The Great East Japan Earthquake and Current Status of Nuclear Power Stations

東京電力 TEPCO

Table of contents

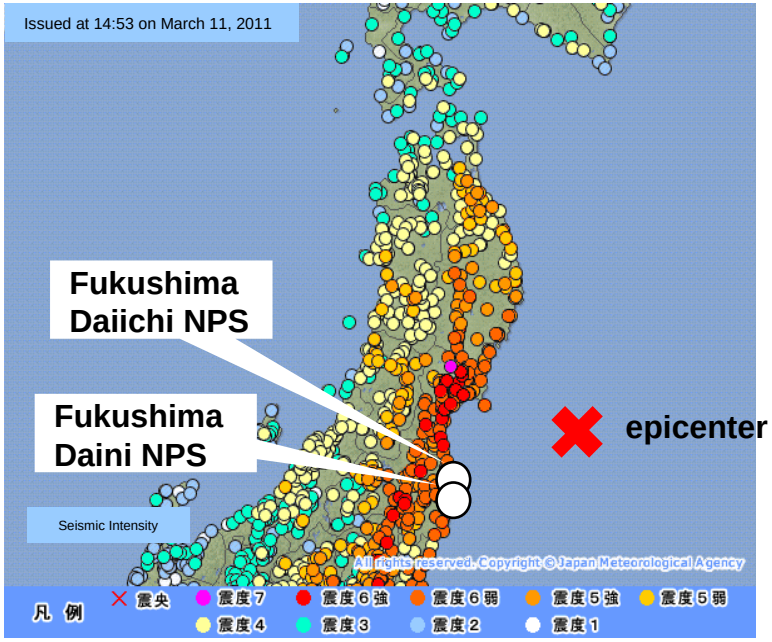
1. Overview of the Earthquake & Tsunami and Nuclear Accident

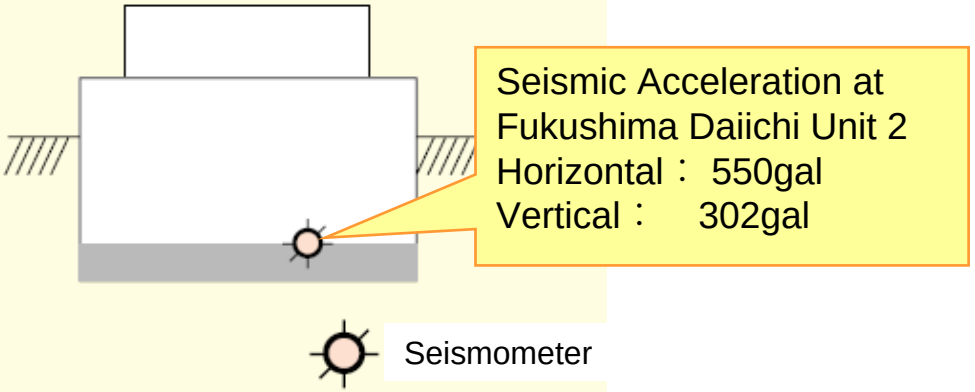
(Updated January 27, 2012)

Tohoku Pacific Ocean Earthquake

- **Time:** 2:46 pm on Fri, March 11, 2011.
- **Place:** Offshore Sanriku coast (northern latitude of 38 degrees, east longitude of 142.9 degrees), 24km in depth, Magnitude 9.0
- **Intensity:** **Level 7** at Kurihara in Miyagi prefecture
  Upper 6 at Naraha, Tomioka, Okuma, and Futaba in Fukushima pref.
  Lower 6 at Ishinomaki and Onagawa in Miyagi pref., Tokai in Ibaraki pref.
  Lower 5 at Kariwa in Niigata pref.
  Level 4 at Rokkasho, Higashidori, Mutsu and Ohma in Aomori pref., Kashiwazaki in Niigata pref.

【Epicenter】





* gal: a unit of acceleration defined as cm/s².

