Progression of Accident at Fukushima Daiichi Nuclear Power Station and the Lessons Learned

&

Measures based on

the Fukushima Daiichi accident

I. Progression of Accident at Fukushima Daiichi Nuclear Power Station and the Lessons Learned

Course of Accident Progression Flow at 1F-1

Date	Time	RPV control	PCV control
March 11,2011	14:46	Reactor scram signal transmitted due to earthquake	
	14:47	EDG automatically started up	•Reactor automatically shutdown (automatic scram) •Turbine & generator shut down •MSIV closed •Off-site power source lost
	14:52	IC automatically started up	
	15:03	IC was manually shutdown → Standby Determined that the reactor coolant cooling rate of 55℃/h, as stipulated in the procedures, cannot be maintained	
	15:10		S/C cooling commenced
		Controlled reader pressure at around 6-7MPa, as stipulated in procedure, with IC system A	
	※ 1st wave15:27 2nd wave15:35	Tsunami arrival Reactor could not be cooled because the isolation valve 3A of return line of IC system A was closed.	
	15:37	EDGA and B were tripped → Station black out (SBO)	
	15:42	Determined to be an event corresponding to Article 10 of the Nuclear Disaster Act (SBO) •DC power sources were lost •Isolated due to loss of DC power source (control power source) IC function was lost due to a false signal (inferred)	•SBO causes loss of function for removing residual heat from PCV
		Determined to be an event corresponding to Article 15 of the Nuclear Disaster Act (the loss of ECCS injection source)	
	16:36	Reactor water level dropped	•March 12, Around 0:00 D/W pressure may have exceeded 600KPa •March 12, 9:04 Work commenced for PCV venting •March 12, 9:15 ・Venting line MO valve 25% ・AO valve in the field could not be operated manually in high radiation dose environment ・Temporary air compressor set up to operate AO valve and venting operation performed
March 12,2011	4:00頃	Fresh water injection was commenced using fire brigade vehicle It is prepared for reshuffling parallel to fresh water injection to seawater injection to be limited in the fresh water of the fire prevention water tank	
	14:30		PCV venting (D/W pressure decline was confirmed)
	15:36	Hydrogen explosion	
	19:04	Seawater injection was commenced using fire engine	

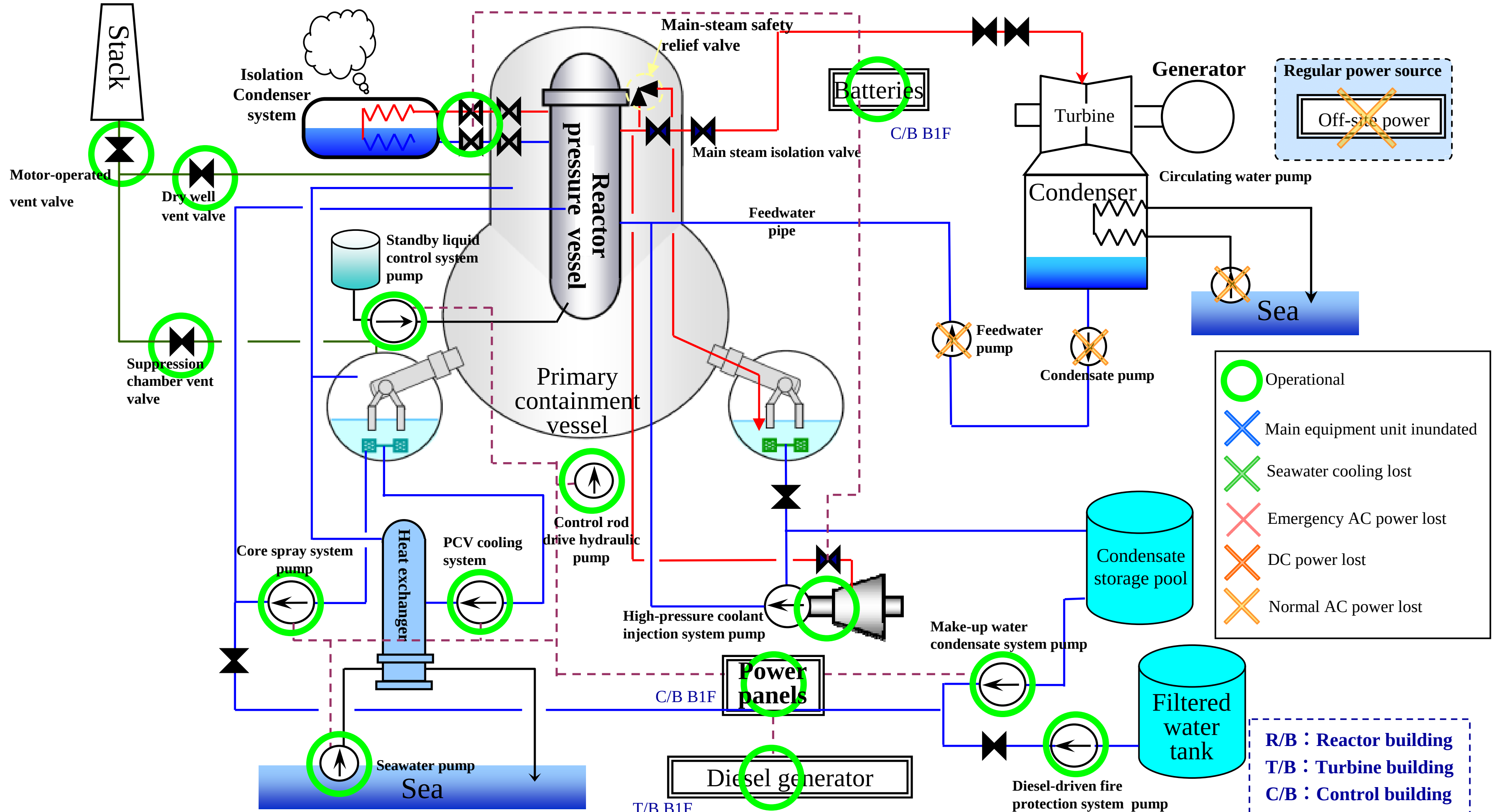
※We show the arrival time to tide gauge at the arrival time of the tsunami (Following page too)

Plant Status Immediately After Earthquake Struck (Unit 1)

Immediately after earthquake

The earthquake interrupted off-site power and the condensate & feed water pumps were shut down.

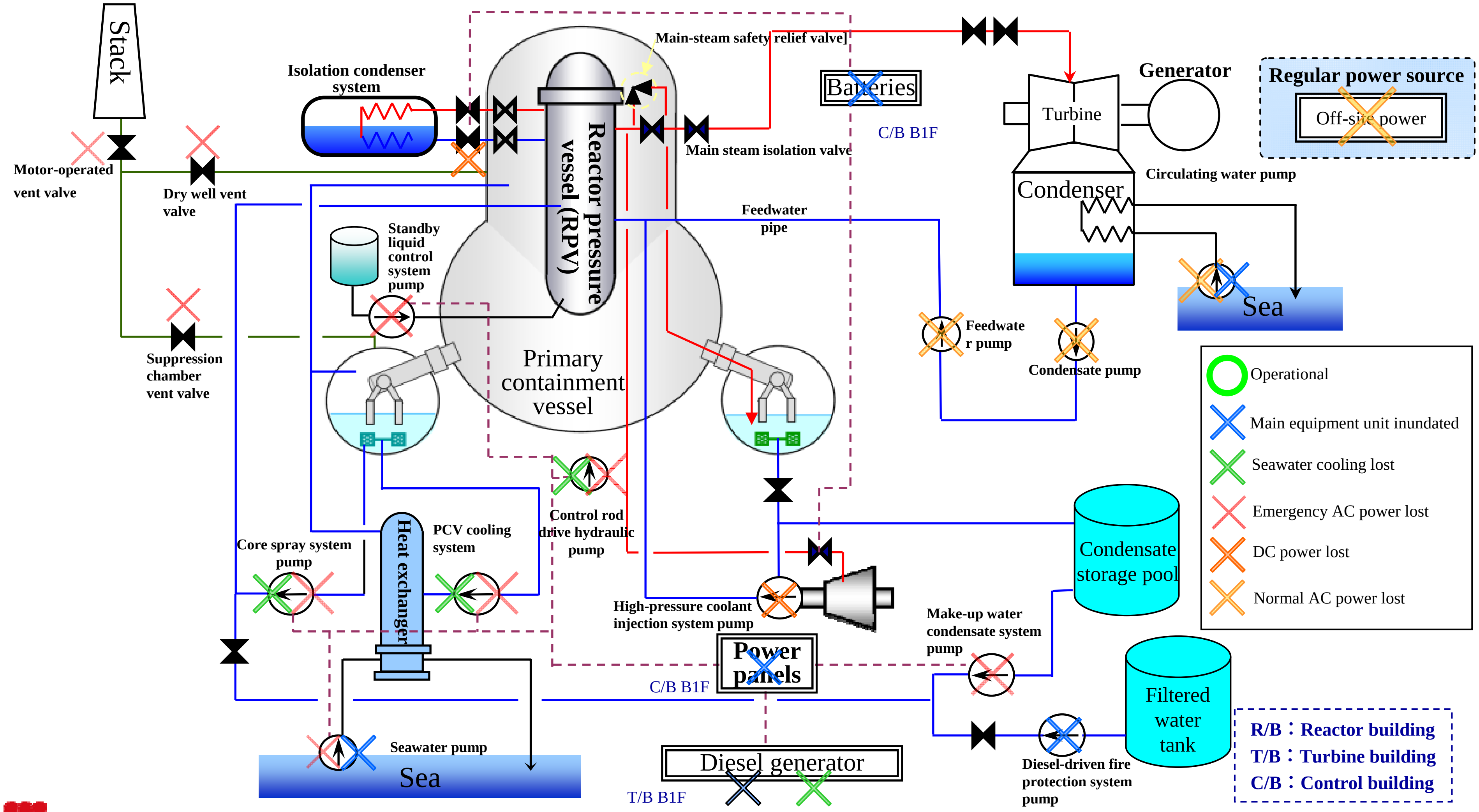
The emergency diesel generators started up and all emergency functions worked properly.



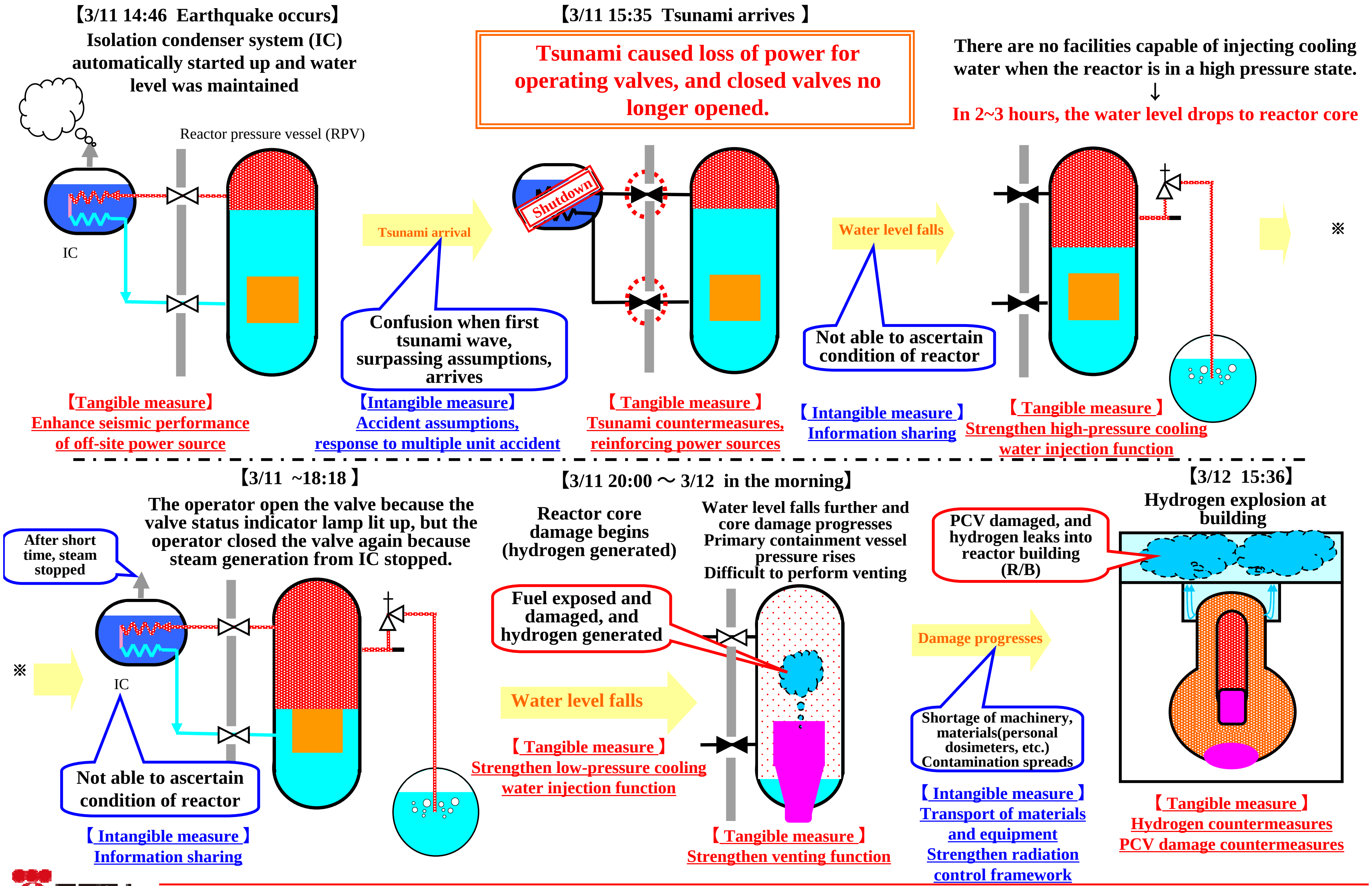
Plant Status After Tsunami Arrival (Unit 1)

After tsunami inundation

The seawater pump shut down and the emergency diesel generators shut down.
The tsunami inundated the building interiors, and battery and power panel function was also lost.
All instrument displays, operational function and lightening were lost.



Progression of Accident at Unit 1 and Necessary Measures



State of SSCs after the earthquake struck (1F-1)

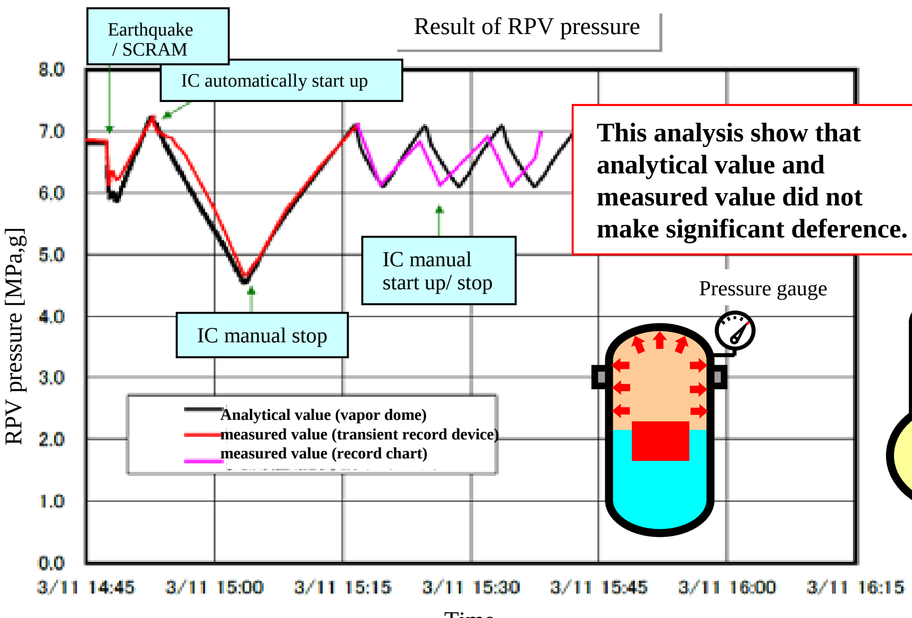
Reactor pressure analysis and visual confirmation were conducted to confirm effects of the earthquake for Unit 1

Reactor pressure analysis

Technical findings for hearing opinion of NISA

Technical findings about Fukushima Daiichi for hearing opinion of NISA reported that if less than 0.3 cm^2 crack occurred, it is not clear RPV pressure difference to check the leakage of coolant. On the other hand, if there is ca, 0.3 cm^2 crack, it effects the accident progression so that amount of 10 ton water leaks from RPV

The RPV pressure analysis was conducted under the conditions of occurring 0.3 cm^2 crack as to these findings

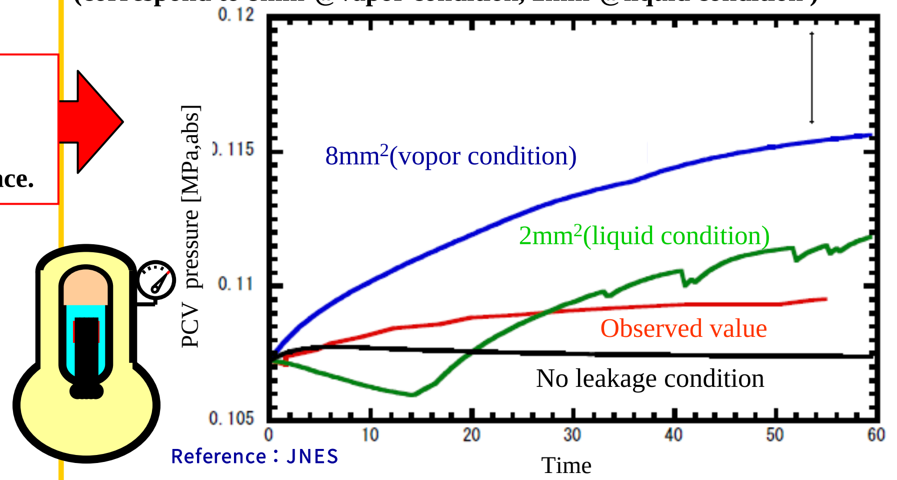


Reference：JNES

This analysis show that analytical value and measured value did not make significant deference.

