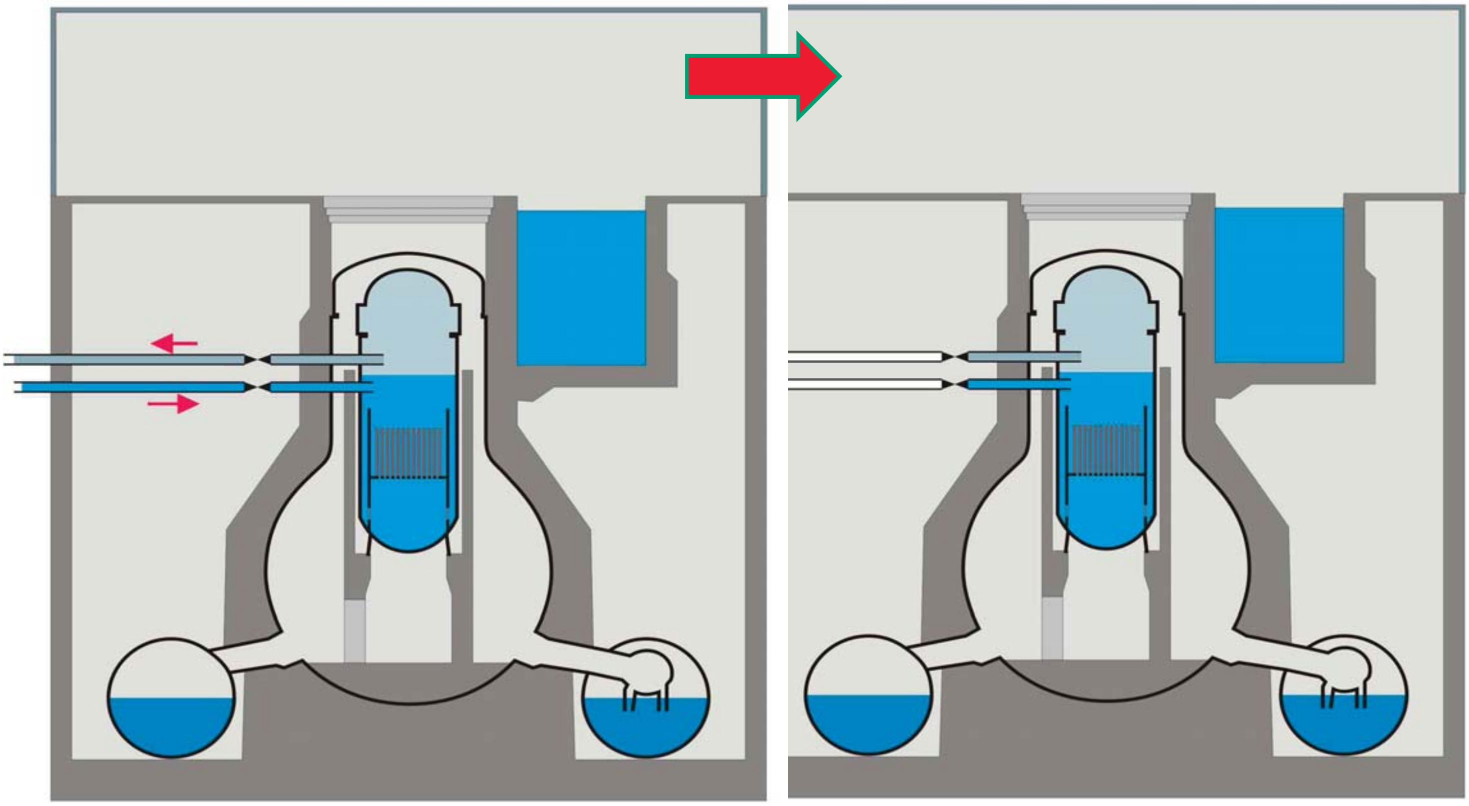


= * Other Npps 13 M (DG- active)

