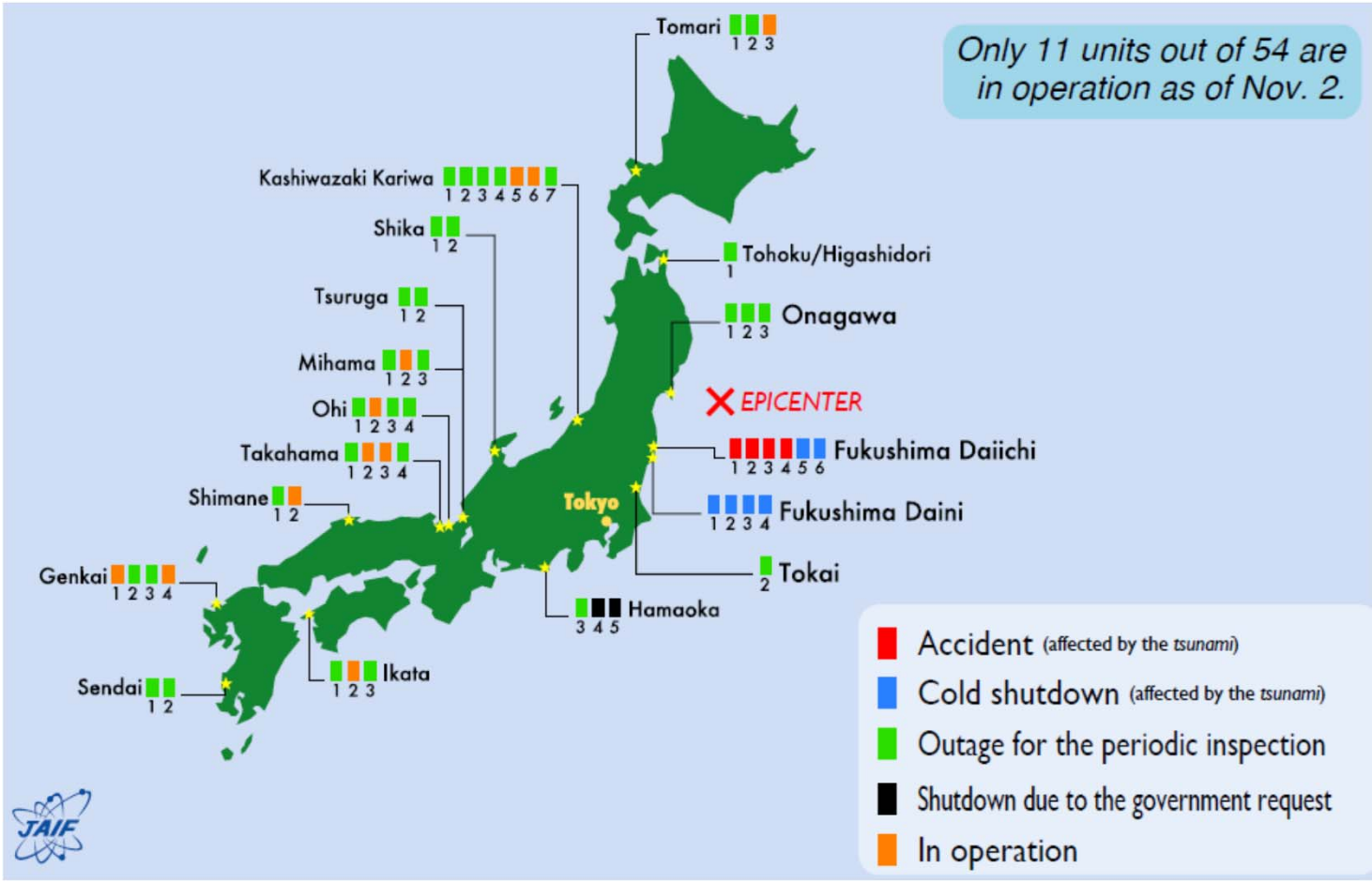
Overview of Fukushima accident

Nov. 9, 2011

Orland, Florida

Nuclear Power Plants in Japan



Japan Atomic Industrial Forum, Inc.

- Tohoku District off the Pacific Ocean Earthquake (2:46pm on Mar. 11, 2011)
- The magnitude was 9.0, the largest in Japan's recorded history.
- 11 reactors located on the Pacific coast were affected, 4 units in Fukushima Dai-ichi NPS fell into the accident
- Only 11 units operating as of Nov. 2. 2011

Summary of Fukushima Dai-ichi NPS

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
	BWR-3	BWR-4	BWR-4	BWR-4	BWR-4	BWR-5
PCV Model	Mark-1	Mark-1	Mark-1	Mark-1	Mark-1	Mark-2
Electric Output (MWe)	460	784	784	784	784	1100
Max. pressure of RPV	8.24MPa	8.24MPa	8.24MPa	8.24MPa	8.62MPa	8.62MPa
Max. Temp of the RPV	302°C	302°C	302°C	302°C	302°C	302°C
Max. Pressure of the CV	0.43MPa	0.38MPa	0.38MPa	0.38MPa	0.38MPa	0.28MPa
Max. Temp of the CV	138°C	138°C	138°C	138°C	138°C	171°C(D/W) 105°C(S/C)
Commercial Operation	1971,3	1974,7	1976,3	1978,10	1978,4	1979,10
Number of DG	2	2 *	2	2 *	2	3*
Electric Grid	275kV x 4				500kV x 2	
Plant Status on Mar. 11	In Operation	In Operation	In Operation	Refueling Outage	Refueling Outage	Refueling Outage

* One Emergency DG is Air-Cooled

Source: Application document of license for establishment of NPP

Main Sequence of the accident of Unit1, Unit2 and Unint3 of Fukushima Dai-ichi NPS

Loss of external power supply due to earthquake

Start-up of emergency power generation

All emergency diesel power generators stopped except for one generator in Unit6 due to tsunami

(11 emergency diesel power generator stopped, and one generator(with air cooling)survived.)