PCV pressure

The safety regulations requires that the coolant leak rate to PCV is within 0.23 m^3/h.Following figure shows that the result of 0.23m^3/h crack occurs (correspond to 8mm^2@vapor condition, 2mm^2@liquid condition)



Reference：JNES

The observed value (red line) is under analytical values (green, blue line)

Judging from PCV pressure trend, it is less likely to effect the accident progression even if some cracks occur.

State of SSCs after the earthquake struck (1F-1)

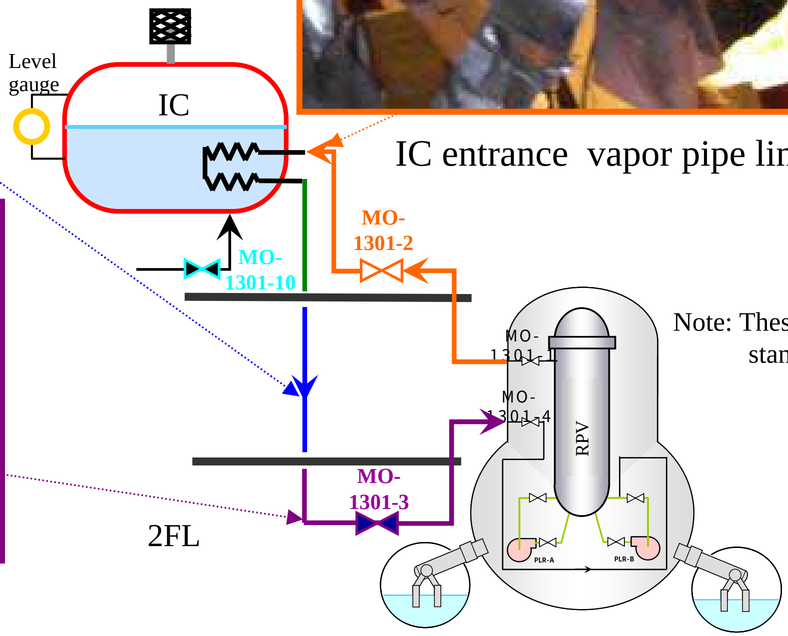
Ex. visual confirmation (IC, Unit 1)

<u>There was no definite evidence leading LOCA at outside of PCV result of visual confirmations</u>

IC (B) condensate water return pipe line

IC (A) condensate water return pipe line

IC entrance vapor pipe line



Othet visual confirmation check points

Unit 5,6 : R/B, T/B
Unit 1,2,3 : T/B
Unit 2 : R/B
Unit 1,2,3,4
: outside installations

Note: These valves drown by this figure are in stand-by state.

<u>The result of visual confirmations and seismic response analysis for unit 1,2 and 3 using observed records shows that SSCs would sustain these requisite functions after the earthquake.</u>

IC operating condition and indication of water level gauge (1F-1)

➢The presumed RPV water level by a MAAP analysis result.

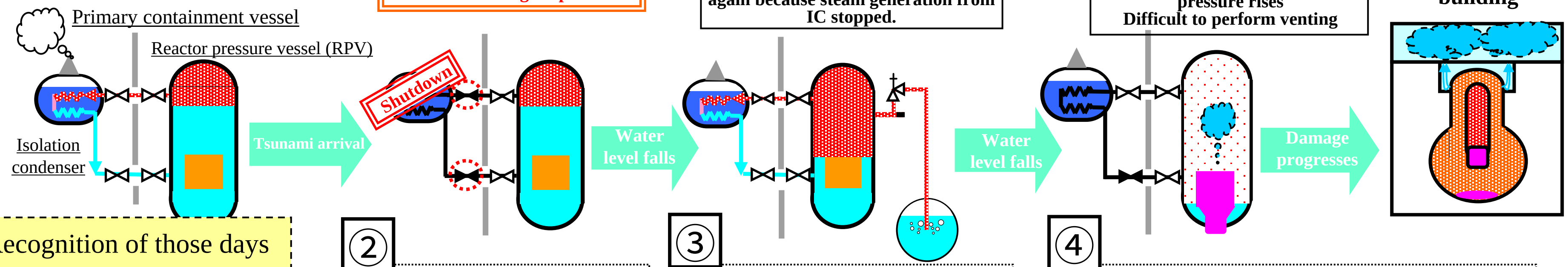
①【3/11 14:46 Earthquake occurs】 Isolation condenser system (IC) automatically started up and water level was maintained

②【3/11 15:35 Tsunami arrives 】
Tsunami caused loss of power for operating valves, and closed valves no longer opened.

③【3/11 ~18:18 】
The operator open the valve because the valve status indicator lamp lit up, but the operator closed the valve again because steam generation from IC stopped.

④【3/11 20:00 ～ 3/12 in the morning】
Water level falls further and core damage progresses
Primary containment vessel pressure rises
Difficult to perform venting

【3/12 15:36】
Hydrogen explosion at building



➢Recognition of those days

① The cold shutdown procedure of training is carried out.

② Tsunami caused became impossible to check parameters, such as RPV water level.

③ Since the vapor efflux of IC stopped, failure of IC is considered and it stops.

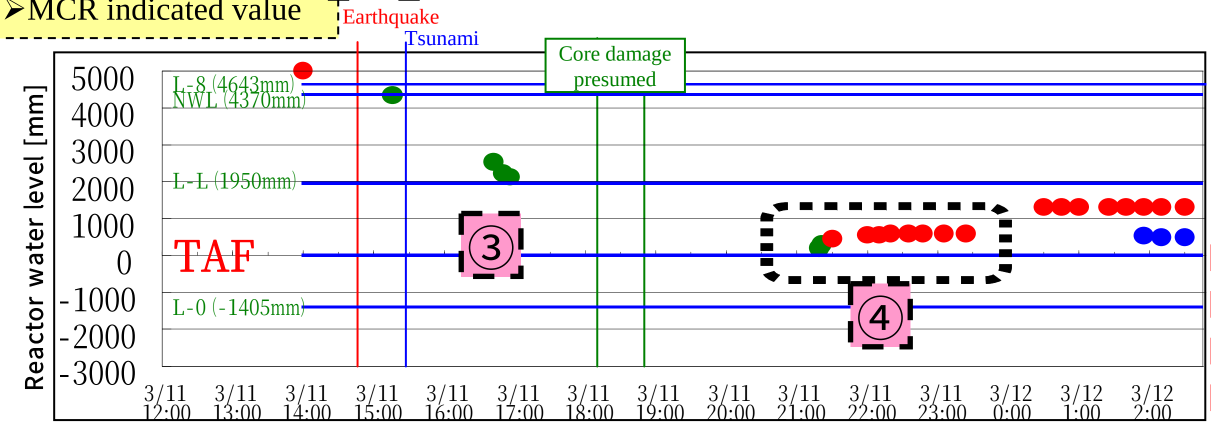
④ Since preparation of a IC was completed, the operation which opens IC valve was carried out and started at 21:30.

It was recognized as the ability of the reactor core to be cooled by that the water gauge of 21:19 showed more than TAF, and operation of D/D FP and IC.

However, …

It is presumed around 21:00 that reactor water levels were few, cooling by IC is not carried out, and core damage had already advanced.

➢MCR indicated value

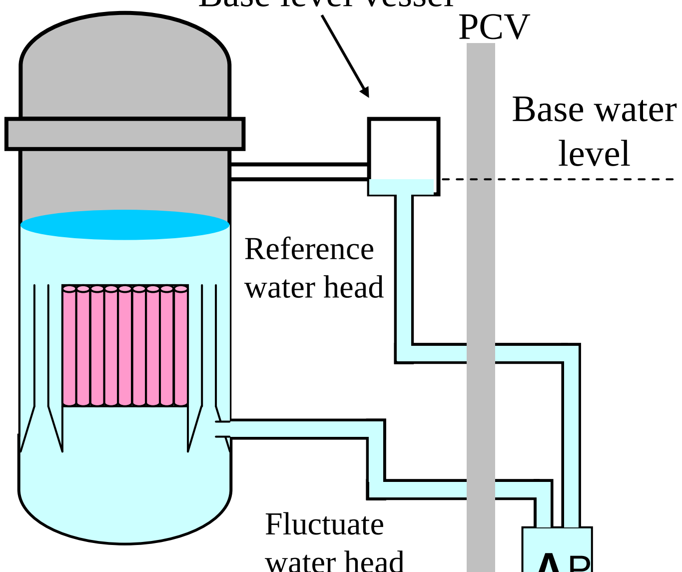


- As for the reactor water gauge of 21:19, the surface of the water established outside of RPV evaporated by a temperature rise by the core damage and was not able to measure exact differential pressure. It was thought that this showed the high water level on appearance, and it was convinced that a reactor core is normal till time (3/11 23:50) for a D/W pressure gauge to restore the persons concerned those days.

About a Water level gauge

The water level in the RPV measures it by the at the water head in the RPV and the difference in pressure of the adjacent datum level device.

Normal case



A water level is measured from pressure difference (ΔP).
A high water level is shown, so that pressure difference is small.

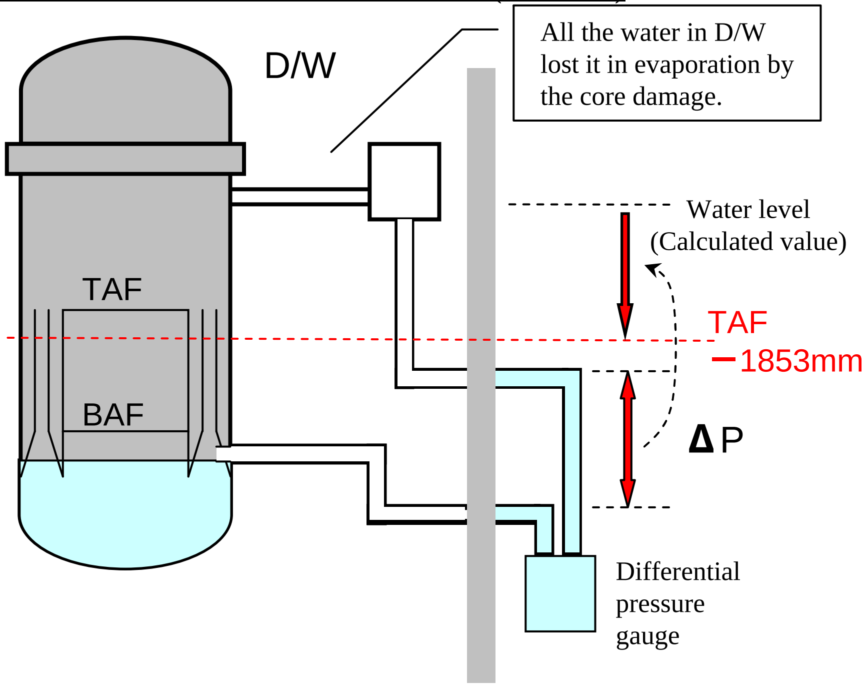
Accident

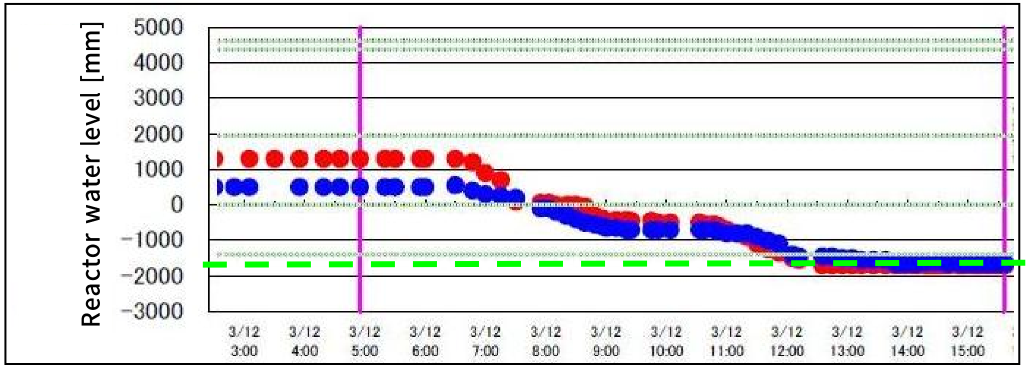
Base water level decreased by evaporation by the core damage.

Difference pressure (ΔP) becomes small and overestimates water level.

A water level higher than an original water level is shown.

The state after the point in time when a water level gauge showed a constant value in the unit 1.(Estimate)





- When the water of instrumentation piping in PCV is lost, if a water level calculates, it will be about TAF-1853 mm.
- This value is almost the same as the steady value which is directing the water gauge of Unit 1 on and after 3/12.