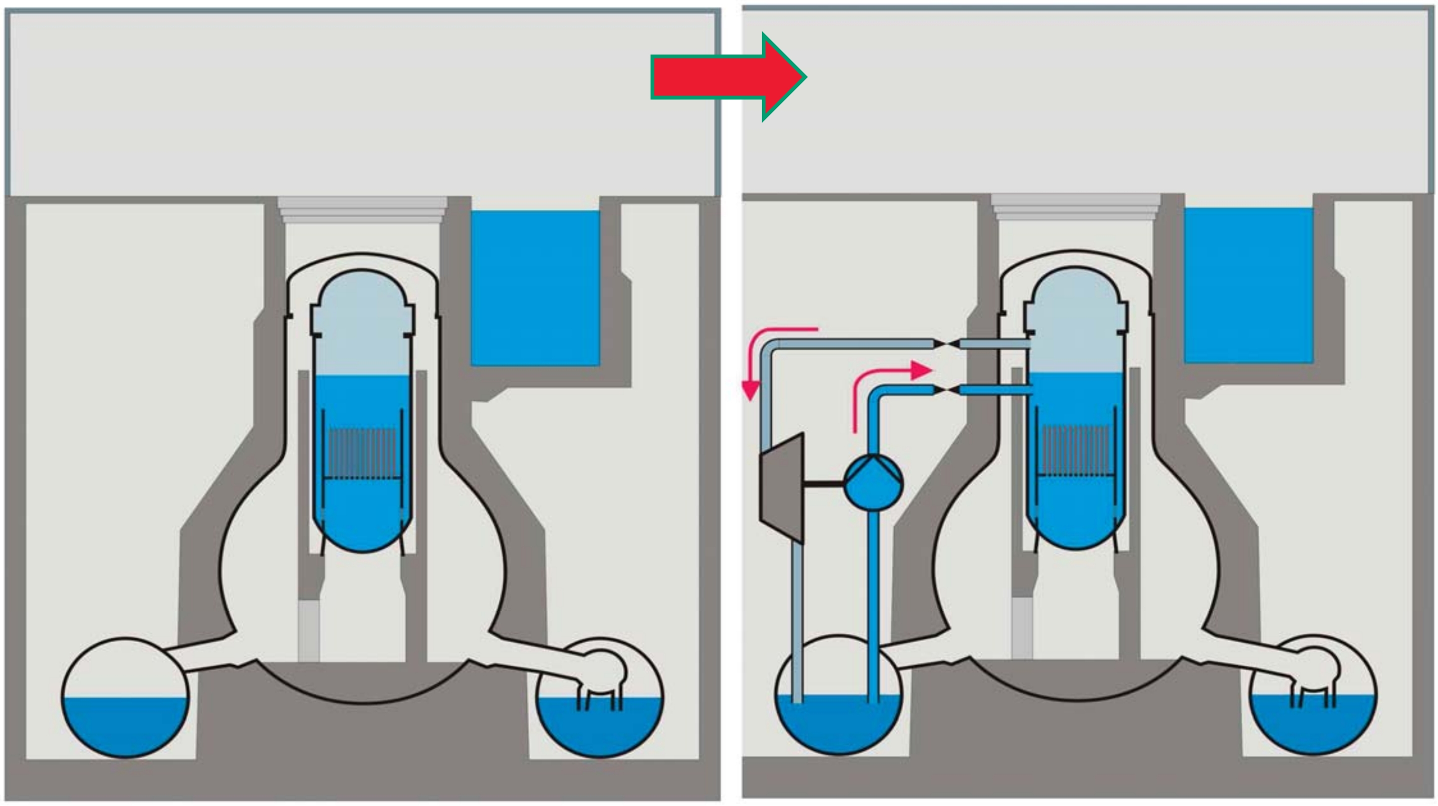
Major Root Cause of the Damage



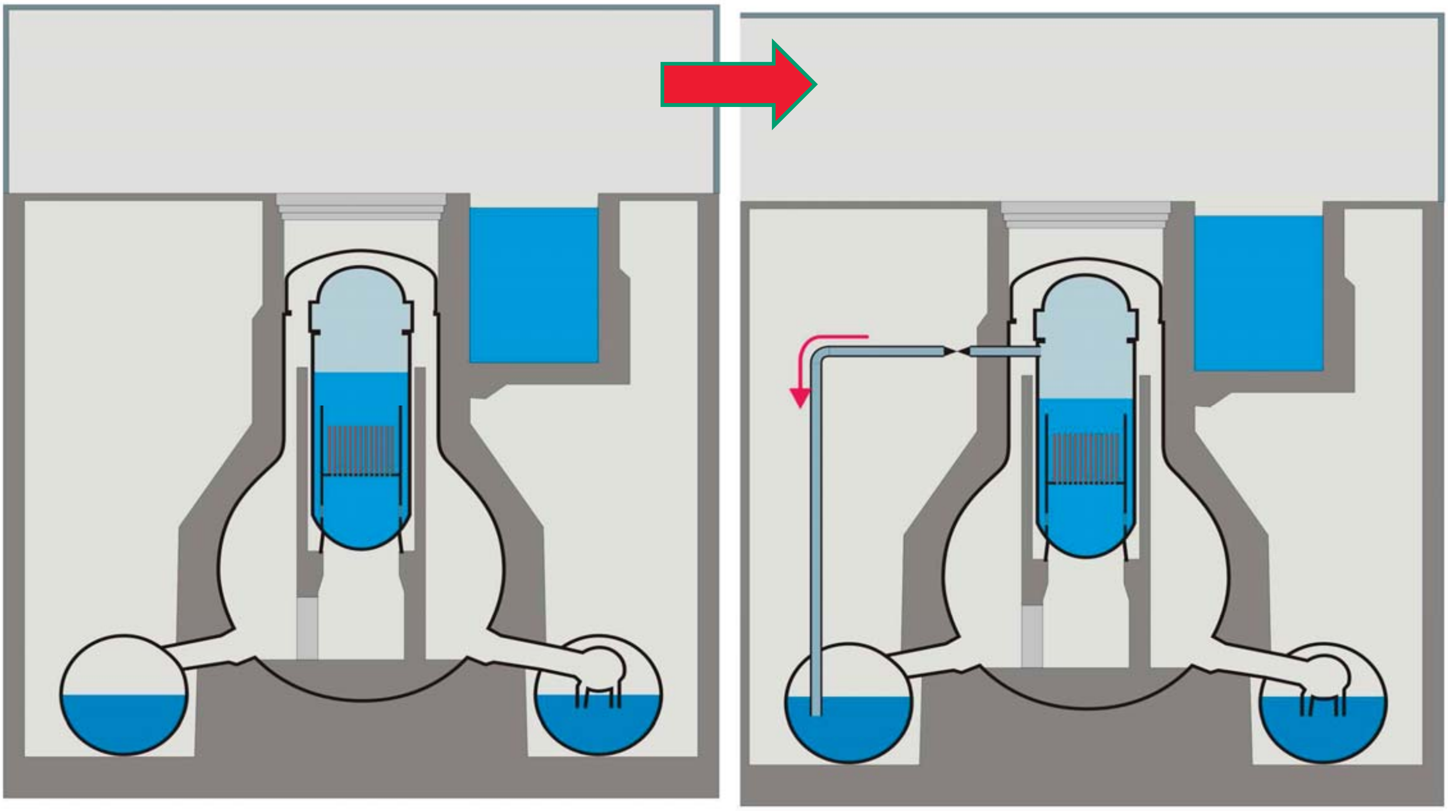
Fukushima Daiichi Accident Process