Loss of all AC power supply except for Unit6

(Unit 5 took power supply from Unit6 on 13 March).

Core cooling system not using AC power

(Unit1:IC(isolation condenser), Unit2 (RCIC(reactor core isolation cooling system), Unit3: RCIC and HPCI (high pressure core injection system)

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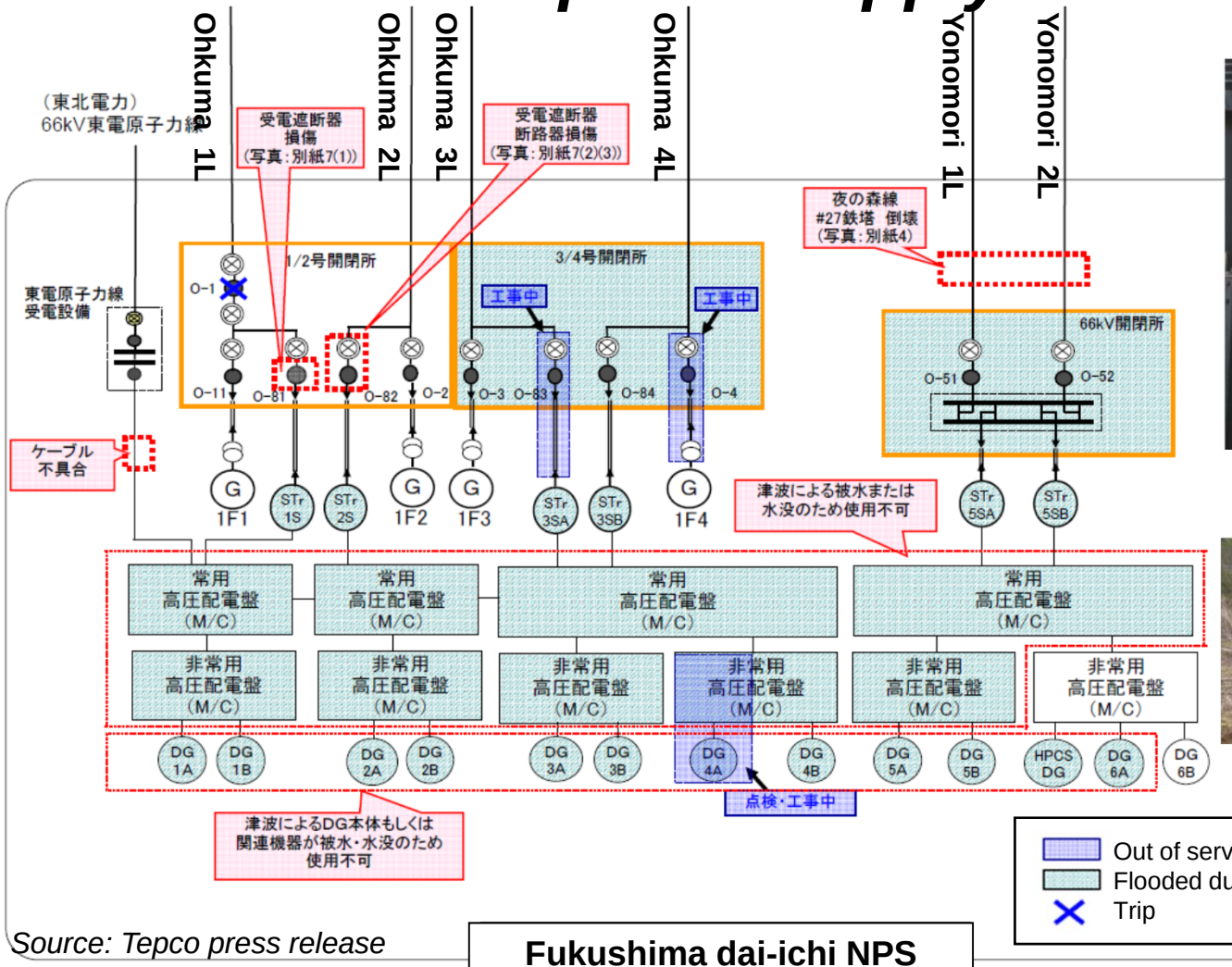
Water injection from a fire extinguishing line

(Unit1:pure water->sea water, Unit2: sea water Unit3: pure water-> sea water)

During this time without cooling, the fuel was exposed and core melt started, generating hydrogen

Loss of external power supply in units 1-6



Breaker damaged

Collapsed pylon

Source: Tepco press release

Fukushima dai-ichi NPS

***TEPCO Nuclear Line* : Tripped due to cable damage by earthquake**

***Ohkuma 1L,2L* : Breakers broke due to the earthquake**

***Ohkuma 3L* : Under modification**

***Ohkuma 4L* : The failure cause is being investigated**

Yonomori 1L,2L :Pylons collapsed due to landslide

All the six external power supply sources were lost because of the earthquake.