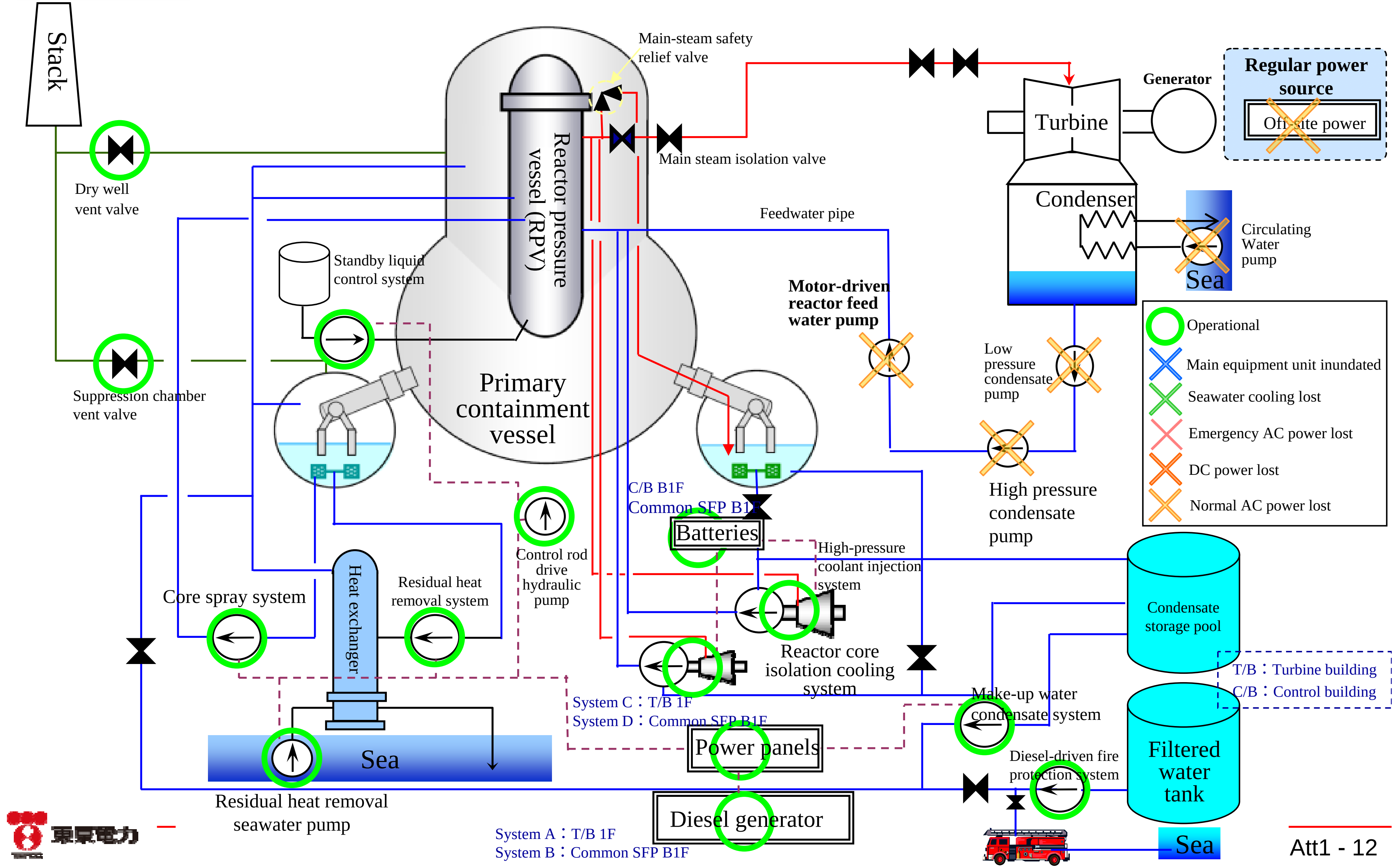
Course of Accident Progression Flow at 1F-2

Date	Time	RPV control	PCV control
March 11,2011	14:47	Reactor scram signal transmitted due to earthquake	
	14:50 ～14:51	RCIC was manually started up ↓ Automatically shut down at reactor water level-8	• Reactor automatically shut down • Turbine & generator shut down • MSIV closed • Off-site power source was lost • EDG automatically started up
	15:02 ～15:28	RCIC was manually started up ↓ Automatically shut down at reactor water level-8	
	15:07		S/C cooling commenced
	1st Wave 15:27 2nd Wave 15:35	Tsunami Arrival	
	15:39	RCIC was manually started up	
	15:41	EDGA and B tripped → SBO	
	15:42	Determined to be an event corresponding to Article 10 of the Nuclear Disaster Act (SBO) • DC power source were lost	• SBO causes loss of function for removing residual heat from PCV
	16:36	Determined to be an event corresponding to Article 15 of the Nuclear Disaster Act (the loss of ECCS injection source)	
March 13,2011	11:00		PCV venting up was completed
March 14,2011	13:25	event corresponding to Article 15 of the Nuclear Disaster Act (Loss of reactor cooling function) (Reactor water level decreased →Determined that function of the RCIC was lost)	• March 14, 11:01 Impact of Unit 3 explosion closed S/C venting line isolation valve • March 14, from around 16:00 S/C venting line and D/W venting line configuration gradually continued. ↓ • S/C side pressure was maintained lower than pressure to rupture the rupture disk. At the same time, D/W pressure exceeded maximum operating pressure, and the inability to depressurize was confirmed.
		Reactor water level dropped Securing of power supply from car Battery, Decompression operation was tried at 16:34, but a valve did not work, A change or the rewiring of the battery connection position was carried out.	
	18:02	Operation commenced to depressurize the RPV using SRV (relief valve function)	
	19:54	Seawater injection commenced using fire engine	
March 15,2011	Around 6:14	A large explosive sound and vibration occurred (at about the same time, S/C pressure scaled down	D/W pressure 7:20 730kPa→ 11:25 155kPa

Plant Status Immediately After Earthquake Struck (Unit 2)

Immediately after earthquake

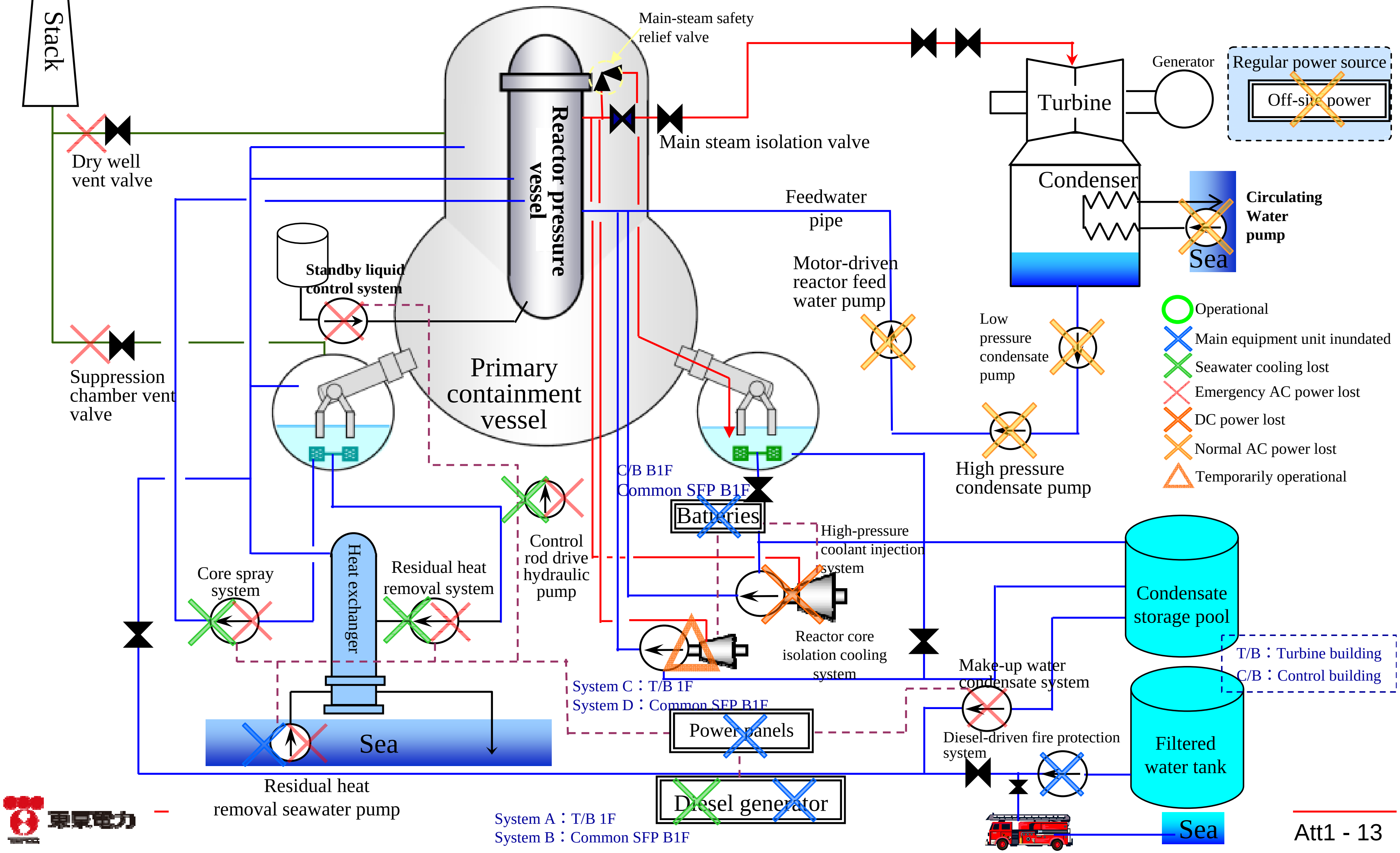
The earthquake interrupted off-site power and the condensate & feed water pumps on normal systems were shut down. The emergency diesel generators started up and all emergency functions worked properly.



Plant Status After Tsunami Arrival (Unit 2)

After tsunami inundation

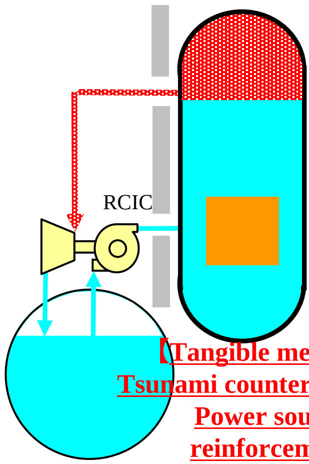
Seawater pumps shut down and emergency diesel generators shut down. The tsunami inundated the building interiors, and battery and power panel function was also lost. Although all instrument displays, operational function and lightening were lost, the reactor core isolation cooling system continued to inject cooling water while the controls were inoperable.



Progression of Accident at Unit 2 and Necessary Measures

【3/11 15:35 Tsunami arrives】

Even though tsunami causes loss of control power source (DC), resulting in inability to control, reactor core isolation cooling system continues to inject cooling water and water level is maintained.



【Tangible measure】
Tsunami countermeasures,
Power source reinforcement

Water level maintained

Confusion when first tsunami wave, surpassing assumptions, arrives

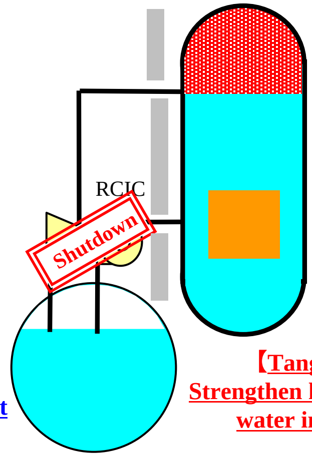
【Intangible measure】
Accident assumptions, response to multiple unit accident

【3/14 ~12:00 RCIC function lost】

3 days after accident

RCIC shuts down

【Intangible measure】
Response to prolonged accident

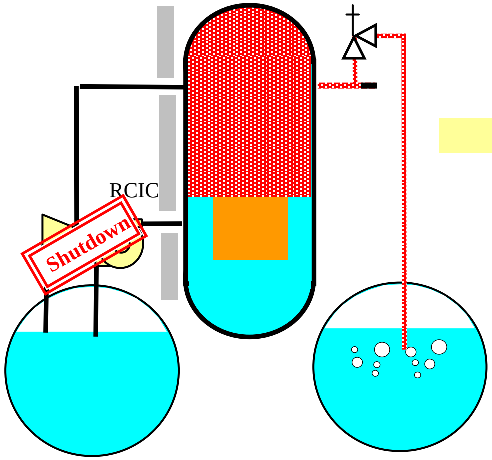


【Tangible measure】
Strengthen high-pressure cooling water injection function

Water level falls

【3/14 ~16:00】

There are no facilities capable of injecting cooling water when the reactor is in a high pressure state.
Water level drops to reactor core in approximately 4 hours

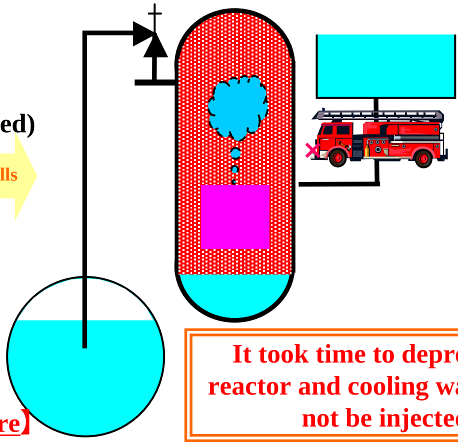


※

【3/14 ~18:00】

Reactor core damage begins (hydrogen generated)

※ Water level falls



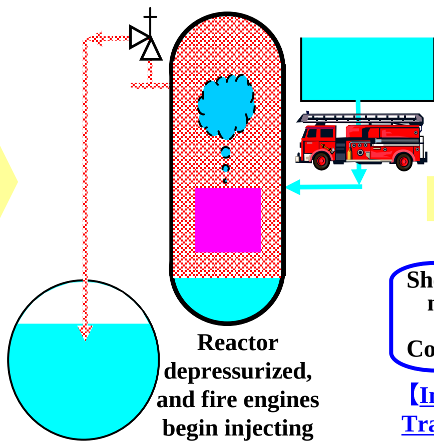
Difficulty in venting PCV

【Tangible measure】
Strengthen venting function

It took time to depressurize reactor and cooling water could not be injected.

【Tangible measure】
Strengthen means of depressurizing reactor

【3/14 ~20:00 Fire engines begin injecting cooling water】



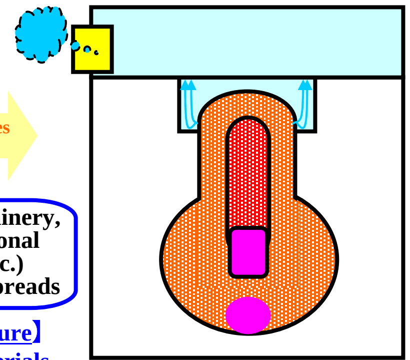
Reactor depressurized, and fire engines begin injecting cooling water

Damage progresses

Shortage of machinery, materials (personal dosimeters, etc.)
Contamination spreads

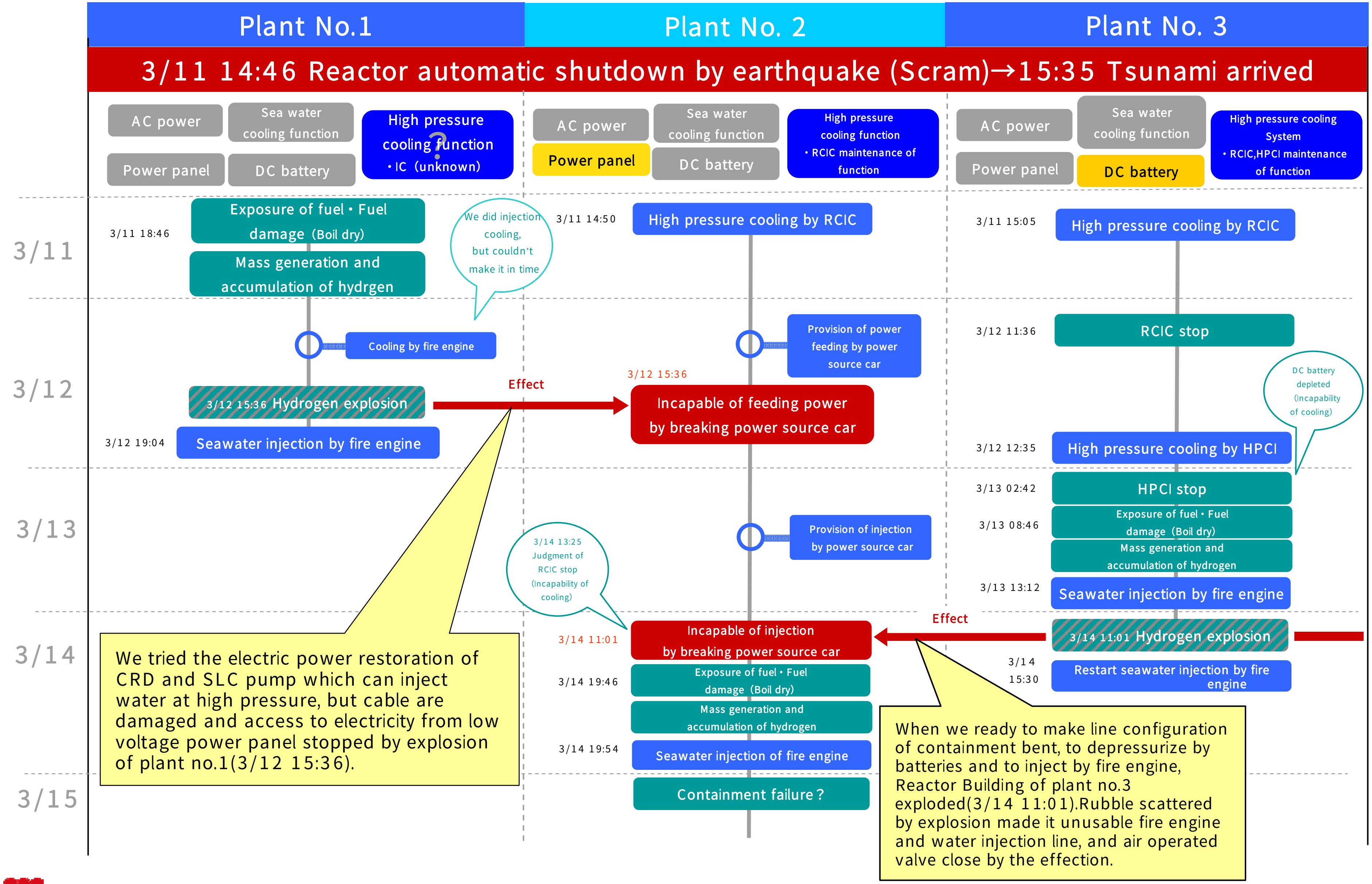
【Intangible measure】
Transport of materials and equipment
Strengthen radiation control framework

There was no hydrogen explosion because a large amount of radiation was released unexpectedly without the capability to vent



【Tangible measure】
Hydrogen countermeasures
PCV damage countermeasures

Delay in taking action at 1F-2 by explosion of other plants.