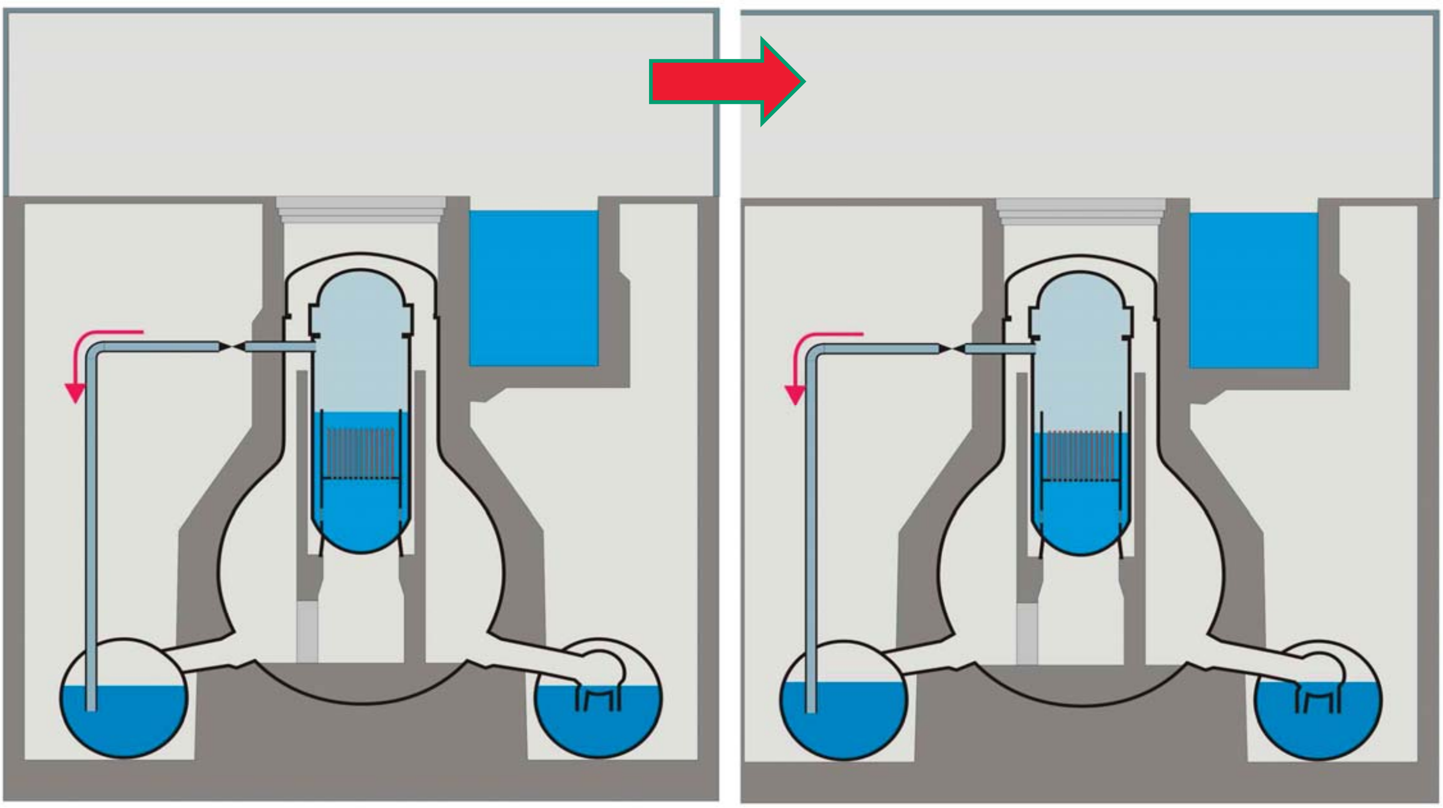
Fukushima Daiichi Accident Process



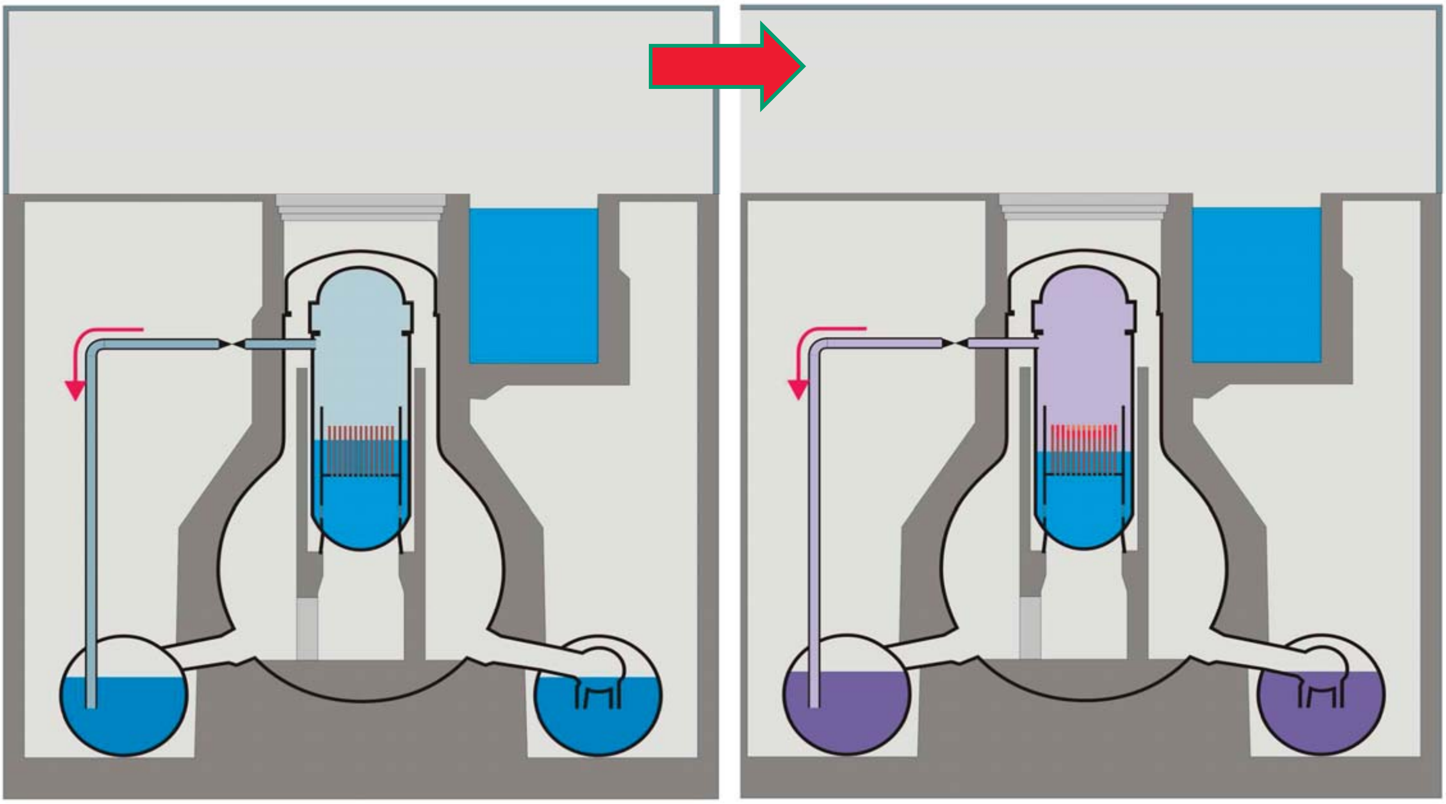
Fukushima Daiichi Accident Process