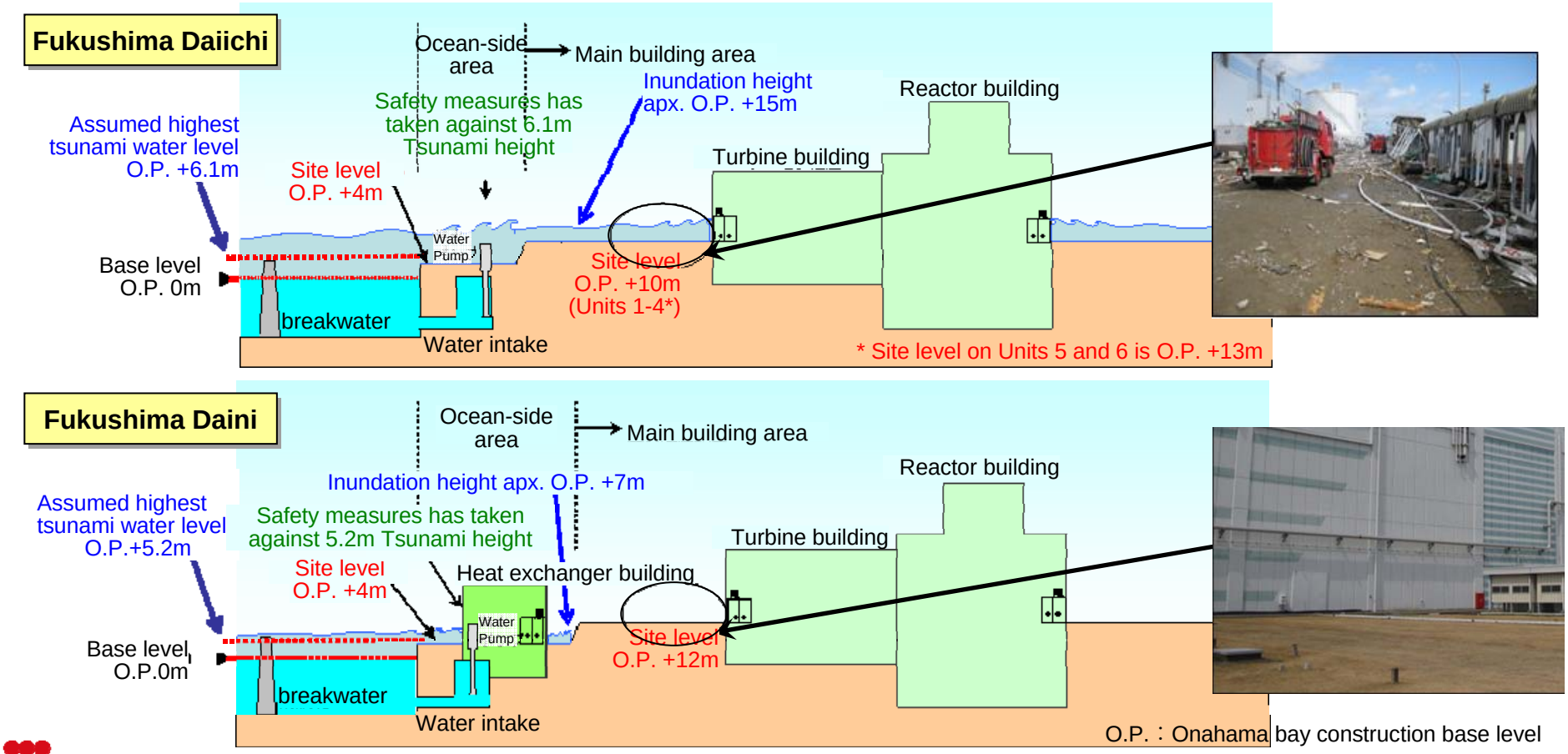
Seismic Observed Data

Comparison between Basic Earthquake Ground Motion and the record of intensity

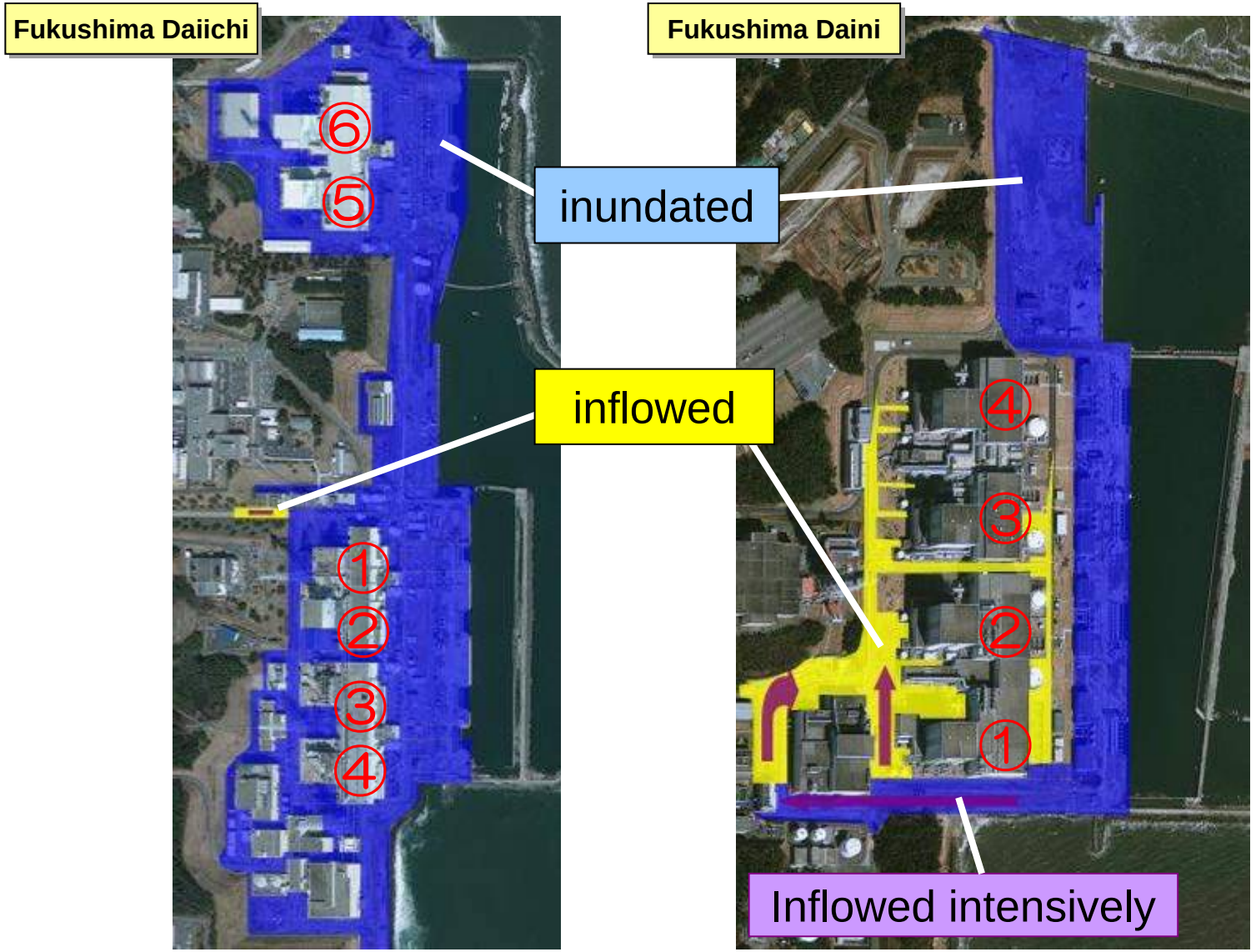
Observation Point (The lowest basement of reactor buildings)		Observed data: Maximum Response Acceleration (gal)			Maximum Response Acceleration against Basic Earthquake Ground Motion (Gal)		
		Horizontal (N-S)	Horizontal (E-W)	Vertical	Horizontal (N-S)	Horizontal (E-W)	Vertical
Fukushima Daiichi	Unit 1	460	447	258	487	489	412
	Unit 2	348	550	302	441	438	420
	Unit 3	322	507	231	449	441	429
	Unit 4	281	319	200	447	445	422
	Unit 5	311	548	256	452	452	427
	Unit 6	298	444	244	445	448	415
Fukushima Daini	Unit 1	254	230	305	434	434	512
	Unit 2	243	196	232	428	429	504
	Unit 3	277	216	208	428	430	504
	Unit 4	210	205	288	415	415	504