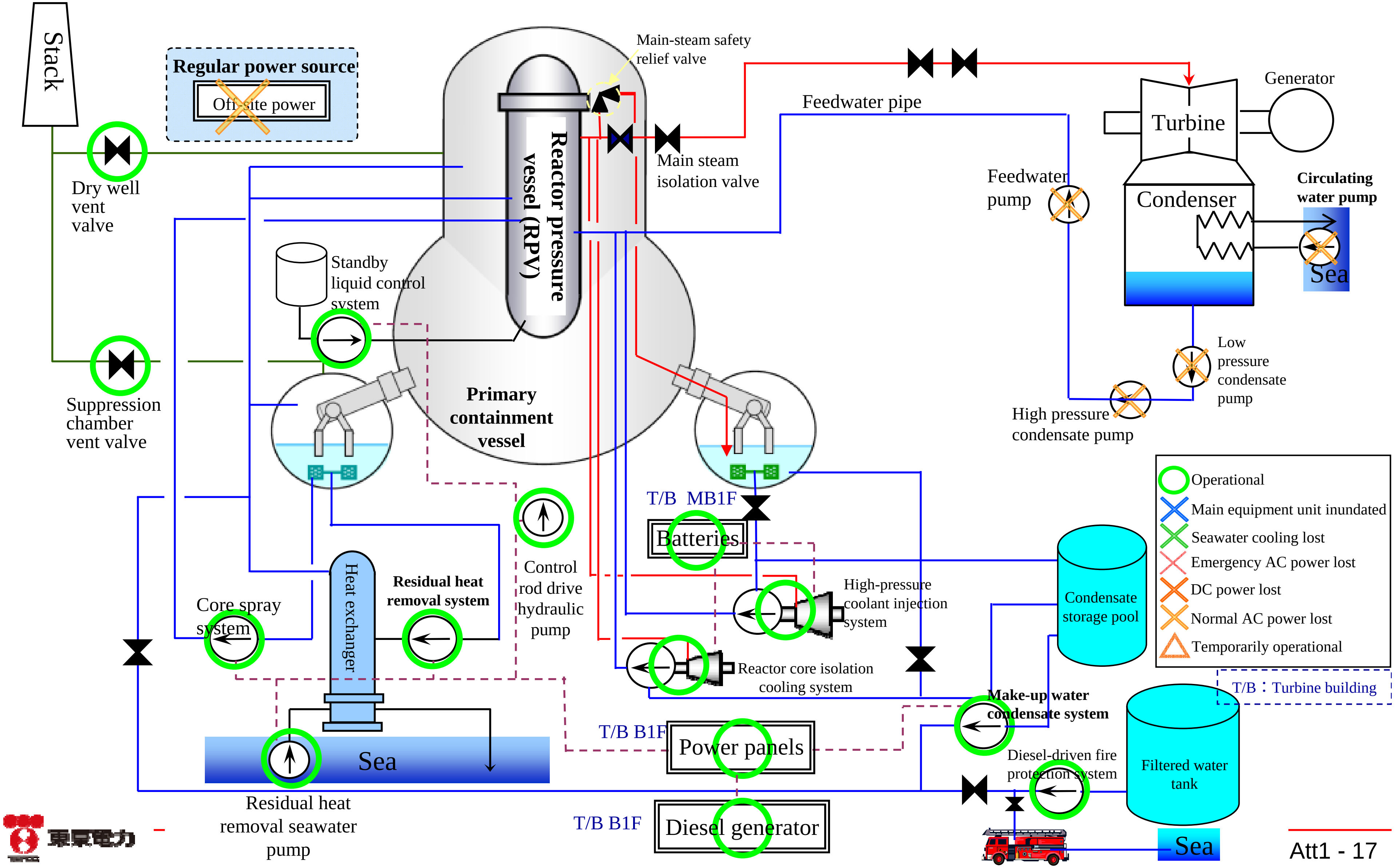
Course of Accident Progression Flow at 1F-3

Date	Time	RPV control	PCV control
March 11,2011	14:47	Reactor scram signal transmitted due to earthquake	• Reactor automatically shut down • Turbine & generator shut down • MSIV closed • Off-site power source was lost • EDG automatically started up
	15:05	RCIC was manually started up	
	15:25	RCIC automatically shuts down at reactor water level-8	
	1st Wave 15:27 2nd Wave 15:35	Tsunami Arrival	
	15:38	EDGA and B tripped → SBO	
	15:42	Determined to be an event corresponding to Article 10 of the Nuclear Disaster Act (SBO)	• SBO causes loss of function for removing residual heat from PCV
	16:03	RCIC was manually started up As a measure to extend the life of the DC power source, unnecessary loads were separated	
March 12,2011	11:36	RCIC automatically shuts down Reactor water level dropped	By D/D FP
	12:06		S/C spray was started
	12:35	HPCI automatically starts up (reactor water level L-2)	
March 13,2011	2:42	HPCI manually shut down	Switched D/D FP to reactor injection
		• Preparation for alternative cooling water injection using the fire protection system employing fire pumps and fire engine	
	5:08		S/C spray was started
	5:10	Determined to be an event corresponding to Article 15 of the Nuclear Disaster Act (the loss of ECCS injection source)	
	7:39		D/W spray was started
	Around	Reactor water level dropped Securing of power supply from car Battery	
	8:41		PCV venting up was completed
	9:08	Operation commenced to depressurize the RPV using SRV (relief valve function)	
	Around 9:20		Decrease confirmed in pressure of PCV
	9:25	Fresh water injection	
	13:12	Seawater injection	
March 14,2011	11:01	Hydrogen explosion	
	Around 15:30	Configured a new seawater injection line and injection was resumed by fire engines	Fire engine and hoses were damaged by the explosion

Plant Status Immediately After Earthquake Struck (Unit 3)

Immediately after earthquake

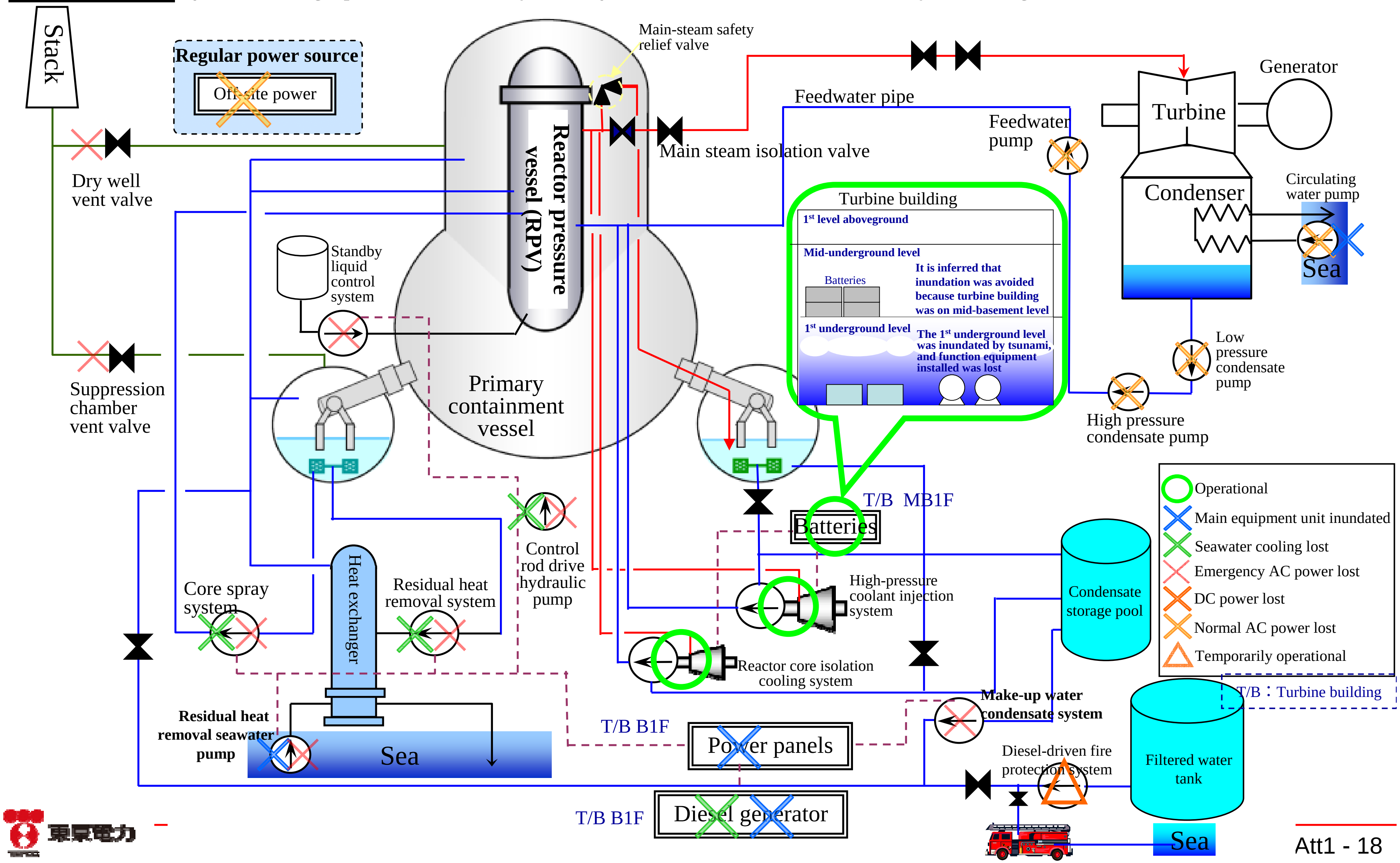
The earthquake interrupted off-site power and the condensate & feed water pumps were shut down.
The emergency diesel generators started up and all emergency functions worked properly.



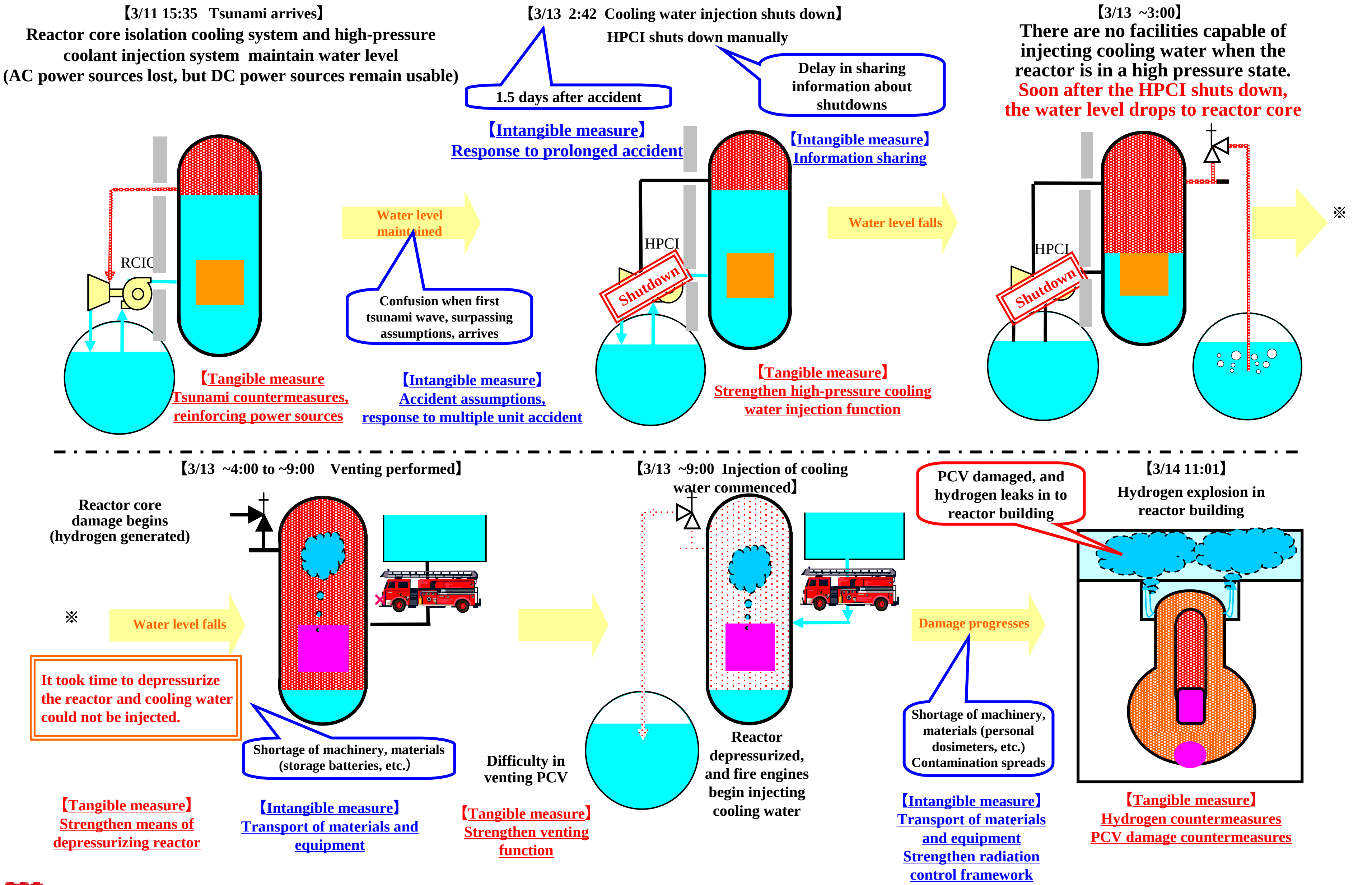
Plant Status After Tsunami Arrival (Unit 3)