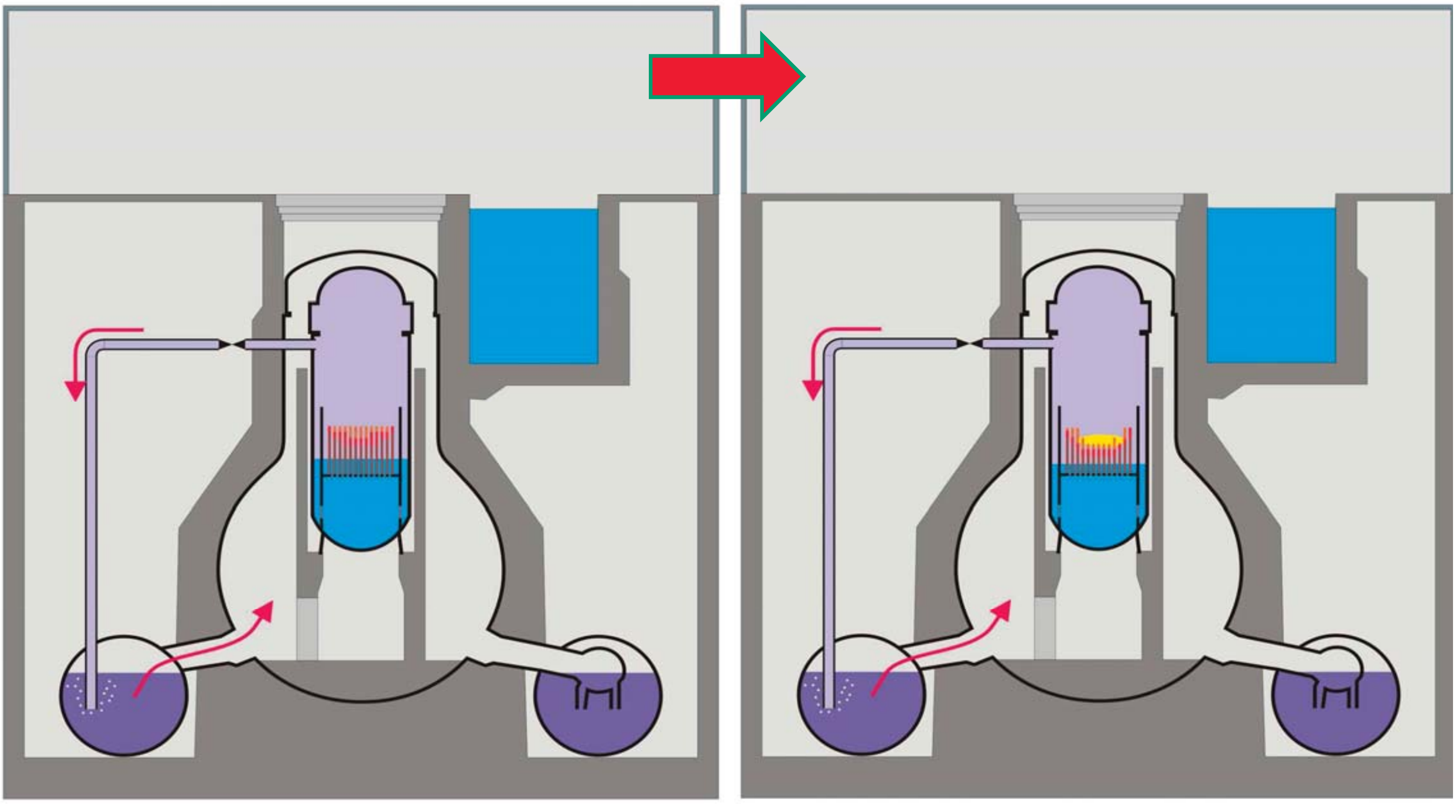
Fukushima Daiichi Accident Process



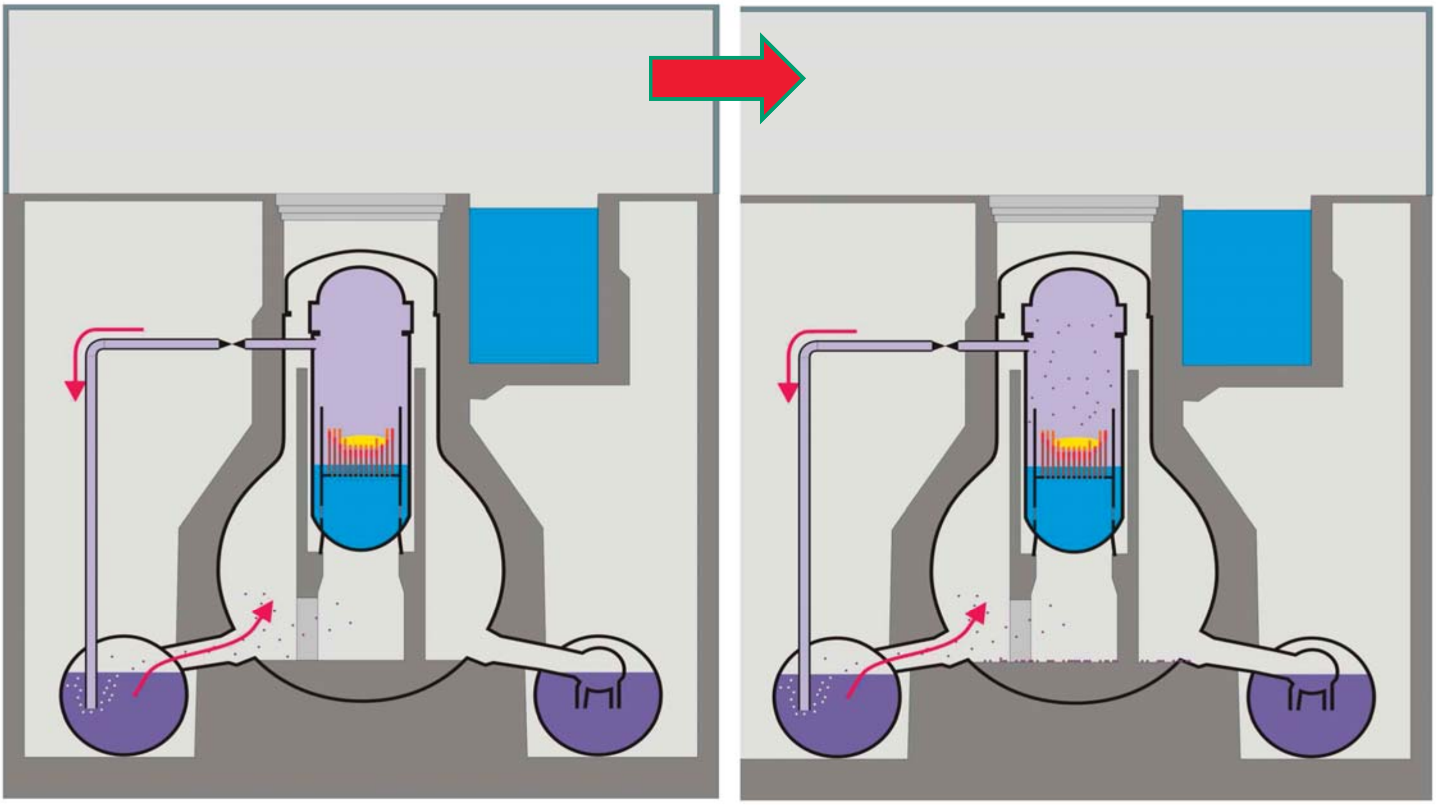
Fukushima Daiichi Accident Process