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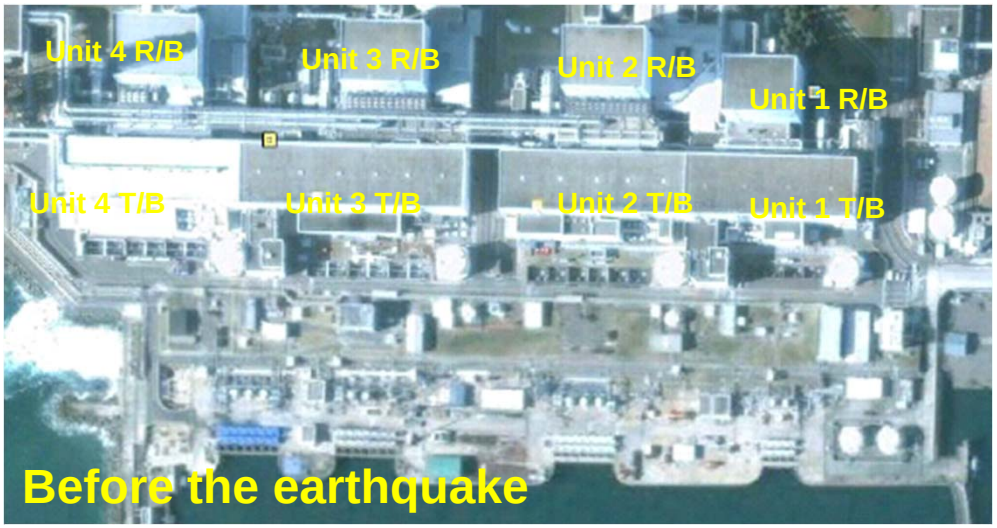
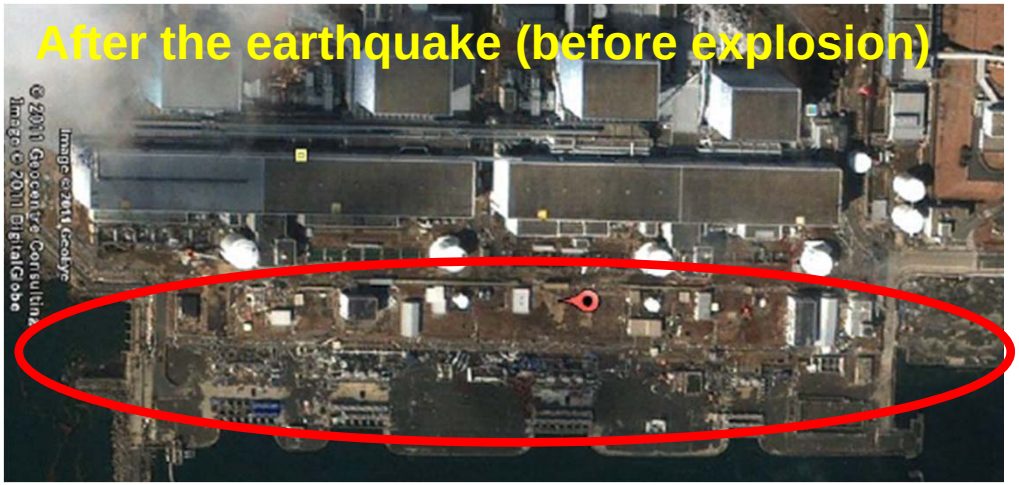
Tsunami getting over seawall

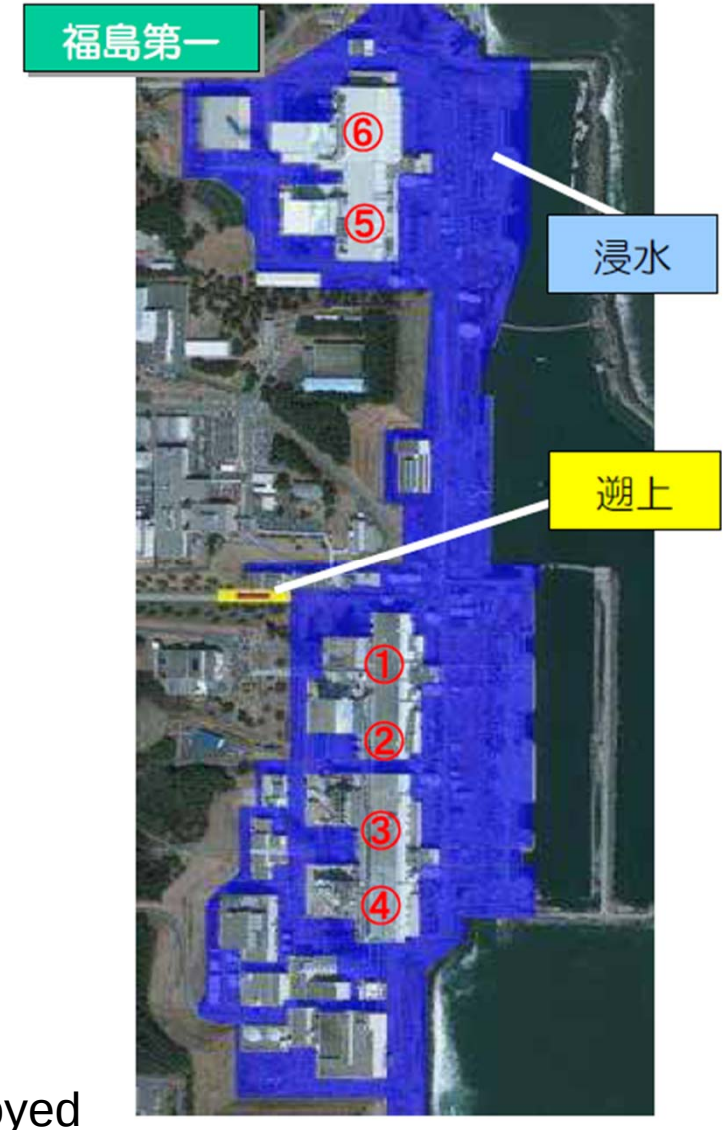
The first major tsunami reached about 49 minutes later after the earthquake