Height of Tsunami

- We assessed the impact of tsunami utilizing the latest bathymetry data, etc. in 2009, and took measures against tsunami, whose height is O.P. +6.1m at Fukushima Daiichi and O.P. +5.2m at Fukushima Daini.
- Inundation height was approximately O.P. +15m at Fukushima Daiichi and approximately O.P. +7m at Fukushima Daini.
- **Accordingly, we have confirmed that the impact of Tsunami (water level and inundated area) was relatively larger in Fukushima Daiichi than Fukushima Daini.**



Inundated and Inflowed Area at Fukushima Daiichi and Daini Site



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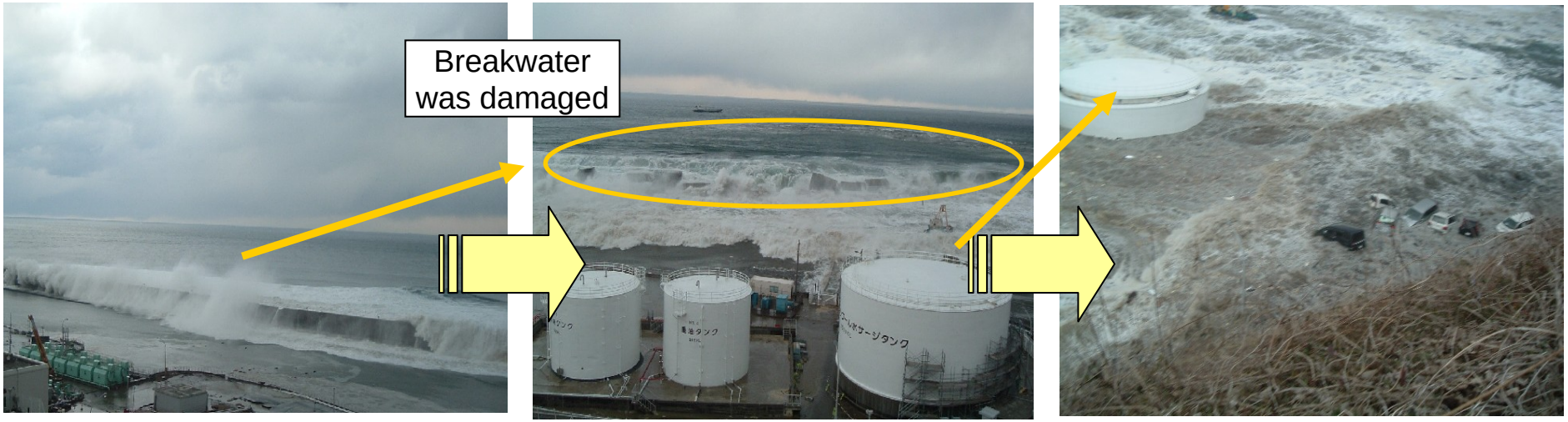
Fukushima Daiichi being struck by the tsunami (1)