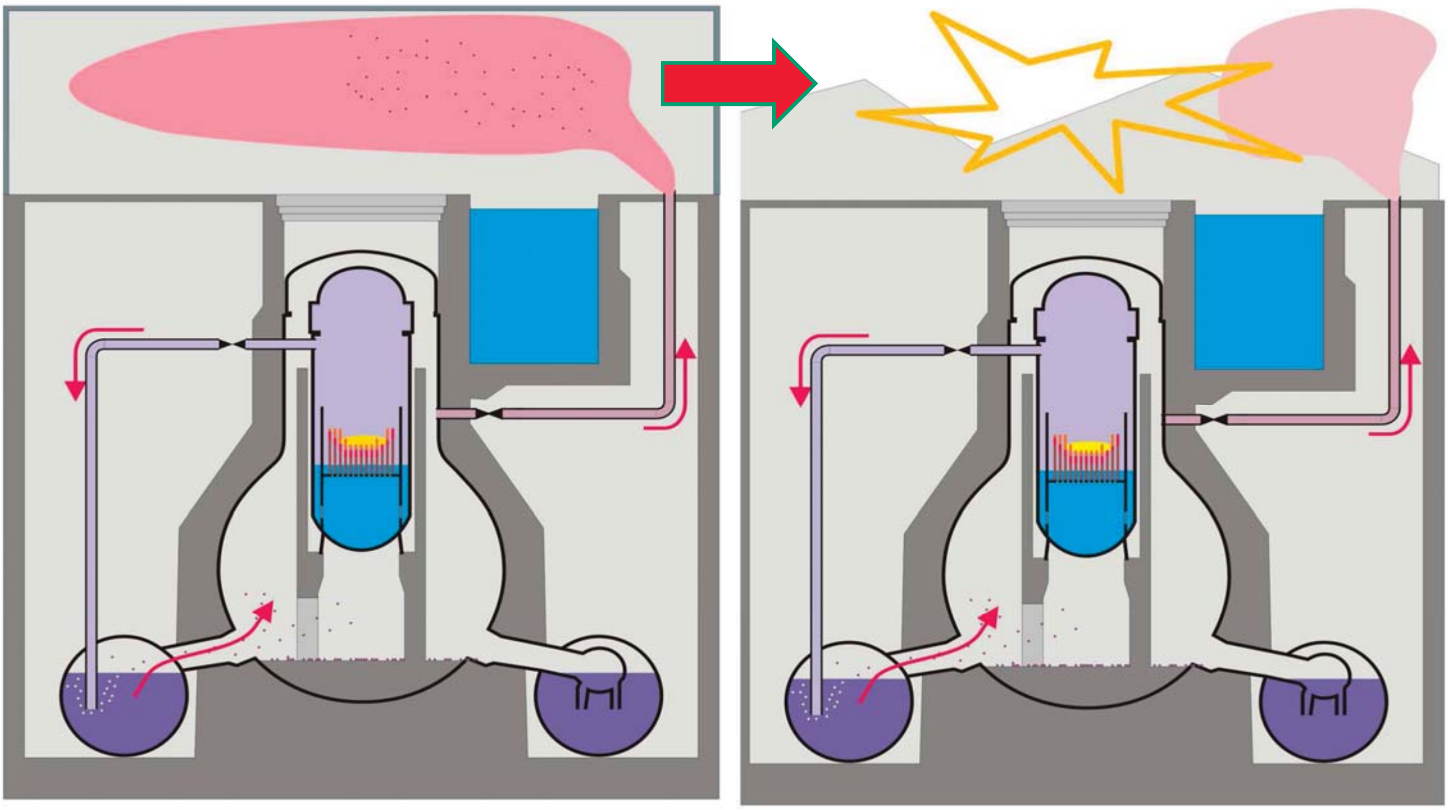
Fukushima Daiichi Accident Process



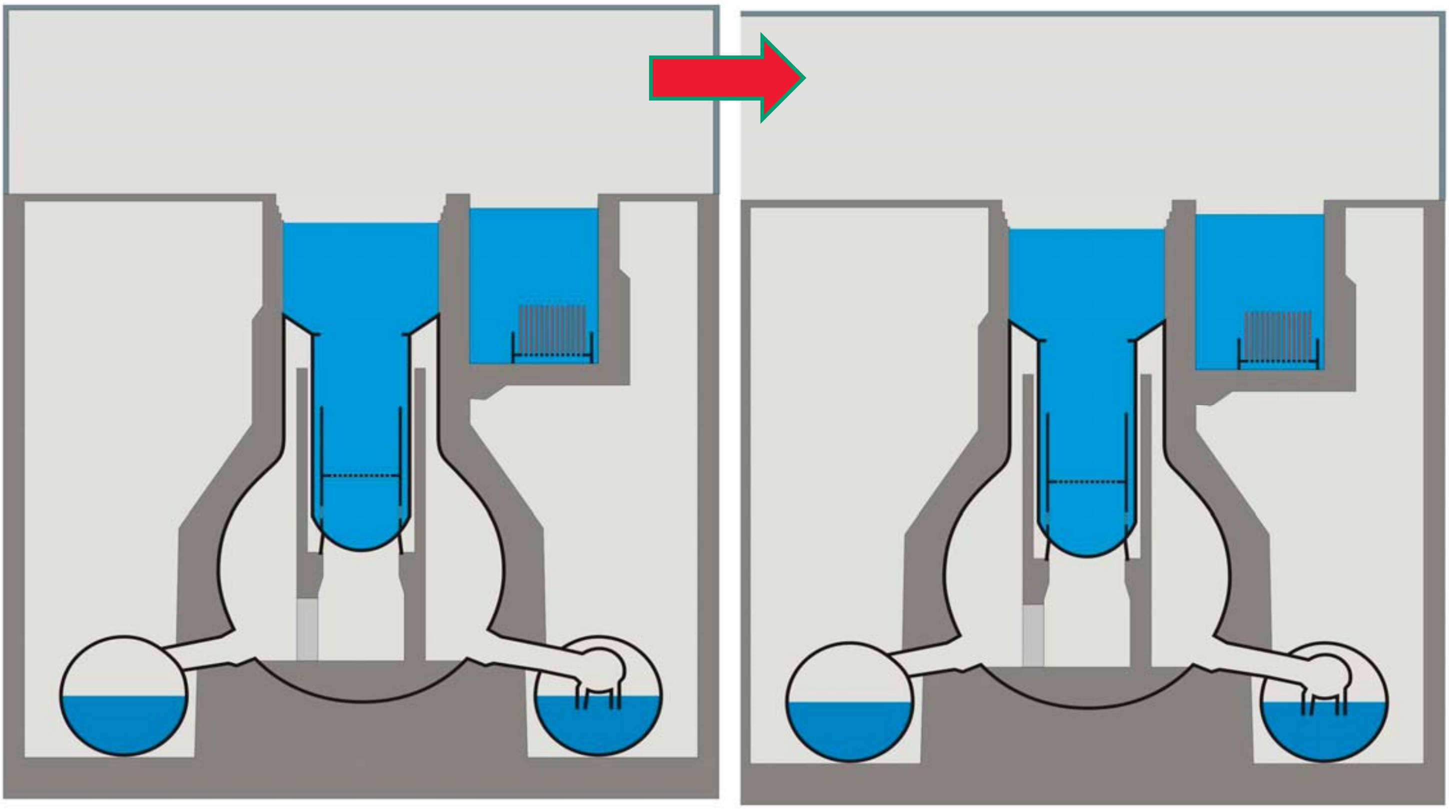
Fukushima Daiichi Accident Process