Satellite view of Fukushima Dai-ichi NPS





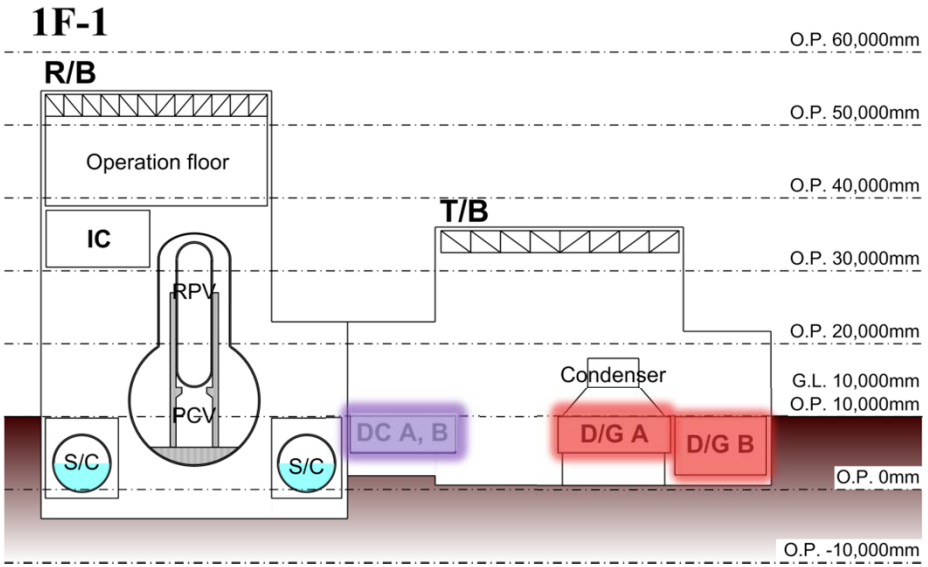
Source: Google Earth

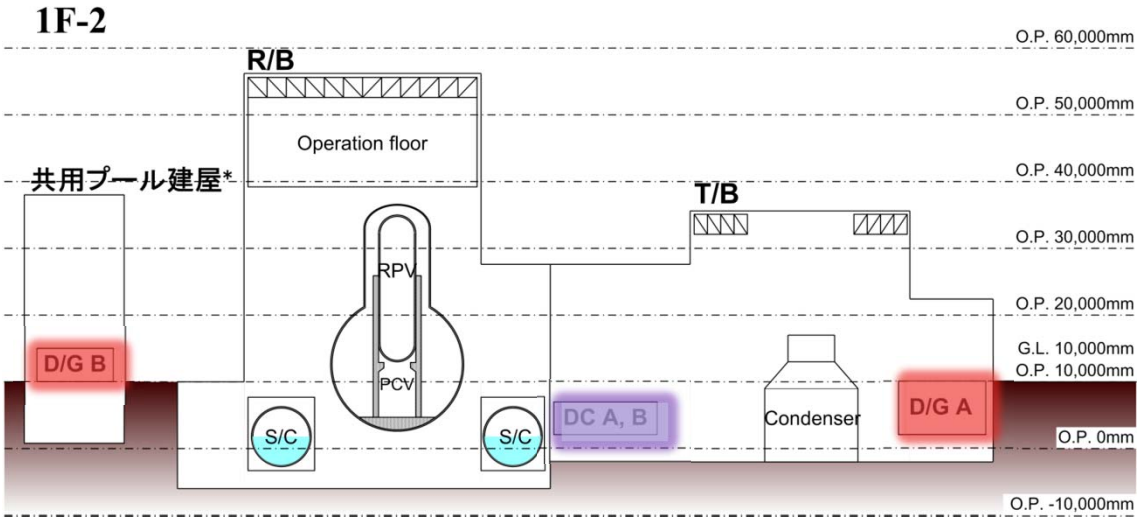


Flooded area by tsunami

- Many components installed near the sea were destroyed
- Seawater pumps for ultimate heat sink and fuel tanks for emergency diesel generators were washed away