Taken from near the south side of Unit 5, looking east



Taken from radwaste building 4th floor, looking north

Tank　Height about 5.5m
（height of ground : O.P.＋10m）

Submerged tank

O.P.：Onahama bay construction base level

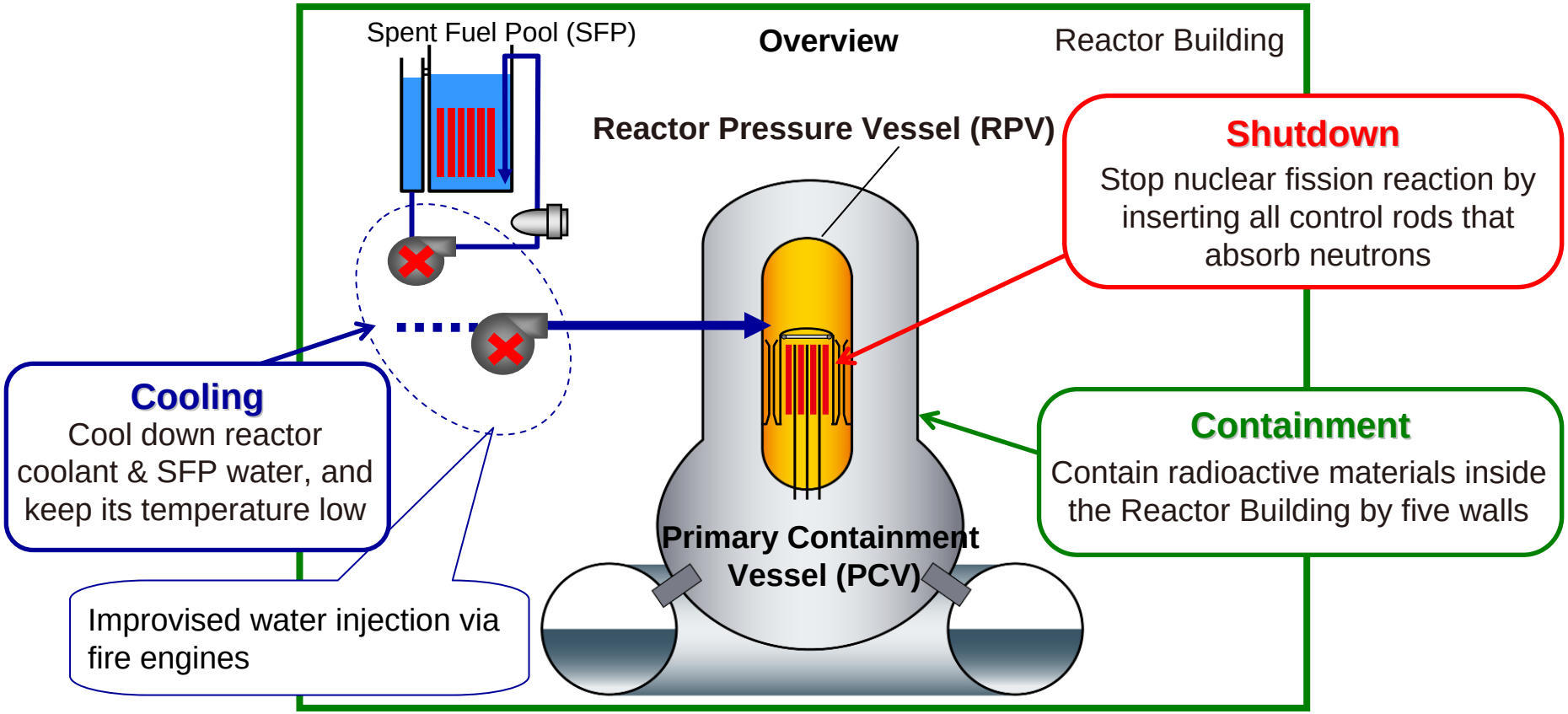
Fukushima Daiichi being struck by the tsunami (2)