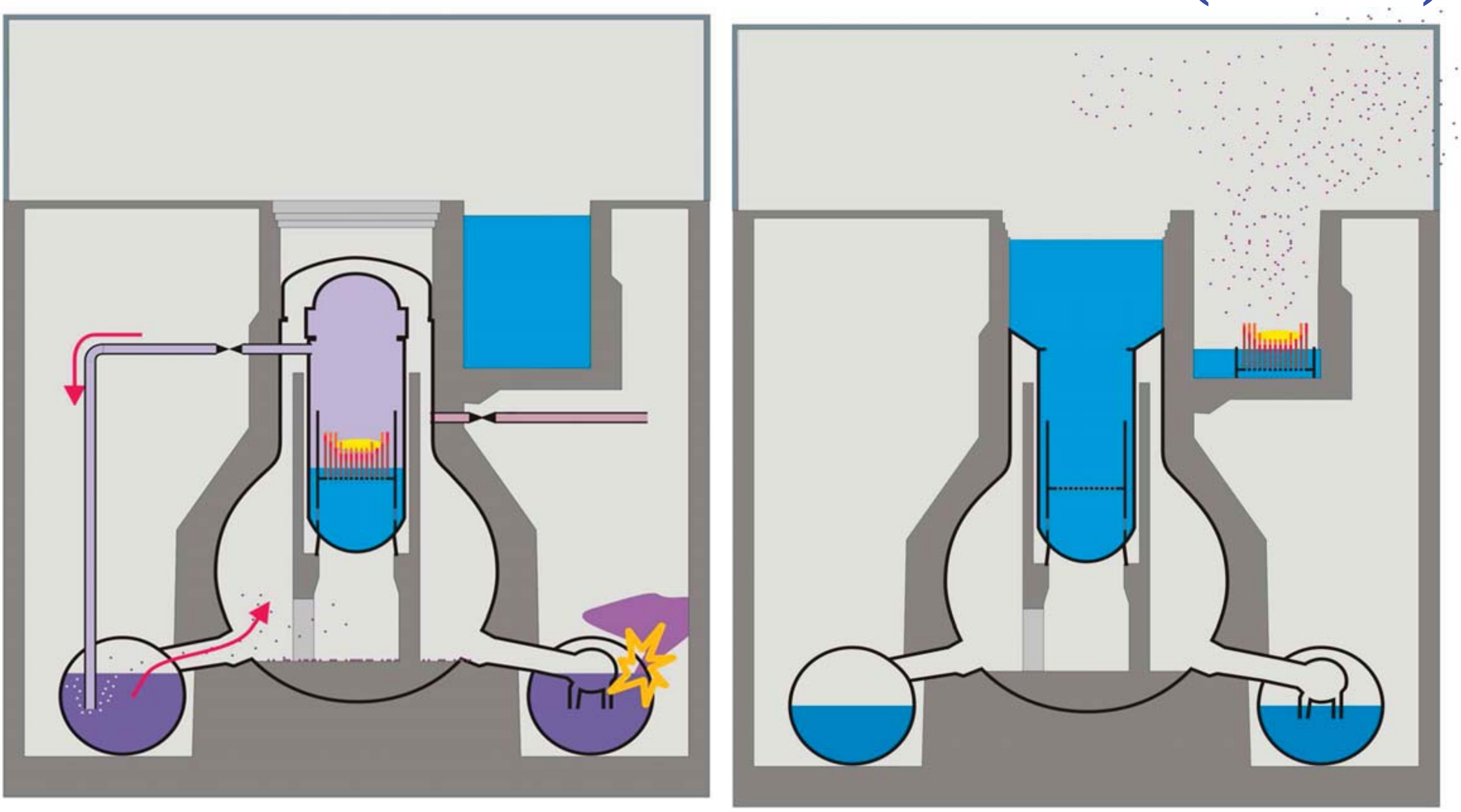
Fukushima Daiichi Accident Process



Fukushima Daiichi Accident Process



Fukushima Daiichi Accident Process(2 and 4)