After tsunami inundation

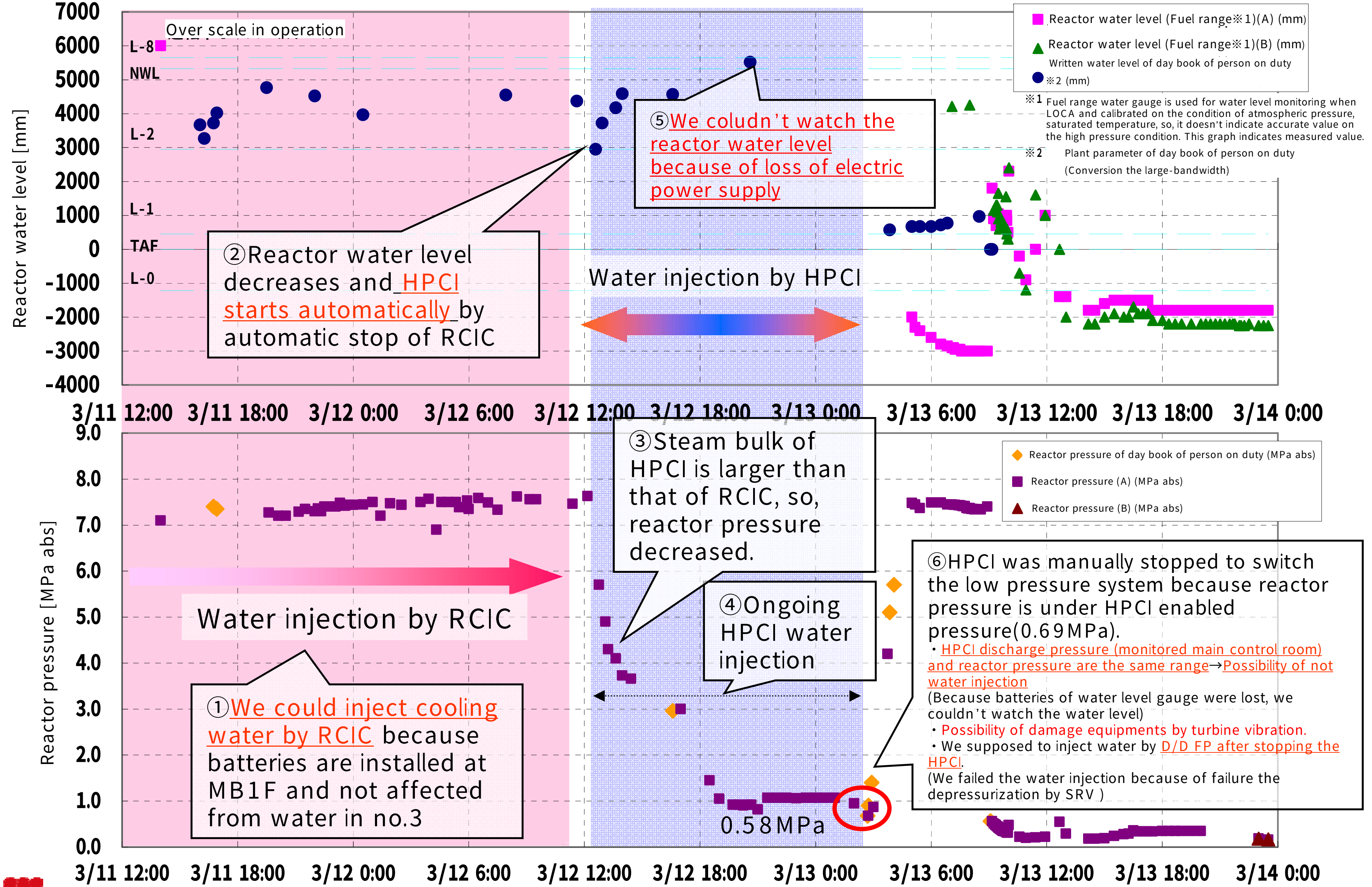
Seawater pumps shut down and emergency diesel generators shut down. The tsunami inundated the building interiors, and battery and power panel function was also lost. DC power sources were still operable, and the reactor core isolation cooling system and high-pressure coolant injection system were used to continue to inject cooling water. Instruments were also normal.



Progression of Accident at Unit 3 and Necessary Measures



How judged the Start/Stop of high pressure cooling water injection system(No.3)



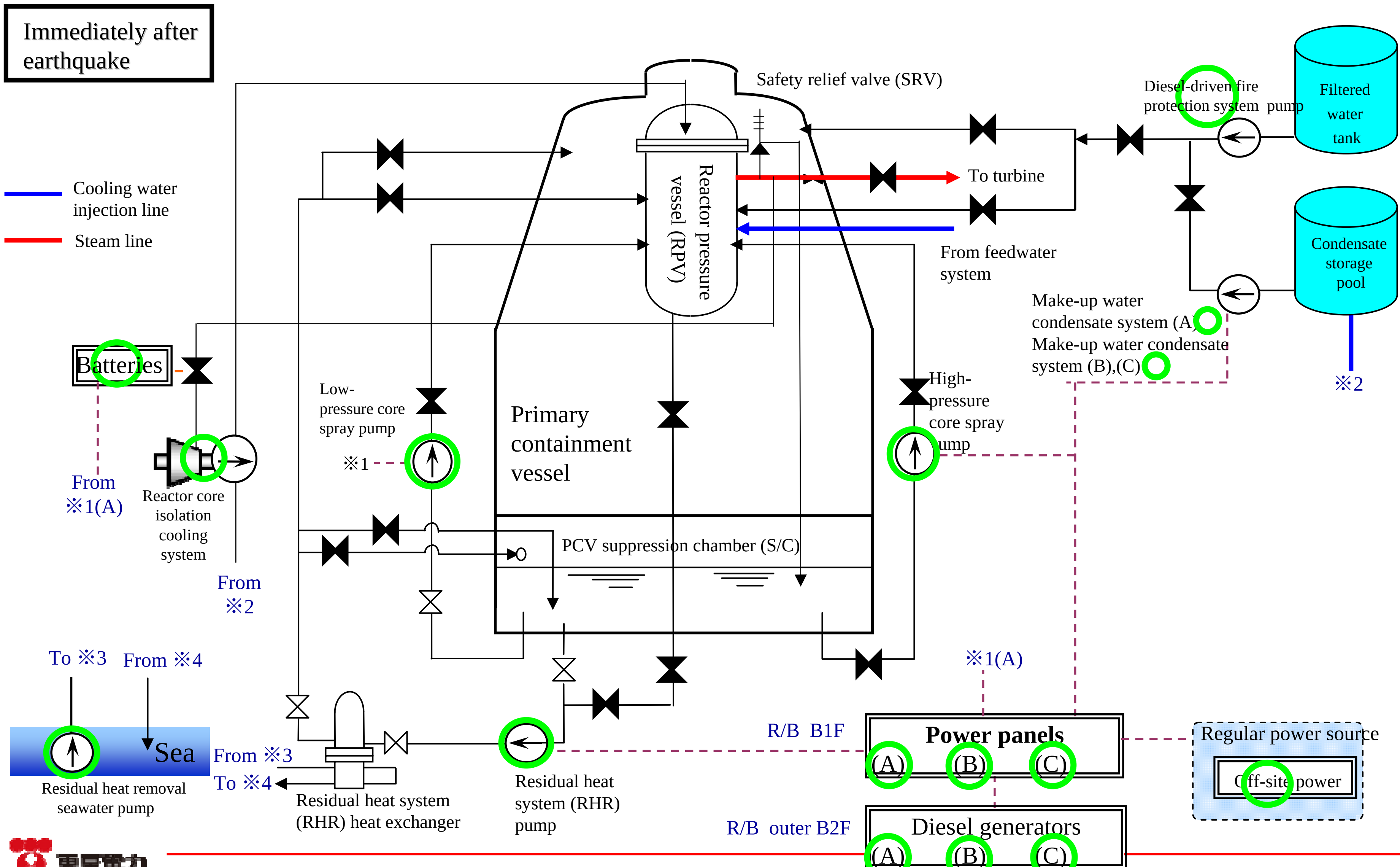
Course of Accident Progression Flow at 2F-1

Date	Time	RPV control	PCV control
March 11,2011		Reactor scram signal transmitted due to earthquake	• Reactor automatically shut down • Turbine & generator shut down
	14:48	Tomioka Line 1 was shut down (power continued to be received)	
	15:22	First tsunami arrival intermittently until 17:14	
	15:34	EDGA,B and H automatically started up They were shut down immediately after due to impact of tsunami	
	15:36	• MSIV was manually started • RCIC was manually started up	
	15:55	Depressurization commenced of reactor (SRV automatically completely opened up)	
	17:53		PCV cooling was manually started up
	15:35	Determined to be an event corresponding to Article 10 of the Nuclear Disaster Act (loss of reactor heat removal function)	
March 12,2011	0:00	Alternative cooling water injection was commenced using MUWC	•Startup of seawater pump can not be confirmed
	3:50～4:56	Rapid depressurization of reactor implemented	
	4:58	RCIC was manually isolated (due to lowered reactor pressure)	
	5:22	Determined to be an event corresponding to Article 10 of the Nuclear Disaster Act (loss of pressure suppression)	S/C Temperature＞100℃
	6:20		S/C Cooling commenced using MUWC
	7:10		PCV spraying implemented using MUWC
	7:37		S/C spraying implemented using MUWC
	10:21～18:30		PCV venting lined up
	1:24	Determined that an event corresponding to Article 10 of the Nuclear Disaster Act is cancelled (recovery of reactor heat removal function)	S/C cooling mode was commenced by manually starting up RHR(B)
	1:44	Emergency auxiliary cooling system (B)	Around 3:39 RHR(B) S/C spray mode commenced
	10:05	Cooling injection into reactor using RHR(B) LPCI mode	
	10:15	Determined that an event corresponding to Article 10 of the Nuclear Disaster Act is cancelled (recovery of pressure suppression function)	S/C Temperature＜100℃
	17:00	Reactor cold shut down（Reactor water temperature＜100℃）	

Plant Status Immediately After Earthquake Struck (Fukushima Daini Unit 1)

Earthquake shut down reactor. Normal condensate & feed water systems were used for cooling.

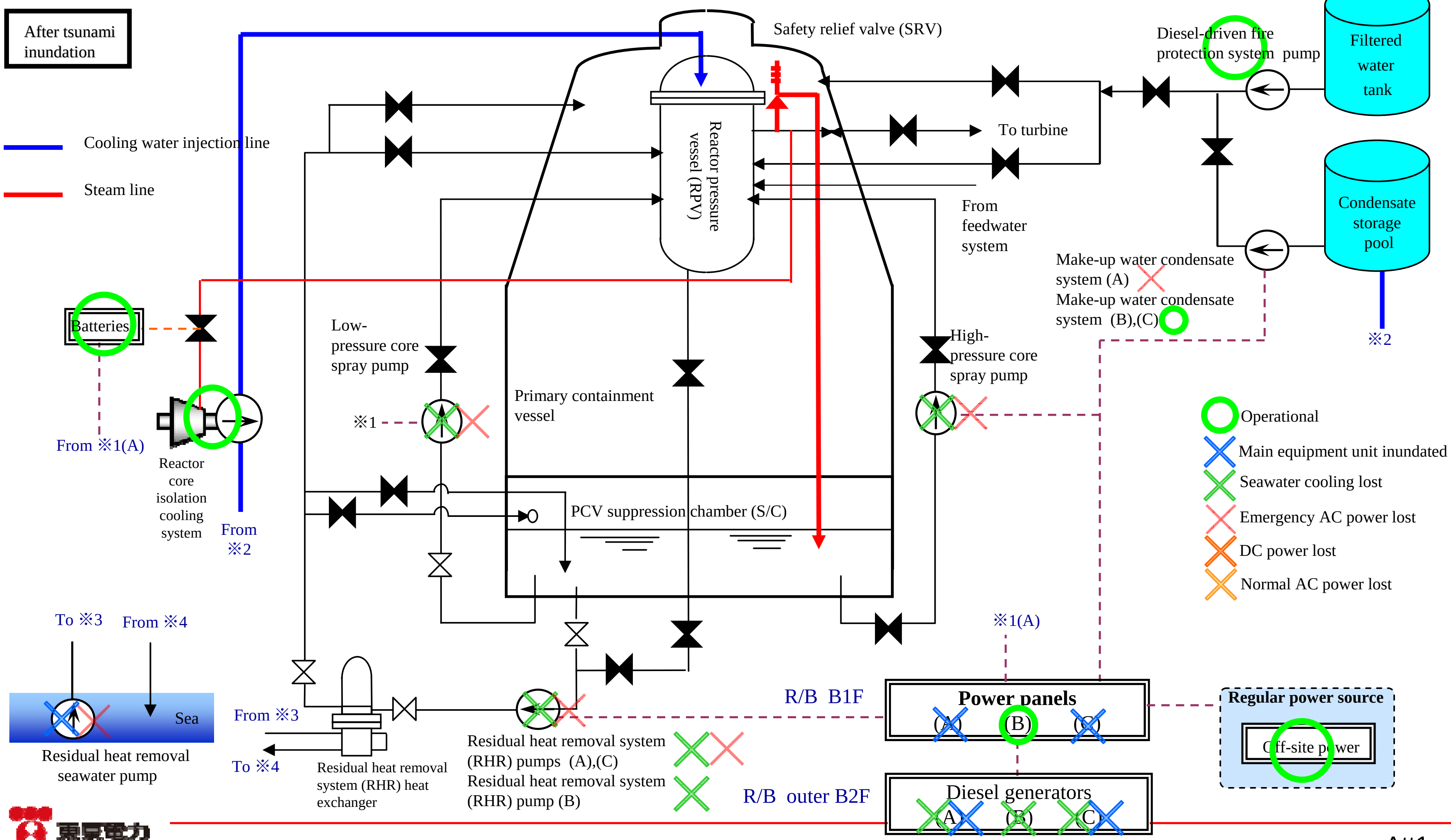
All emergency functions worked properly.



Plant Status After Tsunami Arrival (Fukushima Daini Unit 1)

After tsunami arrival, reactor core isolation cooling system (steam-driven) and make-up water condensate system were used to continue injection of cooling water.

Tsunami inundated some pumps and power panels set up along the coast. Although function of diesel generators was lost due to inundation, **off-site power was available**, so the reactor core isolation cooling system was used to continue injecting cooling water.



How was Fukushima Daini Brought to Cold Shutdown?
(Fukushima Daini Unit 1 as Illustration)

Course of response: Shutting down → Cooling down → Confining inside

Response methods

Shutting down
Reactor emergency shut down (~seconds)
- Emergency insertion of control rods

Cooling down
Reactor depressurized (performed prior to shutdown of high pressure injection system)
- Depressurized immediately after shutdown (~approx. 1 hour later)
(If high pressure injection system unusable)
- Depressurized after continuing high-pressure cooling water injection (~prior to shutdown of high pressure injection system (half day))
(if low pressure water injection system can be switched to)

Reactor cooling by cooling water injection
- Performed by selecting either the high pressure injection system or low pressure injection system depending on reactor pressure

Confining inside
Reactor circulation cooling (~approx. 3 days later)
(Actual restoration at Fukushima Daini)
- Reactor water was recirculated through heat exchanger to remove heat

Summary of response at Fukushima Daini Unit 1

3/11 14：46 Earthquake occurs
15：22 First tsunami wave arrives
15：34 Emergency D/Gs shut down
3/12 4：58 RCIC (high-pressure cooling water injection) shuts down
3/14 1：24 Reactor heat removal commences

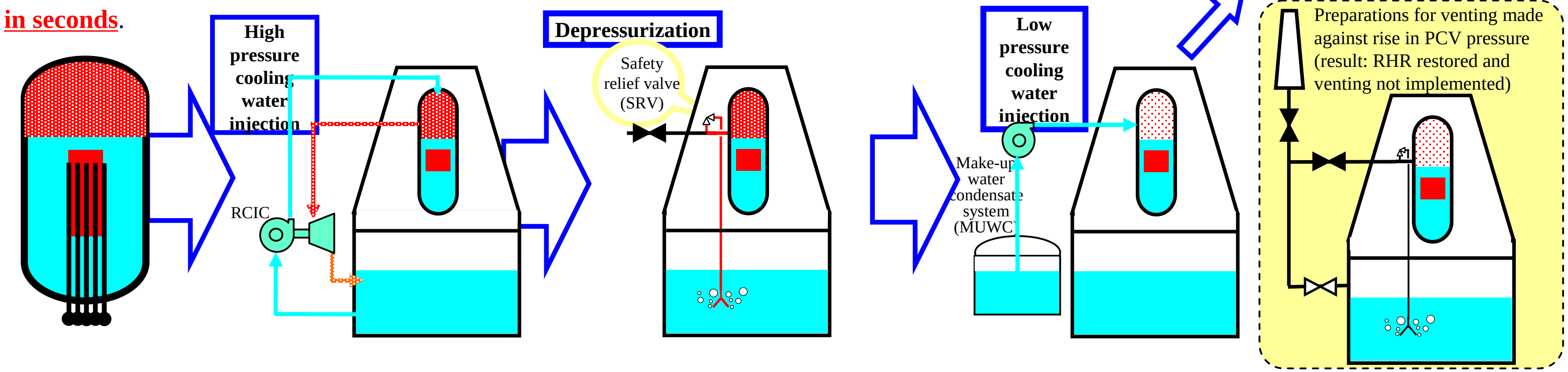
Earthquake detected and emergency shutdown **in seconds**.