Unit 3 Sea Pump Area

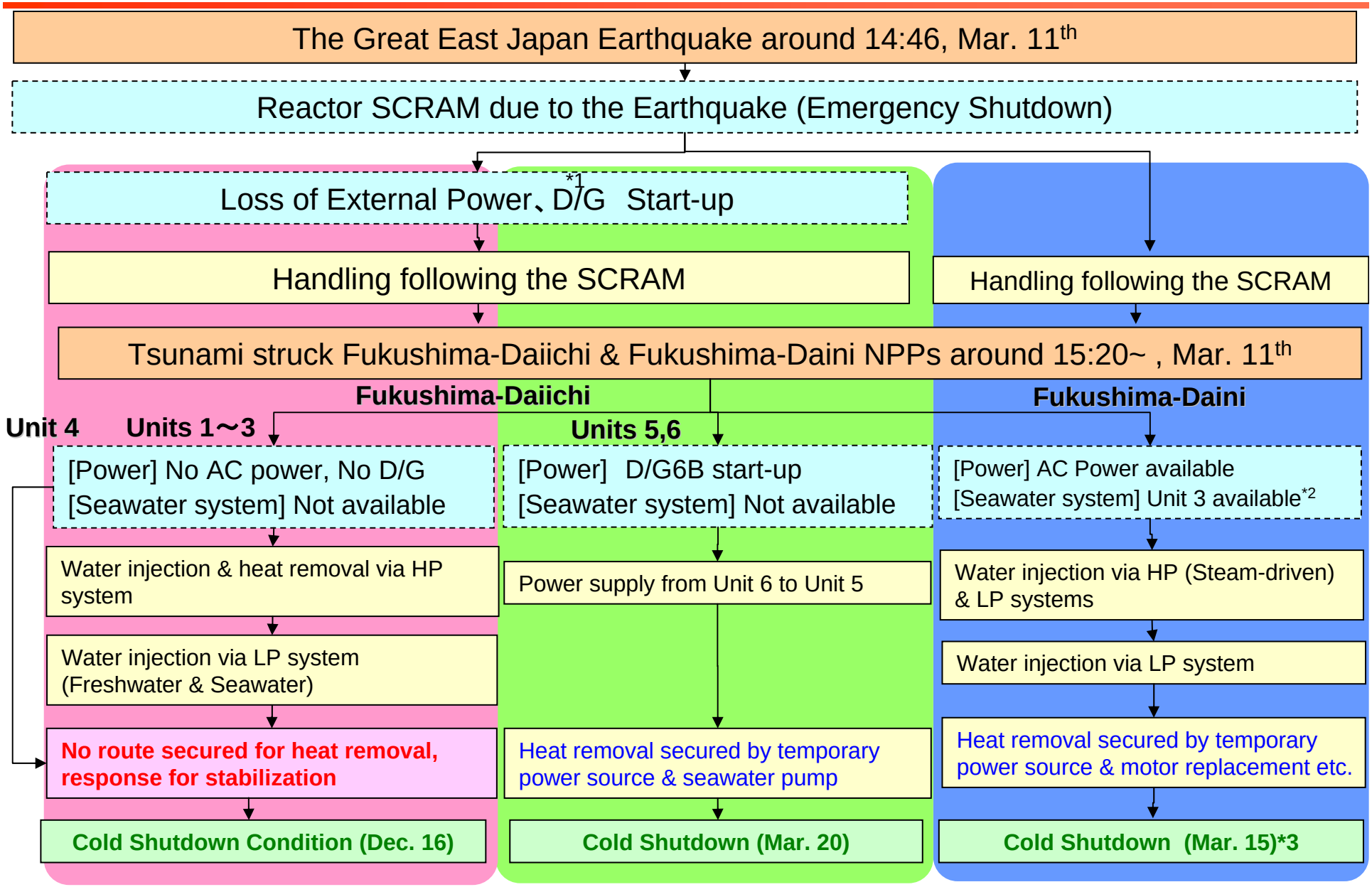
Unit 5,6 Intake Screen Area

Impacts for Safety Function

- Nuclear fission chain reaction was stopped by automatic shutdown with all control rods inserted at the same time of the earthquake
- Off-site power was lost due to the impact of the earthquake, etc. and emergency generator started up. However emergency power became unavailable due to flooding by the tsunami except for Unit 6.
- Finally the “Cooling” function for the reactors and spent fuel pools of Units 1 to 4 were lost due to the loss of AC power supply and seawater systems, etc. caused by the tsunami.
- Given that high level contaminated water has been found in turbine buildings, “Containment” function is presumed to be impaired.



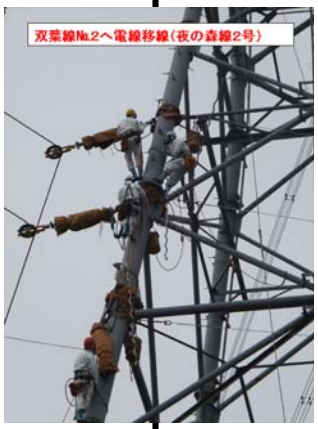
Progress towards Cold Shutdown Status in each Unit (Outline)



*1 D/G：Emergency Diesel Generator　*2 RHR Seawater System　*3 Fukushima-Daini Emergency State was Lifted on Dec.26th

Chronology of Fuel Cooling (Fukushima Daiichi)

SF Pool | Reactor | Power Supply

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5-6	Common SF Pool
March 11, 14:46	**Earthquake**					
11th	11 Cooling by injecting fresh water				One D/G survived	
12th	12 Start injecting sea water		13 Start injecting sea water			
13th						
14th		14 Start injecting sea water				
17th			17 Start watering (sea water, fresh water)	20 Start watering (sea water, fresh water)	20 Reactor cooling shutdown	
20th		20 Start injecting sea water				
21th					20～21 Switched from D/G to offsite power	21 Fresh water injection
22th			22 Recover Main Control Room lighting			
23th	24 Recover Main Control Room lighting					24 Received electricity from offsite
24th		26 Recover Main Control Room lighting				
25th	25 Switch from sea water to fresh water		25 Switch from seawater to fresh water			24 Start cooling by existing system
26th		26 Switch from sea water to fresh water		29 Recover Main Control Room lighting		
27th			29 Switch from seawater to fresh water			
31st	31 Start watering fresh water	29 Switch from sea water to fresh water		30 Switch from sea water to fresh water		

Fukushima-Daiichi Accident response - Main Control Room

On-site testimony：

"When the power source failed, we felt completely helpless."

"Heated discussion broke out among the operators regarding whether it was important to remain in the control room without power and lights."

"I bowed to ask them to remain here and somehow they agreed."