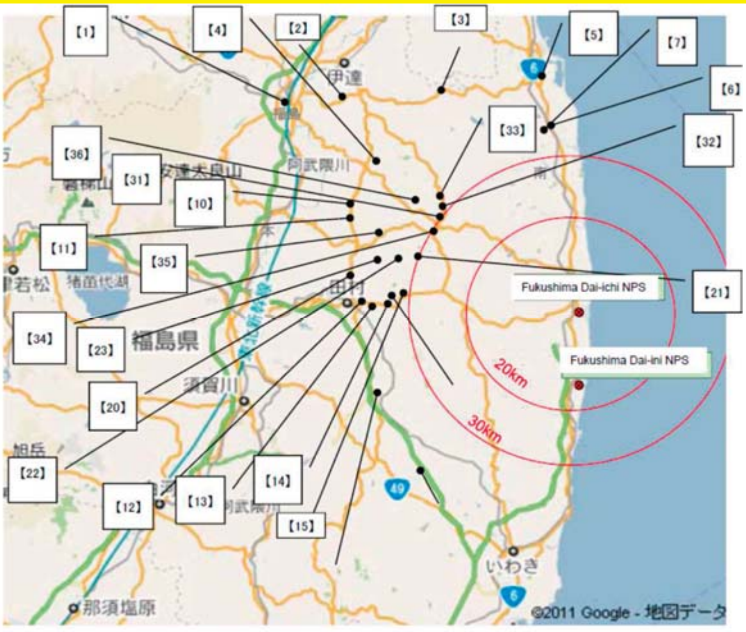
Radiological Impacts

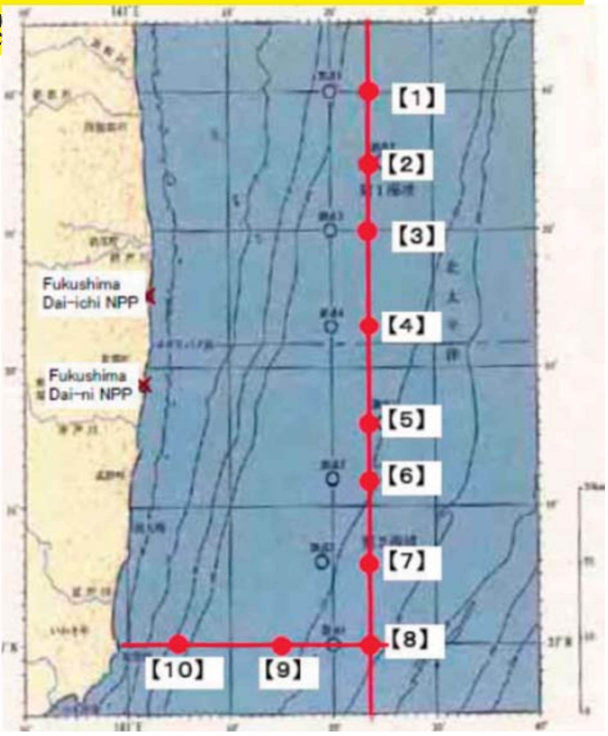
Typical BWR spent fuel pool

- Cooling (3MW)
- Shielding
- Preventing criticality
- About 12m x 12m x 12m
- Concrete thickness is about 1.2 – 2.4 m with a 6 -13 mm steel liner
- Dense fuel racks

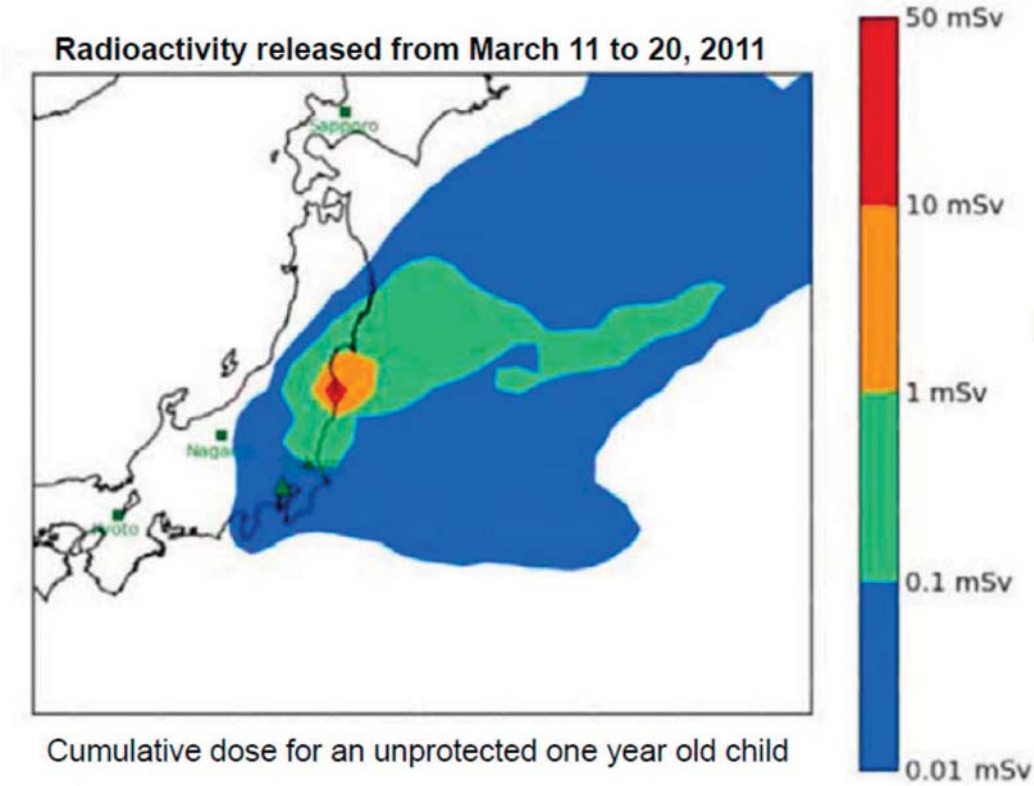
Monitoring locations near Fukushima site

1) Measurement of air dose rate, 2) Measurement of cumulative dose
3) Measurement of radioactive substance concentration in soil
4) Offshore monitoring, 5) Aerial monitoring





Radiology



Extended Tepco Limit: 250 mSv
Initial Tepco Limit: 100 mSv, Maximum Allowed 50 mSv/a,

0.01 mSv: x-ray image in dental care

0.1 mSv: a x-ray image from lungs

2 mSv: flight attendances got from cosmic radiation every year

3.7 mSv: typical background radiation level in EU

20 mSv: dose from computer tomography

50 mSv: dose limit for radiation worker

3000~6000 mSv: fatal dose

Tokyo : 0.1 mSv

Site work and Future plan

Current Priorities

- Six Project Teams have been established under the Integrated Headquarters:
  1) Radiation Shielding/Radioactive Materials Release Reduction
  2) Defuelling /Fuel Transportation
  3) Remote Monitoring/Sampling
  4) Long Term Cooling Circuit Establishment
  5) Contaminated Water Management
  6) Environmental Impact evaluation

- TEPCO's current priorities are on 4) and 5), and on Power System Recovery, which is the basis of all activities.