Even after tsunami impact causes various normal/emergency equipment to lose function, RCIC starts up **and continues to inject cooling water**

Depressurize until switch can be made to low pressure cooling water injection
(state where cooling water injectable using MUWC)

Low pressure cooling water injection after depressurization of reactor
(Make-up water condensate system)

Residual heat removal system (RHR) restored, **circulation cooling of reactor performed**
→Cold shutdown



Unit 1

○Following the arrival of **tsunami exceeding assumptions**, **building interiors and exteriors were inundated**.

○**All power sources were lost**, isolation condenser valves would no longer open and other such circumstances that **all cooling water injection and residual heat removal functions were lost**.

○The loss of cooling water injection and residual heat removal functions led to a drop in water level, resulting in **reactor core damage approximately 4 hours after tsunami arrival**.

○As a consequence of the reactor core damage, hydrogen was produced, which leaked **from the reactor pressure vessel and primary containment vessel into the reactor building and resulted in a hydrogen explosion**.

○In addition to limited **lighting and communication tools** due to the loss of power, **monitoring and measuring means** were also lost and the plant status was no longer able to be ascertained, so **confusion about initial response actions and deficiencies in sharing information** arose.

○Due to severe aftershocks, concerns about tsunami accompanying aftershocks, scattered debris and so on, **accessibility and workability in the yard was reduced**.

○The **work environment severely deteriorated** due to a rise in radiation levels, **shortage of materials and equipment for radiation control** and other responses.

○Along with addressing the core, **responses arose for handling heat removal and injecting cooling water into the spent fuel pool**.

Unit 2

○Following the arrival of **tsunami exceeding assumptions**, **building interiors and exteriors were inundated**.

○**All power sources were lost** and, with the exception of the reactor core isolation cooling system (RCIC), **cooling water injection and residual heat removal functions were lost**. The RCIC, which continued to operate, could not be controlled.

○During depressurization of the reactor after the RCIC shut down, the depressurization did not go well using the storage batteries, which had been urgently readied. As a result of trial and error, **it required time to depressurize, the water level fell and reactor core damage resulted**.

○In addition to limited **lighting and communication tools** due to the loss of power, **monitoring and measuring means** were also lost and the plant status was no longer able to be ascertained, so **confusion about initial response actions** arose as all units fell into a crisis situation simultaneously.

○Due to severe aftershocks, concerns about tsunami accompanying aftershocks, scattered debris following the tsunami and hydrogen explosion and other factors, **accessibility and workability in the yard was reduced**.

○In the wake of the hydrogen explosions at Units 1 and 3, the **work environment severely deteriorated** due to damage to power supply cars and fire engines, a rise in radiation levels, **shortage of materials and equipment for radiation control** and other responses, and the **prolonged response to the accident**.

○Along with addressing to the core, **responses arose for handling heat removal and injecting cooling water into the spent fuel pool**.

Unit 3

○Following the arrival of **tsunami exceeding assumptions**, **building interiors and exteriors were inundated**.

○**All AC power sources were lost**, and AC-driven **cooling water injection and residual heat removal functions were lost**.

○After shutdown of the DC-control cooling water injection system, storage batteries necessary for depressurizing the reactorwere collected from within the station and other efforts **required time for depressurization.** **The water level fell and reactor core damage resulted**.

○As a consequence of the reactor core damage, hydrogen was produced, which leaked **from the reactor pressure vessel and primary containment vessel into the reactor building and resulted in a hydrogen explosion**.

○In addition to limited **lighting and communication tools** due to the loss of power, so **confusion about initial response actions and deficiencies in sharing information** arose as all units fell into a crisis situation simultaneously.

○Due to severe aftershocks, concerns about tsunami accompanying aftershocks, scattered debris and so on, **accessibility and workability in the yard was reduced**.

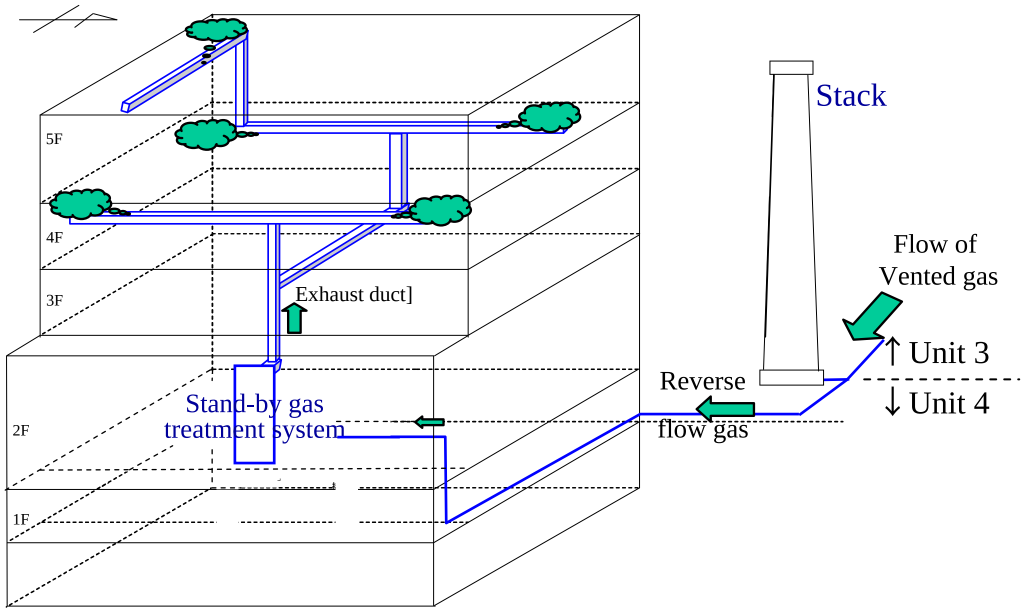
○The **work environment severely deteriorated** due to a rise in radiation levels, **shortage of materials and equipment for radiation control** and other responses, and the **prolonged response to the accident**.

○Along with addressing the core, **responses arose for handling heat removal and injecting cooling water into the spent fuel pool**.

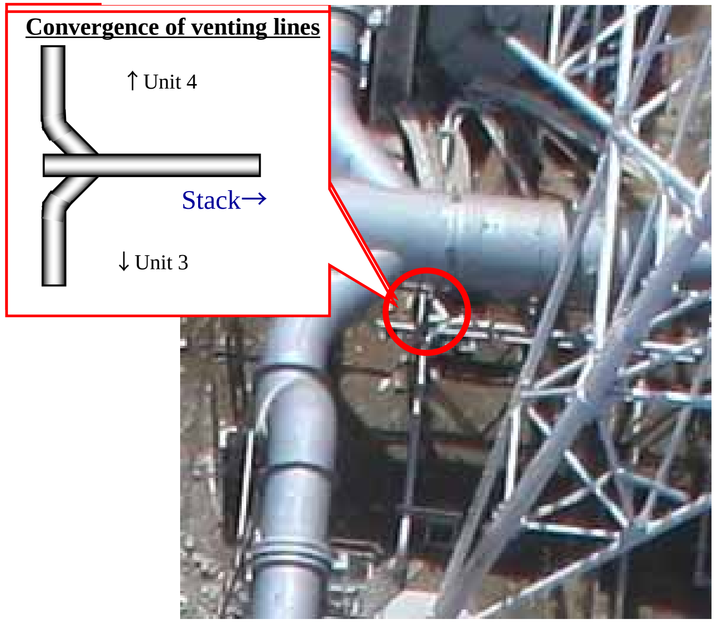
Hydrogen Explosion at Unit 4 Building

〇At Fukushima Daiichi Unit 4 also, an explosion occurred in the reactor building (R/B). For the following reasons, this has been inferred to be **because vented gas, containing hydrogen from Unit 3, flowed into Unit 4**.

- Because Unit 4 was undergoing periodic inspection, all of the fuel for the reactor has been extracted to the fuel pool.
- The fuel in the fuel pool was under water, and there were no indications of damage to the fuel from the results of water analyses.
- The venting line for Unit 3 and 4 converges just before the stack.
- The filter on the Unit 4 standby gas treatment system (SGTS) was highly contaminated by radioactive materials on the downstream (Unit 3) side. Toward the upstream (Unit 4) side, the contamination was low. (Opposite of what it should be.)



Path of flow of PCV vented gas from Unit 3 to Unit 4



At the Kashiwazaki-Kariwa Nuclear Power Station (NPS), all units have separate exhaust lines, and the setup is such that an event in which there is reverse flow from another unit cannot occur, as happened at Fukushima Daiichi Unit 4.

Points at Issue in Accident Response (Tangible Aspects)

○Protection against a tsunami exceeding assumptions was vulnerable.

○Sufficient preparations had not been made for cases where all power sources would be lost nor had there been adequate means provided for the subsequent response (high pressure cooling water injection, depressurization, low pressure water injection, heat removal, injection of cooling water into fuel pool, securing water sources, etc.). Workers were forced to respond while thinking about these issues on the spot.

○Means for mitigating the impact after reactor core damage had not been prepared (preventing primary containment vessel damage, controlling hydrogen, preventing release of large amounts of radioactive materials into the environment, etc.).

○In addition to limited lighting and communication tools, monitoring and measuring means were also lost and the plant status was no longer able to be ascertained.

○Due to severe aftershocks, concerns about tsunami accompanying aftershocks, scattered debris and so on, accessibility and workability in the yard was reduced. These and other factors leading to a deterioration of the work environment made it difficult to respond to the accident.

≪Policy of measures≫

●Enhance resistance to tsunami including existing facilities which are important in security and which assume use by correspondence at an accident through measures against tsunami (water stoppage)

● Measures are adopted at each stage and function on Defense in depth, Thickness of the correspondence ability for each stage and function is Enhanced.

・Ensure measures for continuously responding for a long time when all power supplies are lost and ultimate heat sink is lost.

・Function is secured by flexible measures with application, the mobility

Each stage and function on Defense in depth, Policy of measures

Issues Learned from Tsunami and Subsequent Escalation of Accident

Flow of Defense in Depth (※)

(1) Prevent problems from arising
- ① Implement thorough tsunami countermeasures (multiplex tsunami countermeasures)

(2) Prevent escalation into an accident
- Assure shutting down functions (emergency insertion of control rods, etc.) (operated without problem at both Fukushima Daiichi and Daini)

(3) Prevent damage to reactor core during accident
- ② Reinforce various means of supplying power
- ③ Reinforce water sources (fresh water, sea water) required for injection of cooling water
- ④ Strengthen means for high pressure injection of cooling water with the capability to be implemented promptly
- ⑤ Strengthen means for depressurization prior to loss of means for high pressure injection of cooling water
- ⑥ Strengthen means for stable low pressure injection of cooling water prior to depressurization
- ⑦ Assure heat removal means
  - Reinforce means of removing heat using seawater
  - Reinforce reliable means of venting primary containment vessel (removal of heat through atmospheric release)

(4) Mitigate impact after accident
- ⑧ Strengthen means of mitigating impact after reactor core damage
- ② Reinforce various means of supplying power
- ③ Reinforce water sources (fresh water, sea water) required for injection of cooling water

(5) Accident prevention countermeasures
- Evacuation-related measures (intangible countermeasures)

※ Defense in depth: Approach to ensuring the safety of nuclear power facilities. An approach in which:
Even if (A) fails, respond with (B)
Even if (B) fails, respond with (C)
such that countermeasures are adopted at each level (A)~(E).

Other

Fuel pool cooling
- ⑨ Strengthen **means of removing heat and injecting cooling water into fuel pool**
- ② Reinforce various **means of supplying power**
- ③ Reinforce **water sources (fresh water, sea water)** required for injection of cooling water

Further aseismic reinforcement
- ⑩ Implement **measures for improving aseismicity** from the standpoint of further enhancing safety

Strengthen support functions
- ⑪ Implement other measures essential for supporting accident response
  - Enhance **means of measurement** necessary for plant operation and parameter monitoring
  - Improve **capability (work environment) of the main control rooms and seismic-isolated buildings for responding during an accident**
  - Reinforce **communication tools** usable even during an accident
  - Secure **access routes** to the yard

Measures at the Kashiwazaki Kariwa Nuclear Power Plant based on the lessons learned from the Fukushima Daiichi Nuclear Power Plant accident (Facility aspect)

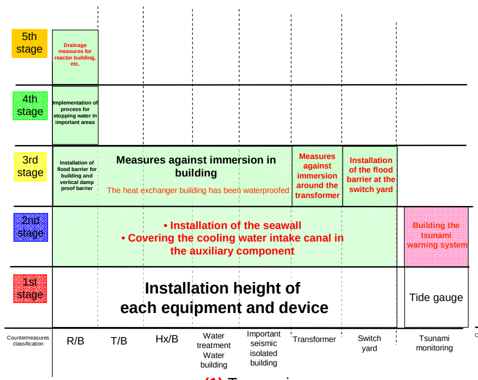
＜Ex. of Kashiwazaki Kariwa Unit1＞

Legend		Legend	
(pink)	Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [medium- to long-term]	(light blue)	Accident management countermeasures developed prior to the accident at the Fukushima Daiichi Nuclear Power Station
Red (green)	Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (being implemented)	(white)	Facilities adopted in the basic design
Black (green)	Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (completed)		
(yellow)	Measures based on the Niigataken Chuetsu-oki Earthquake		

Note: Items in the blue thick frame are facilities in which effect is predicted with water stoppage measures by use of the seawall.

First layer Prevention of trouble

Problem (lessons learned)
Protection against unanticipated tsunami was insufficient.
Policy...Enhanc3 resistance to tsunami including existing facilities through measures against tsunami (water stoppage).

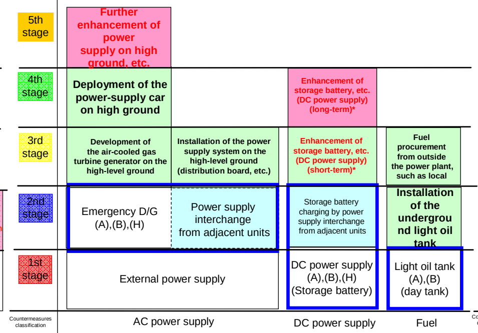


(1) Tsunami

Third layer Prevention of core damage after occurrence of accident (power supply)

Problem (lessons learned)
Sufficient alternative measures for the case where all power supplies (DC and AC power supplies) are lost were not prepared.
Policy
- Protect the existing power supply system through water stoppage measures.
- Ensure new measures for continuously responding for a long time when all power supplies are lost
  Enhance the resistance to tsunami by installing the DC power supply system on high ground

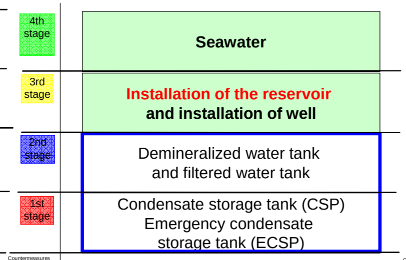
* Emergency generator and DC power supply system are installed on high ground as short-term enhancement measures. Existing DC power supplies are enhanced as long-term enhancement measures.



(2) Power supply

Third layer Prevention of core damage after occurrence of accident (water source)

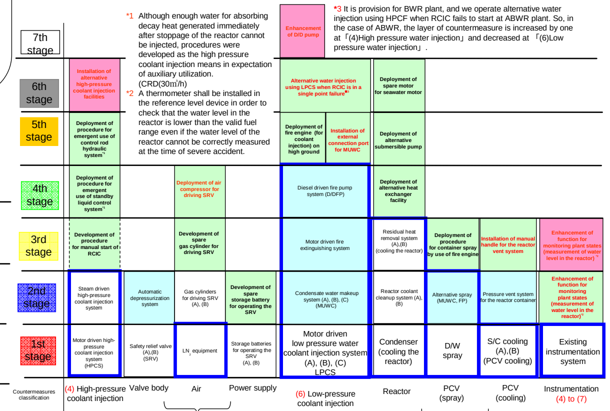
Problem (lessons learned)
Sufficient water source and means for injecting water necessary for preventing core damage and alleviating impact after core damage were not retained.
Policy
- Expecting the existing water source through water stoppage measures.
- Developing measures for injecting coolant using each water source while ensuring various water sources, such as installation of reservoir and well, injection of sea water.