Connecting commuting car batteries into necessary instruments

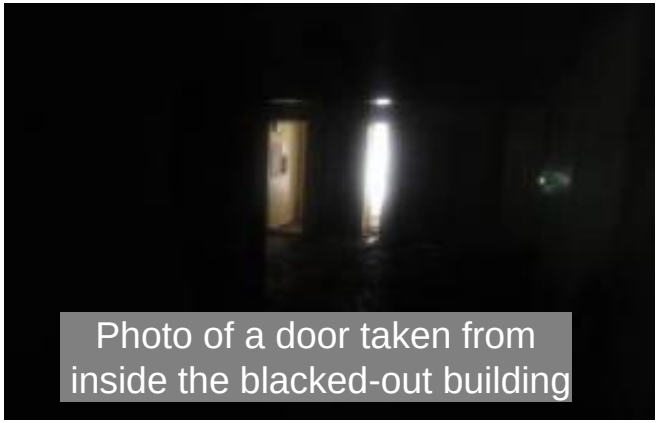
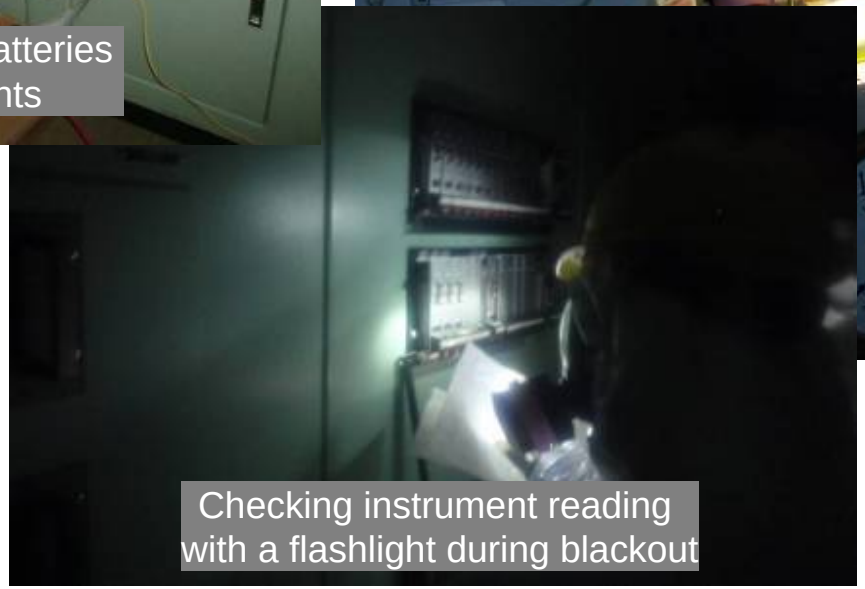


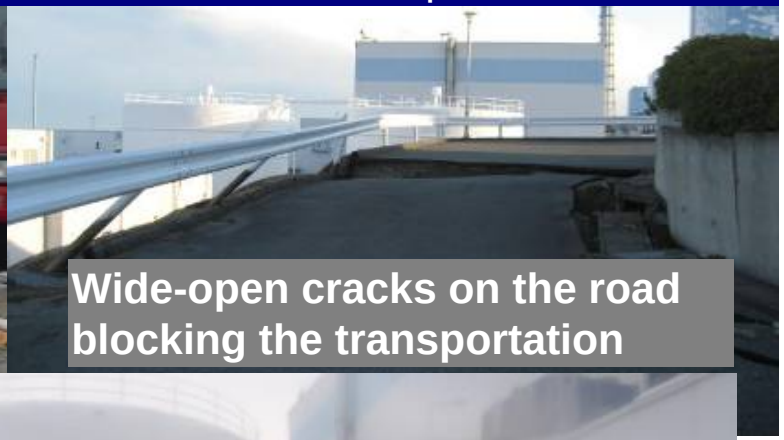
Photo of a door taken from inside the blacked-out building



Checking instrument reading with a flashlight during blackout

Fukushima-Daiichi Accident Response – Water Injection

On-site testimony:
"As the tremendous aftershocks occurred, with our full face masks still on, we frantically headed off to the upper ground."
"While laying down cables at night, entailing the search of penetrations and terminal treatment work, we were terrified that we might be electrocuted due to the outside water puddles."