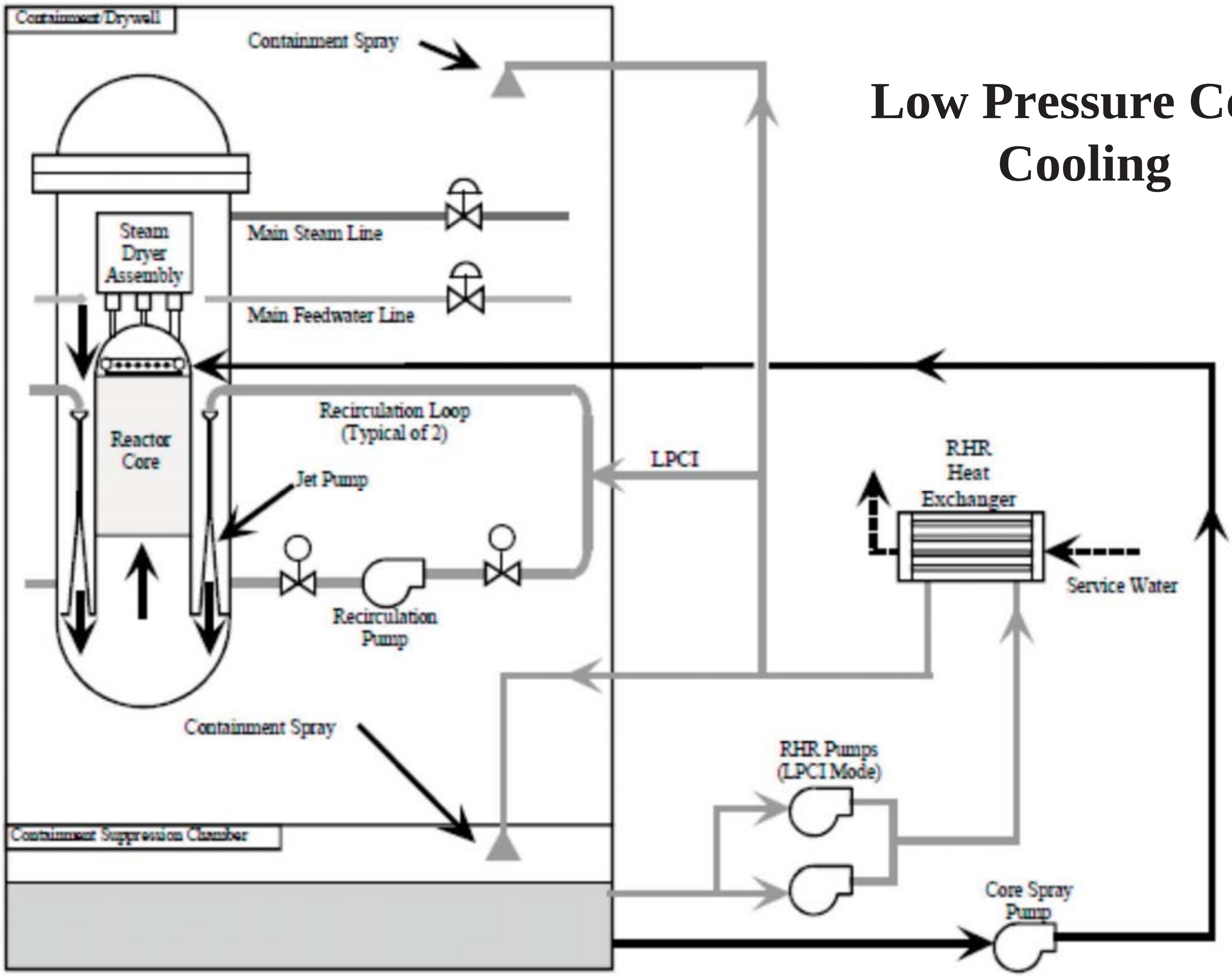
Future Plans

TEPCO Chairman's Announcement on 17 April

- The 1st Stage (3 months):
  – Cool the reactors in a stable manner; and
  – Prevent water with high levels of radioactivity from flowing out of the plant.
- The 2nd Stage (6 to 9 months):
  - Achieve a cold shutdown of the reactors; and
  - Reduce the total amount of radioactive water.

↓

Chief Cabinet Secretary approved the plan as "sufficiently feasible".



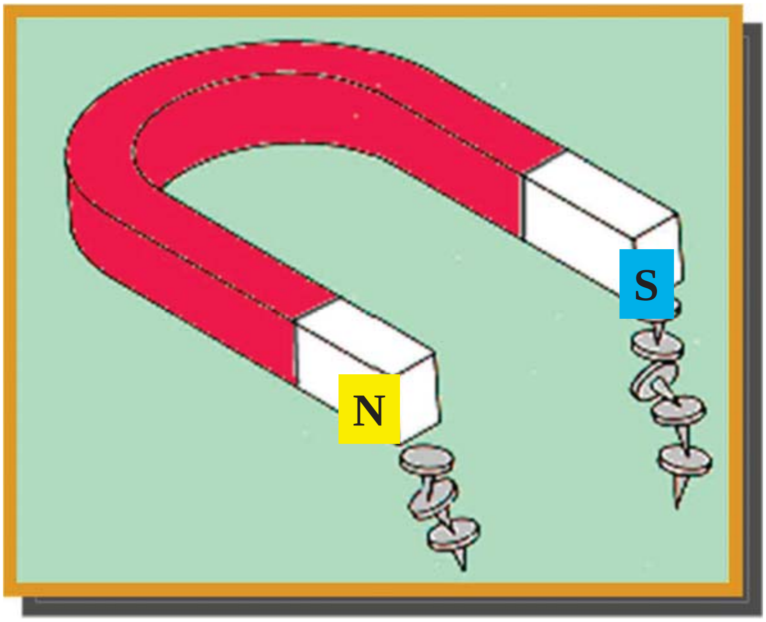
Low Pressure Core Cooling

Safety Assessments as a result of the Fukushima Accident

- Stress Tests Proposed by EU
  - Earthquake, flooding and other external events exceeding design basis
  - Prolonged loss of power and/or ultimate heat sink
  - Combination of above plus multiple units effected simultaneously
  - Accident management, including core melt down and loss of shielding of the spent fuel pools
  - Finalized in 2011

- **Impact of stress tests on additional NDT**
- **Any other developments that may impact on the role of NDT**

Challenges and Opportunities



N and S Poles

- Opposite poles of the magnet
- Do not exist separately.
- Opportunity for some can be a challenge for others,
- Challenge today can become an opportunity tomorrow

All these world challenges will increase the opportunities to strengthen the achievements in Nuclear Power Development