Elevation of DGs and DC batteries

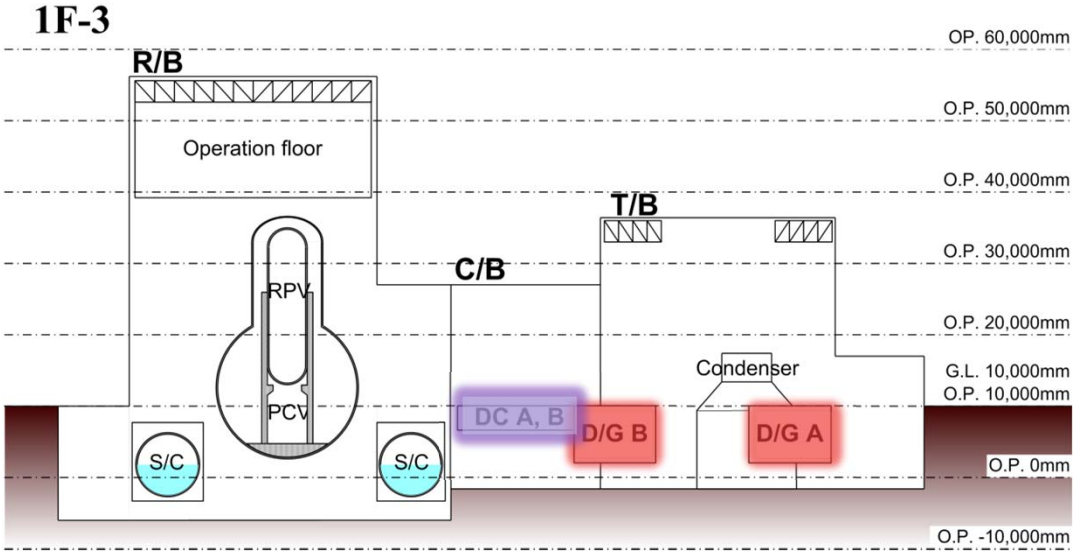


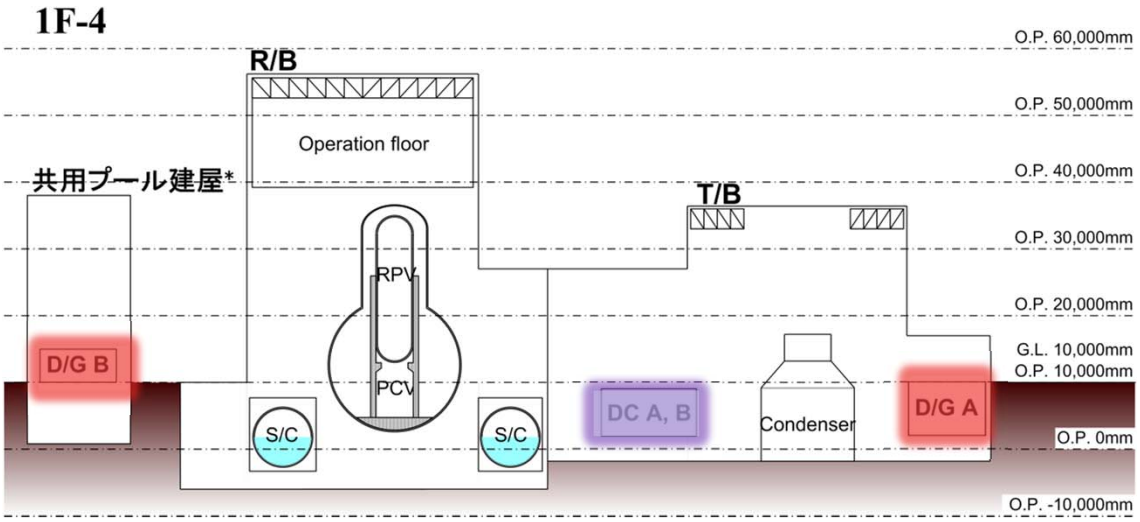


Unit 1, 2, 3 and 4

- Elevation of the ground is 10m
- The Emergency Diesel Generators and Metal Clad Switchgear installed in the basement floor of the reactor buildings and the turbine buildings were flooded

Elevation of DGs and DC batteries





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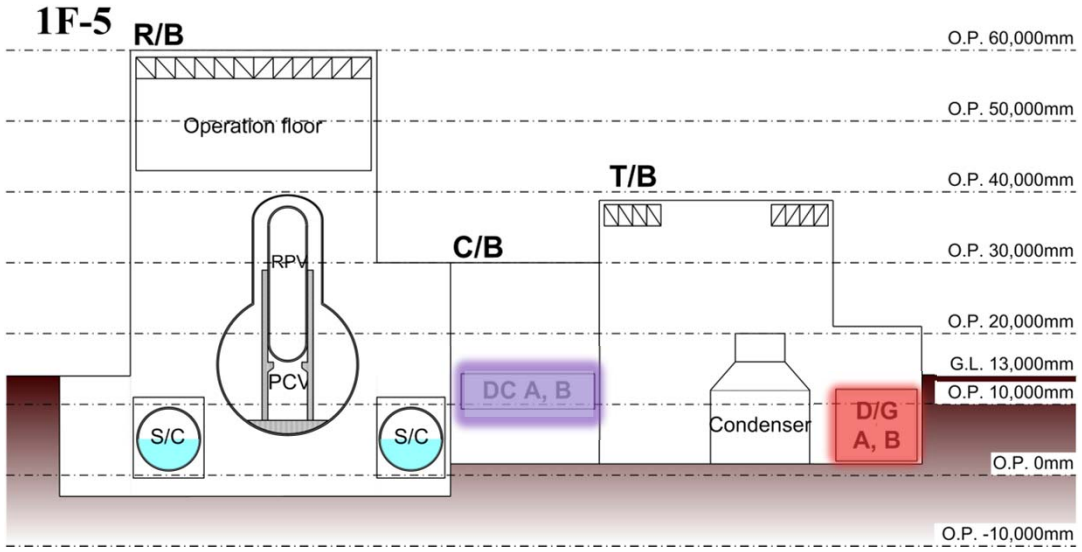