Wide-open cracks on the road blocking the transportation

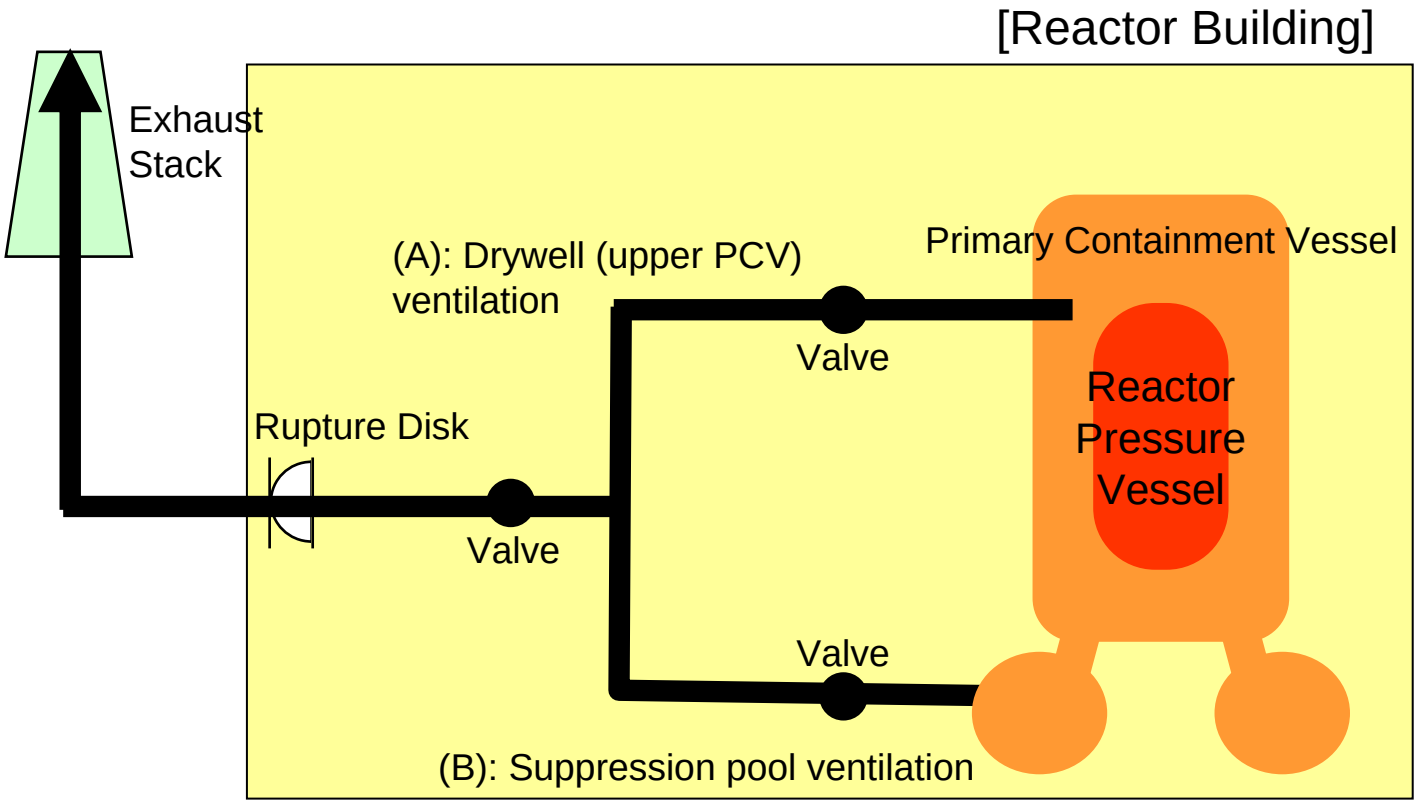
Fire truck and scattered driftage

Heavy oil tank washed away by the tsunami and blocking the road

Measure to Decrease Pressure of PCV (Ventilation)

- Implemented ventilation to reduce the pressure of Primary Containment Vessel (PCV) in Units 1-3 to prevent PCV from getting over pressured.

Worker's testimony：
"When I climbed on top of the torus to reach for the high positioned valve, the soles of my boots quickly melted away."



INES (International Nuclear Event Scale) Evaluation

- On April 12, Nuclear and Industrial Safety Agency released as below:
  - Tentatively assigned Level 7 on INES for the accident at Fukushima Daiichi Nuclear Power Station.
  - In this regard however, the amount of released radioactive materials is one-tenth as much as the accident at Chernobyl.
- We are wrestling with hurdles such as cooling the reactors or reducing the diffusion of radioactive materials in order to resolve the situation as soon as possible. We will commit in full force to resolve this situation along with close coordination and cooperation with the national and local governments.

Data released on April 12

	Estimated release from Fukushima Daiichi		(Reference) Release from Chernobyl
	by NISA*	by Nuclear Safety Commission	
Iodine 131 (a)	130 thousands T Bq (1.3×10^{17}Bq)	150 thousands T Bq (1.5×10^{17}Bq)	1,800 thousands T Bq (1.8×10^{18}Bq)
Cesium 137	6 thousands T Bq (6.1×10^{15}Bq)	12 thousands T Bq (1.2×10^{16}Bq)	85 thousands T Bq (8.5×10^{16}Bq)
Iodine value conversion (b)	240 thousands T Bq (2.4×10^{17}Bq)	480 thousands T Bq (4.8×10^{17}Bq)	3,400 thousands T Bq (3.4×10^{18}Bq)
(a) + (b)	370 thousands T Bq (3.7×10^{17}Bq)	630 thousands T Bq (6.3×10^{17}Bq)	5,200 thousands T Bq (5.2×10^{18}Bq)

INES level 7 equivalent : over 10 thousands Tera Becquerel (T Bq) (over 10^{16}Bq)