(3) Water source

Third layer Prevention of core damage after occurrence of accident (coolant injection, depressurization, cooling)

Problem (lessons learned)
Subsequent high-pressure coolant injection, depressurization, low-pressure coolant injection, cooling and ensuring of water source in the event that all power supplies are lost were not prepared well, personnel at the site had to think and respond on the site.
Policy
Enhancement of each measure (high-pressure coolant injection, depressurization, low-pressure coolant injection and cooling for the reactor and reactor container)



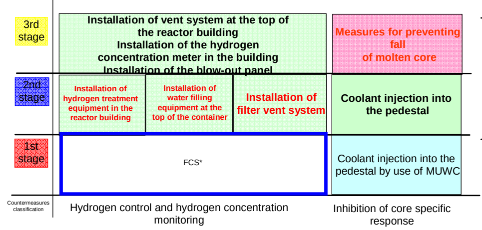
(5) Depressurization

(7) Cooling the reactor and reactor container (cooling)

Fourth layer Alleviation of impact after occurrence of accident

Problem (lessons learned)
Measures for alleviating impact after core damage (prevention of damage to the reactor container, hydrogen control, measures for preventing fall of molten core, prevention of large release of radioactive materials to environment) were not prepared.
Policy
Implementation of measures for alleviating impact after core damage (hydrogen control, monitoring hydrogen concentration and reaction inhibition of core specific response)

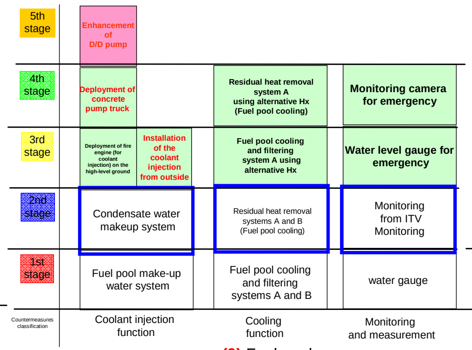
Hydrogen control
Hydrogen generated due to chemical reaction between zirconium and water after occurrence of core damage is properly extracted.
inhibition of core concrete response
Molten core is properly retained and cooled if it falls on the pedestal after the reactor pressure vessel is damaged.
* Since FCS is installed as a measure against LOCA, there is no capacity for fully eliminating a large amount of hydrogen that is generated at the time of SA.



(8) Alleviating impact after occurrence of core damage

Others Fuel pool cooling

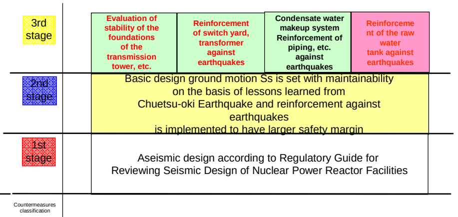
Problem (lessons learned)
Monitoring and measurement of water level and subsequent cooling of the fuel pool, coolant injection and ensuring water source in case that all power supplies were lost were not prepared well, personnel at the site had to think and respond on the site.
Policy
Implementation of enhancement of measures for coolant injection into the fuel pool and cooling the fuel pool (coolant injection function, cooling function, monitoring and measurement)



(9) Fuel pool

Others Enhancement of earthquake-resistance of nonessential equipment that can be expected as one of measures for responding to the accident

Problem (lessons learned)
Although the external power supply system was non-essential equipment, and was not expected to operate at the time of large-scale earthquake, the external power supply that kept functioning during the disaster played an important role for restoration at the Fukushima Daini Nuclear Power Station.
Policy
Even non-essential equipment can be used as one of measures for emergency response, and antiseismic reinforcement shall be implemented for equipment in which additional antiseismic reinforcement is available.

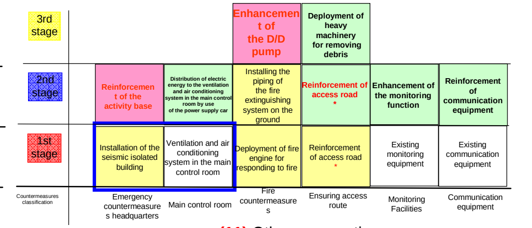


(10) Earthquakes

Others Safety measures from other perspectives

Problem (lessons learned)
Significant environment degradation, such as degradation of accessibility and workability at the site due to scattering of debris made it difficult to respond to the accident.
Policy
- Measures are taken for each function that is necessary to support incident response.

* As for reinforcement of the access road after the Chuetsu-oki Earthquake, ground improvement was implemented at locations where there was ground subsidence and ruptures on the road in the premises. For short-term measures based on the accident at the Fukushima Daiichi Nuclear Power Station, depth of subsidence due to deformation of the culvert having a low antiseismic class, which is expected at the occurrence of earthquake, is controlled and reinforcement work is implemented at the road crossing the culvert having a low antiseismic class in order to assure quick passage of emergency vehicles (power-supply cars and fire engines).



(11) Other perspectives

Issues Pointed Out in the Accident Response Activities (Operation: 1/3)

○ Protection was weak against a tsunami of unexpected size.

- **There was no attitude to make thorough examination as to what would happen if a tsunami of unexpected size hit the plant or to take appropriate measures.**
- **There were insufficient procedures or actions to be taken when all power was lost, to prevent cores from being damaged due to this, or to alleviate the aftermath of core damages. Workers had no choice but to take ad hoc steps at the site.**


Unit 1 (Seaside)


Electric Board Room at the First Basement Floor of the Turbine Building for Unit 1

Issues Pointed Out in the Accident Response Activities (Operation: 2/3)

○ **The plant was in turmoil** due to the complex disaster and simultaneous damages to more than one nuclear plant.

- More than one reactor had a damaged core. Many workers were deployed for protracted actions against the problem. However, the organization failed to shift gears to cope with the problem. While alert conditions continued, the plant had no choice but to try to solve the problems with all workers.
- The director-general of the nuclear emergency response headquarters was occupied with telephone communications and technicians were busy with public relations rather than taking action against the accident.

○ **The updated status of the plant was not understood or shared with outside smoothly**, as the plant had lost all power sources and hence all means of communication.

- Unit 1 lost power sources for indicator lamps and measuring instruments. Due to this, it was not possible to understand the status of the reactor. Communications were not secured so that accurate recognition on how emergency condensers were operated could be shared between the central control room and the nuclear emergency response headquarters.
- When stoppage occurred in the high pressure coolant injection system of Unit 3, it took about an hour to report the fact to the headquarters.
- Sufficient and prompt information sharing was unable to be maintained with relevant organizations.

Temporary batteries were used as the power source for measuring instruments

A flashlight was used to read the measuring instruments.

Issues Pointed Out in the Accident Response Activities (Operation: 3/3)

○ The plant didn't have sufficient materials and equipment to last until the conclusion of the accident.

- Transportation of necessary materials and equipment to the plant was hindered due to damaged roads and deteriorated means of communication due to the earthquake, as well as radioactive contaminants and exposure to radiation.
- Equipment could not be used in an easy to access manner when necessary. For example, parts for individual dosimeters were packed and transported separately and couldn't be used when necessary.
- The areas were designated as evacuation areas, making it impossible to transport and supply required materials to the plant directly and smoothly.

○ The spreading radiation coupled with an insufficient radiation control system made it difficult to cope with the accident.

- The accident spread the contamination and contaminated area outside of the usual control area, making the number of radiation controllers short.
- The tsunami took individual dosimeters away, and loss of power nullified the entire system in the plant. This necessitated tremendous labor to calculate the dose level.
- Due to insufficient infrastructure, tremendous labor was also necessary in controlling people's access, including selecting access points and securing necessary facilities.

Lessons Learned and Action Agenda (Operation)

Unexpected size of tsunami

(12) Too optimistic in foreseeing an accident

Turmoil in action

(13) Failure and insufficient preparation for actions at multiple plants

Failure to understand and share the plant status

(14) Insufficient sharing of information

Lack of materials and equipment to cope with the accident

(15) Transportation of materials and equipment not prepared well

Contamination spread out

(16) Insufficient preparation for radiation control

(17) Inappropriate disclosure when the accident occurred and of related information

(12) Preparedness for an accident of unexpected size
- Thorough examination and taking necessary actions for a tsunami of unexpected size
- Being well-prepared for severe accidents (incl. procedures and drills)

(13) Emergency response preparedness against complex disasters and simultaneous accidents at multiple plants
- Preparing a system that can cope with a complex disaster with natural disasters and simultaneous accidents to multiple plants

(14) Strengthening communication and sharing of information
- Strengthening plant monitoring and means of communication
- Establishing a structure that allows sharing of critical information between the accident site, nuclear emergency response headquarters in the plant, and the head office
- Sharing of accident information in a timely manner between the central government and the relevant authorities and ensuring redundancy of means of communication

(15) Strengthening the system for procuring and transporting materials and equipment
- Keeping inventory of materials and equipment at the plant so that they can be swiftly used after an accident
- Establishing a system that ensures the supply of necessary materials and equipment to the affected plant even when the area is designated as an alert area

(16) Strengthening radiation control systems in the event of an accident
- Enhancing the reliability of monitoring posts and reinforcing monitoring cars
- Increasing the number of dosimeters and radiation protection facilities deployed to the nuclear emergency response headquarters and the central control room
- Training radiation measurement technicians
- Protecting the nuclear emergency response places from contamination by radiation and shielding these places against radiation

(17) Announcement and dissemination of accident information to society
- Re-establishment of media response system and proactive dissemination of information through the Internet, as well as making reference documents that will be used if a severe accident occurs.
- Concentration of public relation activities by strengthening the off-site center functions

Measures at the Kashiwazaki Kariwa Nuclear Power Plant based on the lessons learned from the Fukushima Daiichi Nuclear Power Plant accident (Operational)

- (pink) Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [medium- to long-term]
- Red: Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (being implemented)
- Black: Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (completed)
- (yellow) Measures based on the Niigataken Chuetsu-oki Earthquake
- (light blue) Accident management developed prior to accident at the Fukushima Daiichi Nuclear Power StationCountermeasures
- (white) Facilities adopted in the basic design

Note: Items in the blue thick frame are facilities in which effect is predicted with water stoppage measures by use of the seawall.

(12) Status of operational countermeasures of preparations for accidents

Problem (lessons learned)
Protection against unanticipated tsunami was insufficient.

Policy
- Preparing procedure for responding to the accident surpassing conventional anticipation, such as tsunami and loss of all power supplies.
- Implementing repeated education and training sessions for deployed response procedure.
- Making employees acquire necessary qualifications for driving heavy machinery

Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [medium- to long-term]
Red Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (being implemented)
Black Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (completed)
Measures based on the Niigataken Chuetsu-oki Earthquake, etc.
Accident management countermeasures developed prior to the accident at the Fukushima Daiichi Nuclear Power Station
Conventional responses being continued

Specific response

Preparation of response procedures		Education and training		Acquisition of training
More improvement of guidance		Simulator training for operators Earthquakes + Tsunami + SBO		
Guidance for responding in the event that functions of the power supply are lost	Flexible response guidance in case of emergency	Training for response in case of loss of power supply functions, etc.	Reinforcement of emergency response training	
Guidance for accident management (AM)	Guidance of AM (accident management) for tsunami	Training for operators regarding guidance of AM (accident management) for tsunami	Anticipation of a severe accident during emergency response training	
Guidance for accident management (AM)	Severe accident in emergency operating procedures	Training regarding AM (accident management) for operators	Training regarding accident management	
Operation manual upon actuation of alarms	Emergency operating procedures	Simulator training for operators	Emergency response training	Acquisition of necessary qualifications for heavy machinery, etc.

Countermeasures classification

(13) Operation status of countermeasures upon occurrence of complex disaster or simultaneous disaster at multiple plants

Problem (lessons learned)
The organization was confused when complex disaster and disaster occurred at multiple plants at the same time.

Policy
- Sharply increasing the number of personnel responding emergency at the power plant in order to respond to accidents that occur at multiple plants and long-term accident.
- Increasing the number of operators and personnel on duty for onsite response at initial phase.
- Increasing the number of personnel on duty and personnel for emergency response at the head office in order to support the power plant properly.
- Additional deployment of the alternative command post (alternative TSC)
- Introduction of ICS (Incident Command System)
- Clarifying the chain of instruction and command at the emergency countermeasures headquarters.
- Reinforcing the support system from cooperative firms and manufacturers, etc.
- Preparing the nuclear rescue unit equipped with remotely-operable robot, etc. in the Federation of Electric Power Companies.

Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [medium- to long-term]
Red Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (being implemented)
Black Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (completed)
Measures based on the Niigataken Chuetsu-oki Earthquake, etc.
Accident management countermeasures developed prior to the accident at the Fukushima Daiichi Nuclear Power Station
Conventional responses being continued

Specific response

Increase in number of personnel for response		Preparation of organization		
Increasing the number of personnel on duty during night time and holidays (personnel for onsite response)				
Increasing the number of personnel on duty during night time and holidays (personnel for external communication and personnel for collecting information)	Increasing the number of operators			
Reinforcement of the number of personnel for radiation control in the system of personnel on duty during night time and holidays	Sharp increase of the number of personnel for emergency response	Introduction of ICS	Reinforcement of the support system	
System of personnel on duty during night time and holidays	Personnel for emergency response	Clarification of the chain of instruction and command (arrangement of the person responsible for the unit)	Preparation of the nuclear rescue unit	Additional arrangement of the alternative command post

Countermeasures classification

(14) Reinforcement of plant oversight, communication means, information sharing <communication and information sharing>

Problem (lessons learned)
Communication means, such as communication equipment, were restricted due to blackout, etc. and sharing information about the status became difficult; therefore plant states could not be smoothly determined and shared.

Policy
- Reinforcing monitoring and communication means, such as reinforcement of power supply and diversification of communication means.
- Formalizing information necessary at the accident in advance and preparation of guidance that is shared among operators, emergency countermeasures office and head office.
- National government dispatches members of the nuclear regulatory commission and director-general for emergency response measure. Also, cooperation is developed with the video conference system linking the national government and related organizations.

Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [medium- to long-term]
Red Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (being implemented)
Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (completed)
Black Measures based on the Niigataken Chuetsu-oki Earthquake, etc.
Accident management countermeasures developed prior to the accident at the Fukushima Daiichi Nuclear Power Station
Conventional responses being continued

Specific response

Reinforcement of monitoring of plant oversight		Plant parameter	Cooperation with the national government
Reinforcement of communication means in the main control room			
Deployment of storage battery, etc. at the main control room			Diversification of the report means to the local government
Satellite-based mobile phone equipped with the outdoor antenna	Reinforcement of deployment of satellite-based mobile phone	Guidance for sharing plant information when at the time of shutdown of SPDS	Development of cooperation with the video conference system linking the national government
Hot line between the main control room and the important seismic isolated building	Satellite-based mobile phone	Plant parameter transmission system (SPDS)	Video conference system

Countermeasures classification

(15) Operation status of countermeasures for reinforcing procurement of materials and equipment and transportation system

Problem (lessons learned)
There was a shortage of materials and equipment for mitigating the accident.

Policy
- Storing food and beverages, which are necessary at the moment, in the power plant in consideration of deterioration of traffic situation.
- Making agreements with shipping companies and providing education regarding radiation protection to operators in order to transport necessary goods while a restricted area is set.
- Arranging logistic support bases (transportation base and access control base) reflecting lesson learned from the accident at the Fukushima Daiichi Nuclear Power Station.

Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [medium- to long-term]
Red Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (being implemented)
Black Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (completed)
Measures based on the Niigataken Chuetsu-oki Earthquake, etc.
Accident management countermeasures developed prior to the accident at the Fukushima Daiichi Nuclear Power Station
Conventional responses being continued

Specific response

Storage	Reinforcement of transportation system	Logistic support base
Agreement on procurement of fuel in emergency	Education regarding radiation protection for operators in shipping companies	
Storage of fuel	Transportation contract with shipping companies (including the restricted area)	
Storage of 7 days' worth food and beverage for personnel for emergency response	Transportation contract with shipping companies	Logistic support bases

Countermeasures classification

(16) Operation status of countermeasures for reinforcing the radiation control system at the time of an accident

Problem (lessons learned)
Dispersion of contamination and insufficient radiation control system made response to the accident difficult.