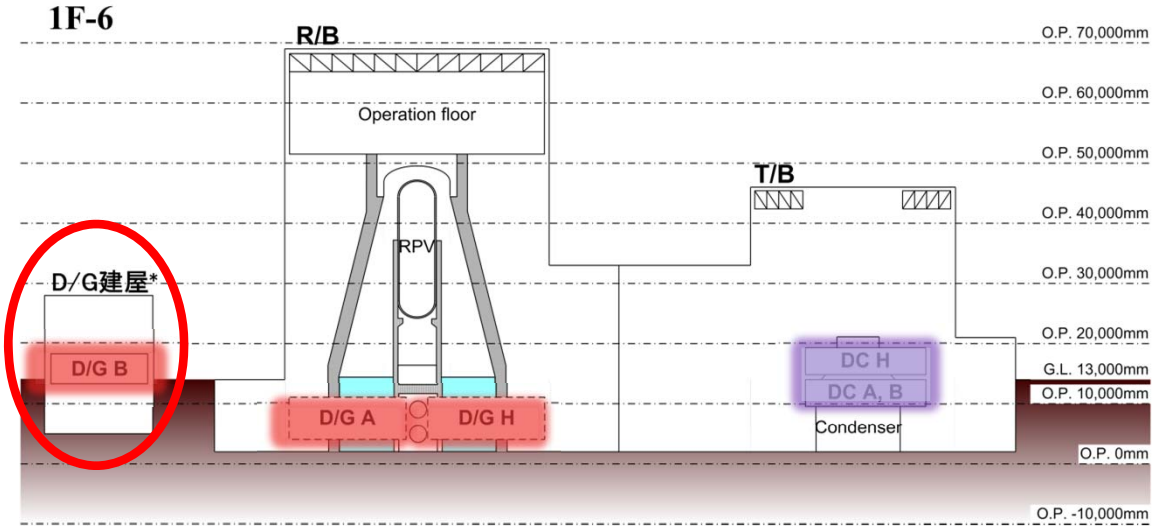

Unit 5 & 6

- Elevation of the ground is 13m
- One air-cooled EDG of Unit 6 which is located on the ground level and Metal Clad Switchgear were not lost
- Temporary sea water pump installed after the earthquake was operable, making use of power source from survived EDG

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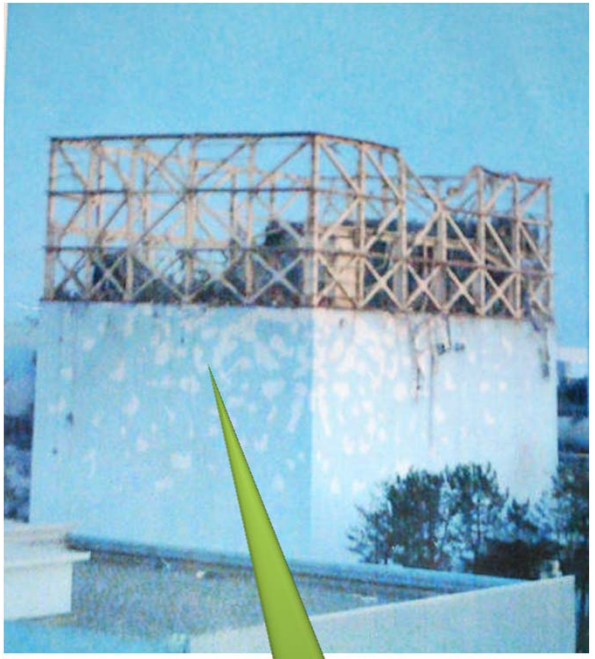
Damage of reactor buildings



Unit 1

Unit 3

Unit 4

Current status estimation of the NPS

	Unit 1	Unit 2	Unit 3	Unit 4
Fuel in RPV	**Damaged** **Fuel was melted**	**Damaged** **Fuel was melted**	**Damaged** **Fuel was melted**	**-**
RPV	**There may be rupture at the bottom head**	**There may be rupture at the bottom head**	**There may be rupture at the bottom head**	**Not damaged**
PCV	**Leak path may exist**	**There may be rapture at the S/P**	**Leak path may exist in D/W**	**Not damaged**
Reactor Bldg.	**Hydrogen explosion occurred on March 12**	**The blow-out panel was opened due to the explosion in unit 3**	**Hydrogen explosion occurred on March 14**	**Building damage was identified on March 15**

Identified 28 lessons in Japanese government report

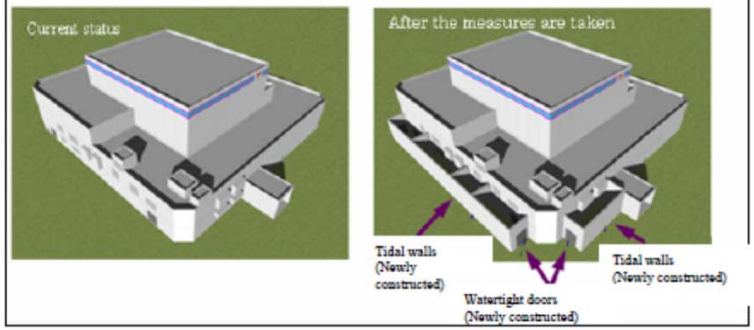
Category	Items
Strengthen preventive measures against a severe accident	(1) Strengthen measures against earthquakes and tsunamis (2) Ensure power supplies (3) Ensure robust cooling functions of reactors and PCVs (4) Ensure robust cooling functions of spent fuel pools (5) Thorough accident management (AM) measures (6) Response to issues concerning the siting with more than one reactor (7) Consideration of NPS arrangement in basic designs (8) Ensuring the water tightness of essential equipment facilities
Enhancement of response measures against severe accidents	(9) Enhancement of measures to prevent hydrogen explosions (10) Enhancement of containment venting system (11) Improvements to the accident response environment (12) Enhancement of the radiation exposure management system at the time of the accident (13) Enhancement of training responding to severe accidents (14) Enhancement of instrumentation to identify the status of the reactors and PCVs (15) Central control of emergency supplies and equipment and setting up rescue team
Enhancement of nuclear emergency responses	(16) Responses to combined emergencies of both large-scale natural disasters and prolonged nuclear Accident (17) Reinforcement of environmental monitoring (18) Establishment of a clear division of labor between relevant central and local organizations (19) Enhancement of communication relevant to the accident (20) Enhancement of responses to assistance from other countries and communication to the international community (21) Adequate identification and forecasting of the effect of released radioactive materials (22) Clear definition of widespread evacuation areas and radiological protection guidelines in nuclear emergency
Reinforcement of safety infrastructure	(23) Reinforcement of safety regulatory bodies (24) Establishment and reinforcement of legal structures, criteria and guidelines (25) Human resources for nuclear safety and nuclear emergency preparedness and responses (26) Ensuring the independence and diversity of safety systems (27) Effective use of probabilistic safety assessment (PSA) in risk management
Thoroughly instill a safety culture	(28) Thoroughly instill a safety culture