Source: Nuclear and Industrial Safety Agency

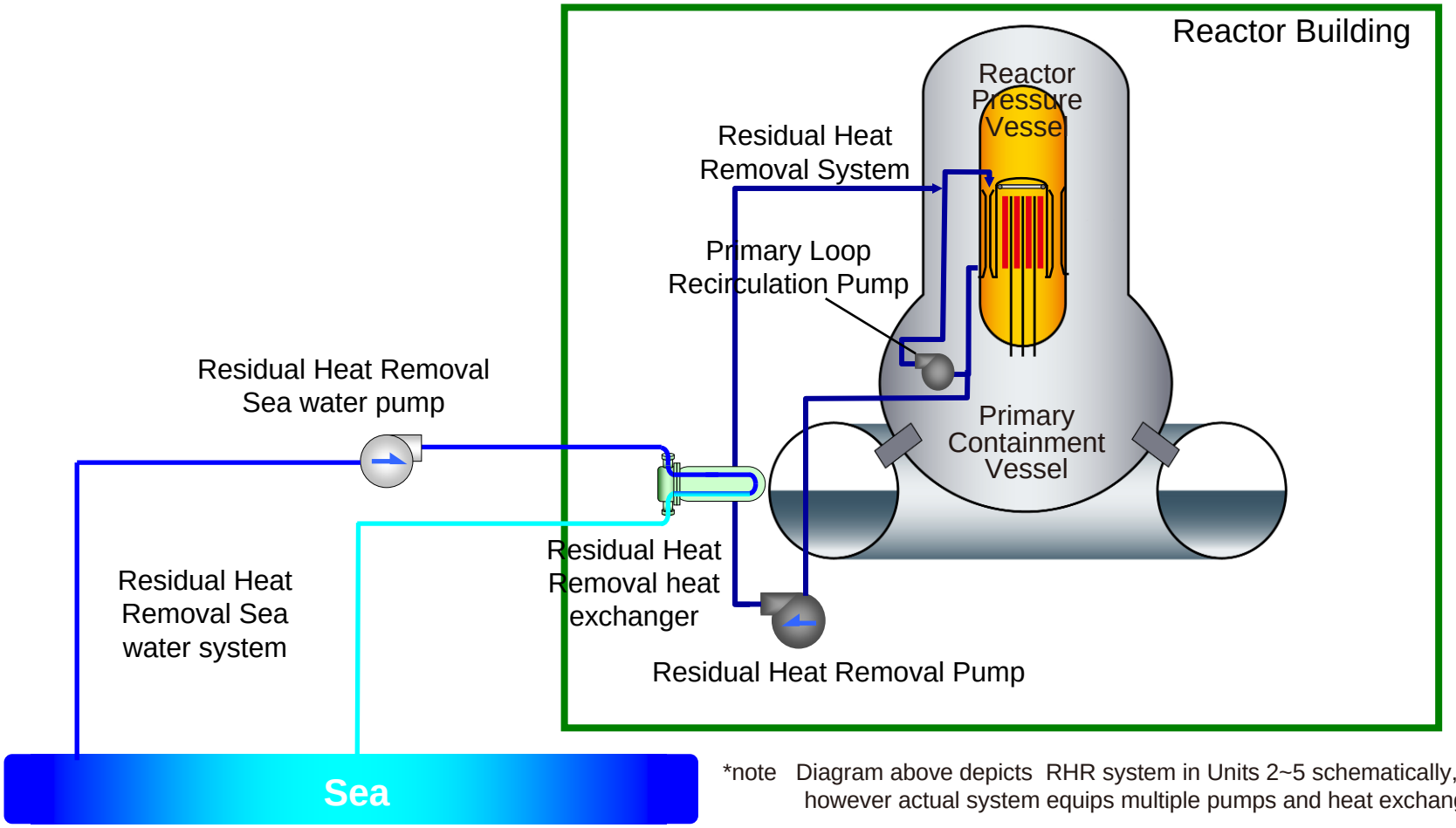
*As a result of reanalyzing using immediate post-earthquake plant data etc., the estimated release amount was corrected as follows;
Iodine 131 : 1.6×10^{17}Bq, Cesium 137 : 1.5×10^{16} Bq.
Source: "Report of Japanese Government to the IAEA Ministerial Conference on Nuclear Safety", Nuclear Emergency Response Headquarters (June 7, 2011).

On the other hand, according to the document of the 31st Nuclear Safety Commission (May 12, 2011), the estimated release amount was corrected as follows due to re-examining the abundance ratio of Iodine and Cesium in the dust;
Iodine 131 : 1.5×10^{17}Bq, Cesium 137 : 1.3×10^{16} .

At the 63rd Nuclear Safety Commission (Aug. 22, 2011), the release rate estimated from airborne radioactivity concentration has been partly re-estimated as follows;
Iodine 131: 1.5×10^{15}Bq/h (Mar. 13), 2×10^{15}Bq/h (7:00am~10:00am, Mar.15), 4×10^{15}Bq/h (1:00pm~5:00pm, Mar. 15)

[Reference] Core Cooling System under Normal Shutdown

- Nuclear fuels continue to generate decay heat even after stop of fission by control rod insertion
- In order to remove decay heat, “Residual Heat Removal System (RHR)” is installed. RHR pumps circulate reactor coolant and remove heat by sea water through heat exchanger in “Residual Heat Removal Sea water System”
- This will enable fuels in reactors to be kept in stabilized cooling state (under 65℃).



*note Diagram above depicts RHR system in Units 2~5 schematically, however actual system equips multiple pumps and heat exchangers.