Outline of safety measures for other NPPs considering Fukushima accident

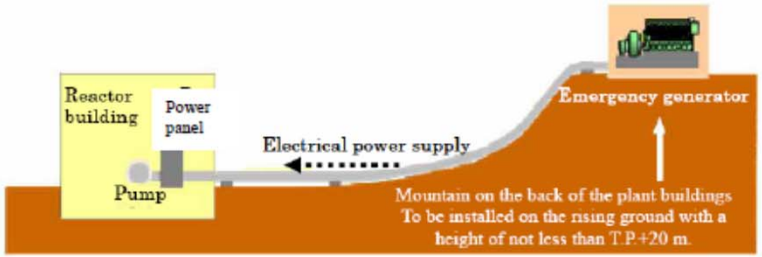
	Short term (finished)	Mid-term/Long-term (in 2-3years)
Emergency Safety Measures (instructed Mar. 30, 2011)	-Deployment of power-supply car -Deployment of pumping vehicle -Installation of fire hose	-Construction of seawalls -Installation of watertight doors -Preparation of spare motor for sea water pump -Installation of flood barrier -Installation of air-cooled large generator
Countermeasures to enhance the reliability of external power supply (instructed Apr. 15, 2011)	-Mutual connection of emergency bus among units for sharing EDGs	-Inspection and seismic strengthening of pylons of external power transmission line -Seismic strengthening of switchyard
Countermeasures for severe accident (instructed Jun. 7, 2011)	-Ensuring the function of control room air emergency recycle system -Ensuring measures for discharging hydrogen	-Passive hydrogen recombiner (PWR) -Installing hydrogen vent system and hydrogen detector (BWR)

An example of tide embankment walls (Kashiwazaki-Kariwa)

As measures for preventing tsunami from invading the reactor building, tidal walls and other measures are to be installed in front of the reactor building where components important to safety including power systems, standby diesel generators are installed to ensure safety of the power plant.



Installation of EDG at higher elevation

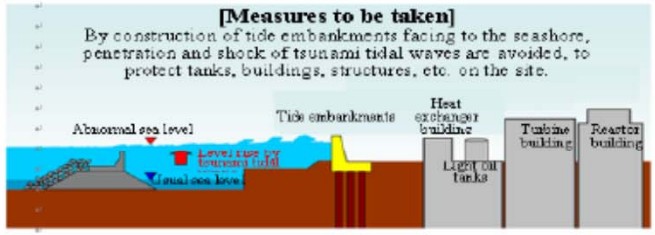


[Image drawing of power supply by emergency generator]

Construction of sea wall (Kashiwazaki-Kariwa NPS)

[Measures to be taken]

By construction of tide embankments facing to the seashore, penetration and shock of tsunami tidal waves are avoided, to protect tanks, buildings, structures, etc. on the site.



[Image drawing of improvement against tsunami tidal waves]

[Image drawing of tide embankments]

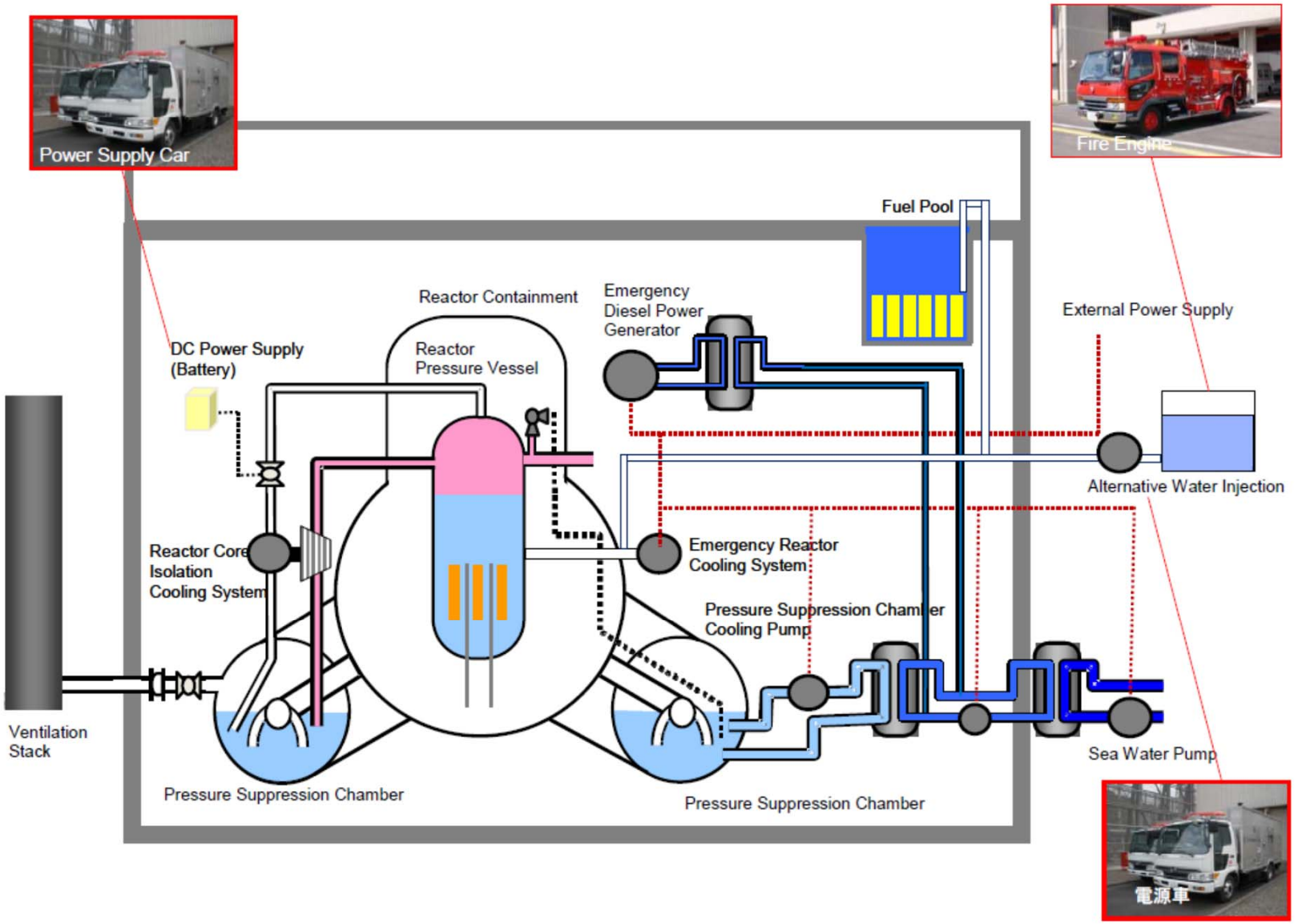
Watertight door (Ikata NPS)

Existing door

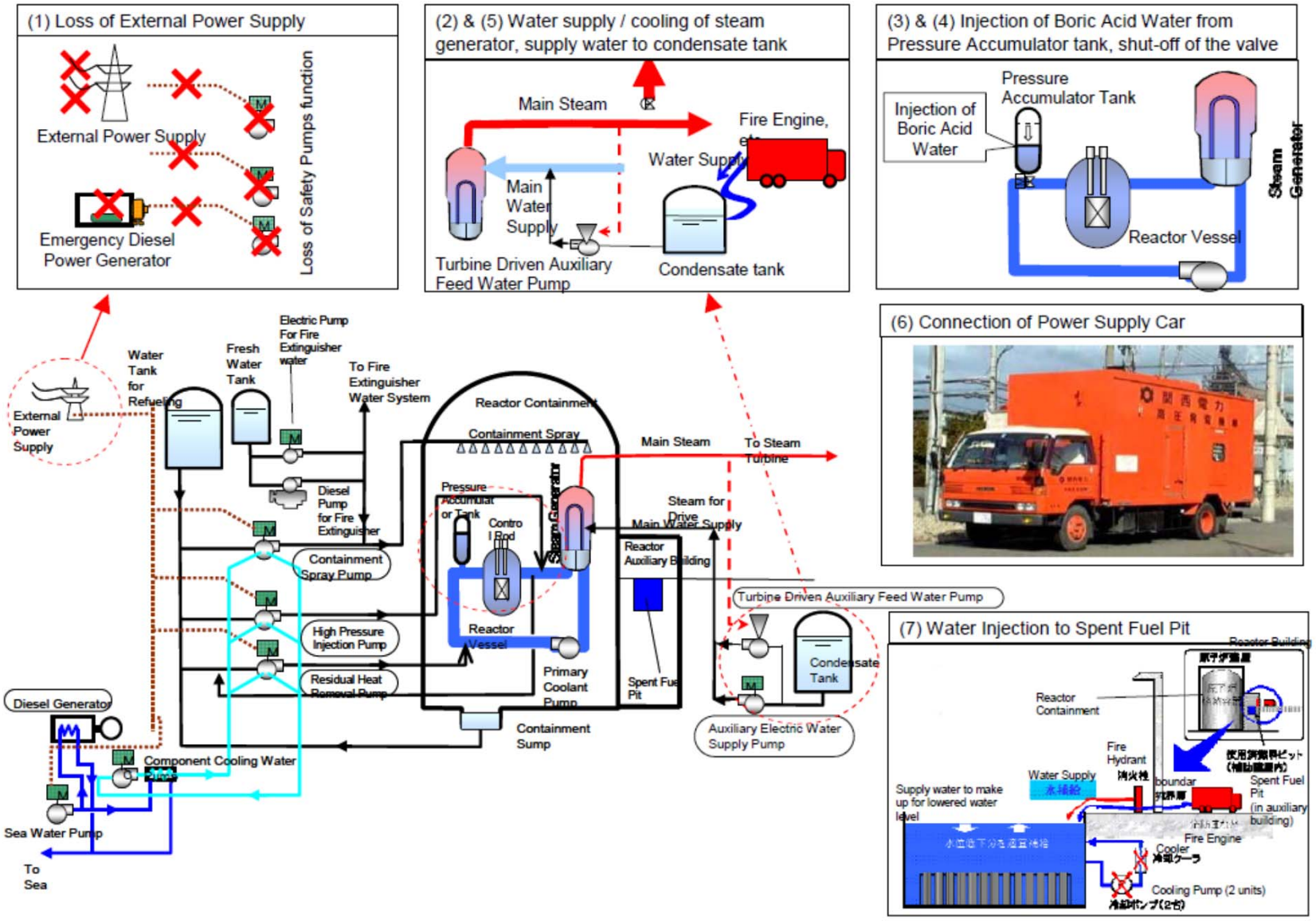
Watertight door (example)

Source: NISA press release

Series of Events and Countermeasures for Tsunami for BWR (The case of loss of all AC power)



Series of Events and Countermeasures for Tsunami for PWR (The case of loss of all AC power)



Impact on EQ ?

- Electrical and I&C components are thought to have functioned appropriately until SBO
- Instrumentation of RPV (water gauge, pressure gauge) didn’t function correctly under the severe accident environment.
  - A research on instrumentation equipment for severe accident environment is under planning
- Details of other environmentally qualified components are still not clear because it is difficult to access them due to high radiation
- Further investigation is needed for reviewing regulation and standards related to EQ