Policy
- Reinforcing the power supply at the monitoring post and reinforcing the monitoring car.
- Deploying additional radiation measuring device, materials and equipment for radiation protection at the emergency countermeasures office and the main control room. .
- Preparing the method for evaluating internal exposure at the time of an accident and response procedure.
- Establishing the method for preventing inflow of radioactive materials into the emergency countermeasures office and implementing the training.
- Implementing education for personnel measuring radiation at all offices in order to enable them to perform radiation measurement in wide area.

Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [medium- to long-term]
Red Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (being implemented)
Black Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (completed)
Measures based on the Niigataken Chuetsu-oki Earthquake, etc.
Accident management countermeasures developed prior to the accident at the Fukushima Daiichi Nuclear Power Station
Conventional responses being continued

Specific response

Reinforcement of monitoring device		Materials and equipment for radiation protection, method for evaluating internal exposure, prevention of inflow of radioactive materials, increase the number of personnel	
		Deployment of simple WBC	
	Deployment of a movable monitoring post	Deployment of the simple area entry control device	Sharp increase of radiation measurement personnel
Reinforcement of monitoring car (1 unit to 3 units)	Reinforcement of the power supply of the monitoring post (emergency power supply)	Increasing the number of APD at the important seismic isolated building and the main control room	Measures for preventing inflow of radioactive materials into the emergency countermeasures office
Deployment of one unit of monitoring car	Duplication of the power supply and transmission system at the monitoring post	Deployment of radiation protection accessories and APD for restoration personnel	Reinforcement of deployment of radiation protection accessories for restoration personnel

Countermeasures classification

(17) Announcement and transmission of information to society at the time of an accident

Problem (lessons learned)
Announcement and communication at the event of the accident were not sufficient.

Policy
- Reconstruction of the system for handling news report
- Preparation of documents that are used in case of a severe accident
- Active transmission of information by use of Internet

Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [medium- to long-term]
Red Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (being implemented)
Black Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (completed)
Measures based on the Niigataken Chuetsu-oki Earthquake, etc.
Accident management countermeasures developed prior to the accident at the Fukushima Daiichi Nuclear Power Station
Conventional responses being continued

Specific response

Reinforcement of announcement and transmission of information to society at the time of an accident		
		Active transmission of information by use of Internet
		Transmission of information by use of emergency radio-casting
		Transmission of information by use of PR car
Reconstruction of system for handling news report	Preparation of documents that are used in the event of a severe accident	Real-time release of monitoring post data, etc.

Countermeasures classification

(1) Sharing of information using a video conference system formed by the central government
(2) Diversification of means of communication with the relevant governmental authorities
(3) Expanding reporting networks by signing a disaster communication agreement

Video Conference System

Video conference system for relevant sites

• Introduction of the government-sponsored video conference system to connect the central government, the head offices of electricity companies, and other relevant governmental organizations

Diversification of means of communication

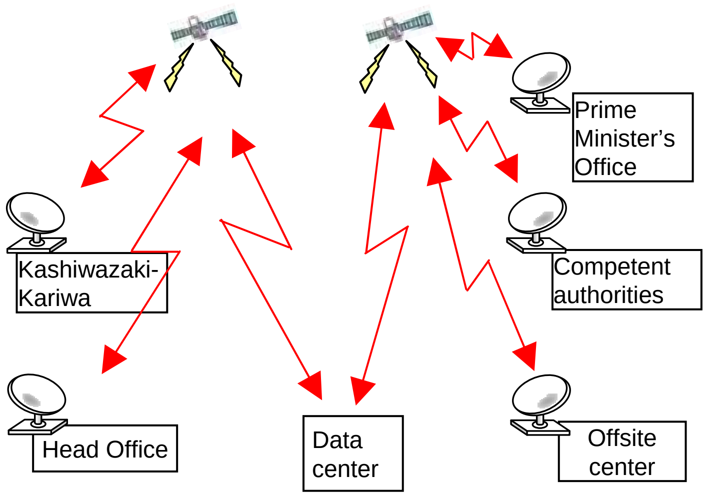
Improvement of satellite mobile lines and establishing a communication network using satellite connections

• Examine introduction of mass e-mails from satellite mobile lines to mobile phones and broadcasting faxes using satellite connections

Expanding reporting networks

Facilitating sharing of information under normal circumstances and making quick and sure reporting

• Signing a new accident reporting and communication agreement with 28 municipalities in Niigata Prefecture
• Signing a Memorandum on Disaster Communication with Nagano and Tochigi prefectures



Affiliating the Government's Video Conference System

☆ A safety agreement already signed with prefectures and municipalities which have nuclear plants

Parties concerned

Kashiwazaki-Kariwa: Niigata Prefecture, Kashiwazaki City and Kariwa Village

Ⅱ． Measures based on the Fukushima Daiichi accident

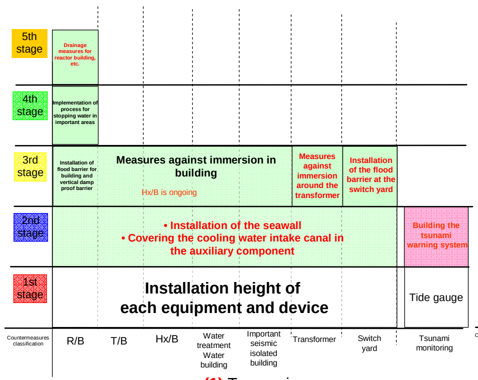
Measures at the Kashiwazaki Kariwa Nuclear Power Plant based on the lessons learned from the Fukushima Daiichi Nuclear Power Plant accident (Facility aspect)
<Ex. of Kashiwazaki Kariwa Unit1>

Legend	
(Pink)	Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [medium- to long-term]
Red	Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (being implemented)
Black	Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (completed)
(Yellow)	Measures based on the Niigataken Chuetsu-oki Earthquake
(Light blue)	Accident management countermeasures developed prior to the accident at the Fukushima Daiichi Nuclear Power Station
(White)	Facilities adopted in the basic design

Note: Items in the blue thick frame are facilities in which effect is predicted with water stoppage measures by use of the seawall.

First layer Prevention of trouble

Problem (lessons learned)
Protection against unanticipated tsunami was insufficient.
Policy...Enhanc3 resistance to tsunami including existing facilities through measures against tsunami (water stoppage).

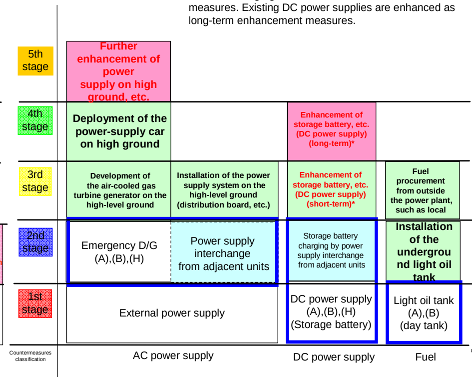


(1) Tsunami

Third layer Prevention of core damage after occurrence of accident (power supply)

Problem (lessons learned)
Sufficient alternative measures for the case where all power supplies (DC and AC power supplies) are lost were not prepared.
Policy
- Protect the existing power supply system through water stoppage measures.
- Ensure new measures for continuously responding for a long time when all power supplies are lost
  Enhance the resistance to tsunami by installing the DC power supply system on high ground

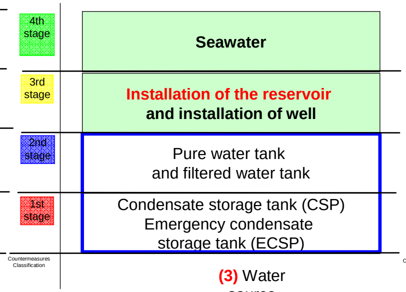
* Emergency generator and DC power supply system are installed on high ground as short-term enhancement measures. Existing DC power supplies are enhanced as long-term enhancement measures.



(2) Power supply

Third layer Prevention of core damage after occurrence of accident (water source)

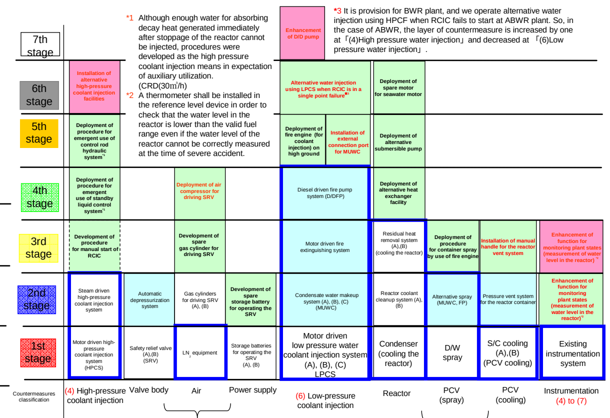
Problem (lessons learned)
Sufficient water source and means for injecting water necessary for preventing core damage and alleviating impact after core damage were not retained.
Policy
- Expecting the existing water source through water stoppage measures.
- Developing measures for injecting coolant using each water source while ensuring various water sources, such as installation of reservoir and well, injection of sea water.



(3) Water source

Third layer Prevention of core damage after occurrence of accident (coolant injection, depressurization, cooling)

Problem (lessons learned)
Subsequent high-pressure coolant injection, depressurization, low-pressure coolant injection, cooling and ensuring of water source in the event that all power supplies are lost were not prepared well, personnel at the site had to think and respond on the site.
Policy
Enhancement of each measure (high-pressure coolant injection, depressurization, low-pressure coolant injection and cooling for the reactor and reactor container)



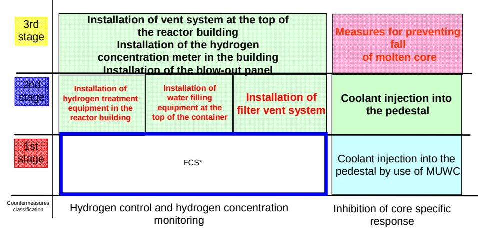
(5) Depressurization

(7) Cooling the reactor and reactor container (cooling)

Fourth layer Alleviation of impact after occurrence of accident

Problem (lessons learned)
Measures for alleviating impact after core damage (prevention of damage to the reactor container, hydrogen control, measures for preventing fall of molten core, prevention of large release of radioactive materials to environment) were not prepared.
Policy
Implementation of measures for alleviating impact after core damage (hydrogen control, monitoring hydrogen concentration and reaction inhibition of core specific response)

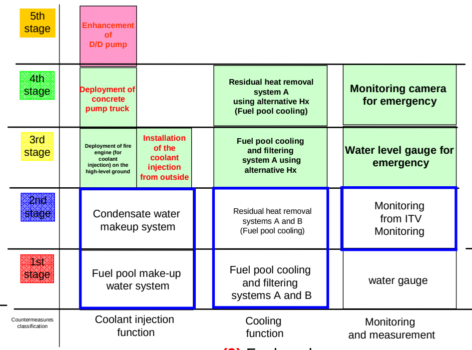
Hydrogen control
Hydrogen generated due to chemical reaction between zirconium and water after occurrence of core damage is properly extracted.
inhibition of core concrete response
Molten core is properly retained and cooled if it falls on the pedestal after the reactor pressure vessel is damaged.
* Since FCS is installed as a measure against LOCA, there is no capacity for fully eliminating a large amount of hydrogen that is generated at the time of SA.



(8) Alleviating impact after occurrence of core damage

Others Fuel pool cooling

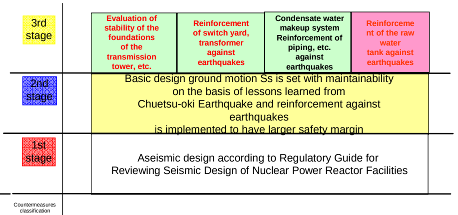
Problem (lessons learned)
Monitoring and measurement of water level and subsequent cooling of the fuel pool, coolant injection and ensuring water source in case that all power supplies were lost were not prepared well, personnel at the site had to think and respond on the site.
Policy
Implementation of enhancement of measures for coolant injection into the fuel pool and cooling the fuel pool (coolant injection function, cooling function, monitoring and measurement)



(9) Fuel pool

Others Enhancement of earthquake-resistance of nonessential equipment that can be expected as one of measures for responding to the accident

Problem (lessons learned)
Although the external power supply system was non-essential equipment, and was not expected to operate at the time of large-scale earthquake, the external power supply that kept functioning during the disaster played an important role for restoration at the Fukushima Daini Nuclear Power Station.
Policy
Even non-essential equipment can be used as one of measures for emergency response, and antiseismic reinforcement shall be implemented for equipment in which additional antiseismic reinforcement is available.

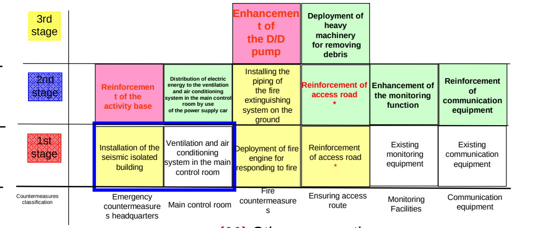


(10) Earthquakes

Others Safety measures from other perspectives

Problem (lessons learned)
Significant environment degradation, such as degradation of accessibility and workability at the site due to scattering of debris made it difficult to respond to the accident.
Policy
• Measures are taken for each function that is necessary to support incident response.

* As for reinforcement of the access road after the Chuetsu-oki Earthquake, ground improvement was implemented at locations where there was ground subsidence and ruptures on the road in the premises. For short-term measures based on the accident at the Fukushima Daiichi Nuclear Power Station, depth of subsidence due to deformation of the culvert having a low antiseismic class, which is expected at the occurrence of earthquake, is controlled and reinforcement work is implemented at the road crossing the culvert having a low antiseismic class in order to assure quick passage of emergency vehicles (power-supply cars and fire engines).



(11) Other perspectives

Layer 1 Preventing Problems

Issues (Lessons) ... Protection was weak against a tsunami of unexpected size.
Policy ... Add tsunami prevention measures to enhance the ability to withstand tsunamis, including existing facilities

Legend	
(pink)	**Measures (mid- to long activities) based on the Fukushima Daiichi Plant accident**
Red	**Measures (short-term) based on the Fukushima Daiichi accident (ongoing)**
Black	**Measures (short-term) based on the Fukushima Daiichi accident (done)**
(yellow)	Measures against the Niigata Prefecture Chuetsu Off-shore Earthquake
(light blue)	Accident management measures set up before the Fukushima Daiichi Plant accident
(white)	Facilities employed under the basic design

Note: Actions in the bold blue frame refer to facilities where tsunami prevention measures using tide embankments can be effective.

Classification of measures	R/B	T/B	Hx/B	Water treatment building	Important anti-seismic building	Transformer	Switching stations	Monitoring tsunamis
Stage V	**Water drainage of R/B, etc.**							
Stage IV	**Waterproofing at critical areas**							
Stage III	**Installing tide barriers and vertical damp proof barriers at buildings**	**Measures against inundation of buildings** Hx/B is ongoing				**Measures against inundation around transformers**	**Installing tide barriers at switching stations**	
Stage II	**Installing a coast levee Covering auxiliary machine water-intake channel**							**Installing a tsunami warning system**
Stage I	**Height of installation of each facility and equipment**							Tidal level meter

(1) Tsunami

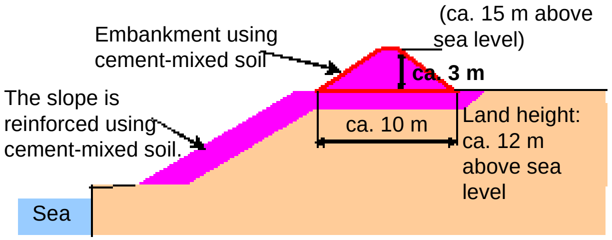
(1) Reducing Inundation and Avoiding Aftermath by Installing a Tide Levee <Tsunami Countermeasures>

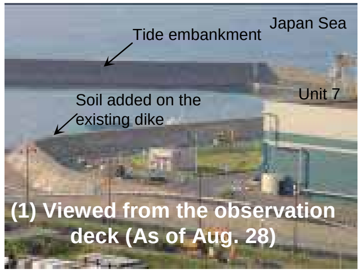
A 15-m high tide levee from the sea level can reduce flooding of buildings at the site and help avoid the aftermath of a tsunami of over the design height of 3.3 m.

Tide embankment on the side of Unit 5 to 7 (dike)

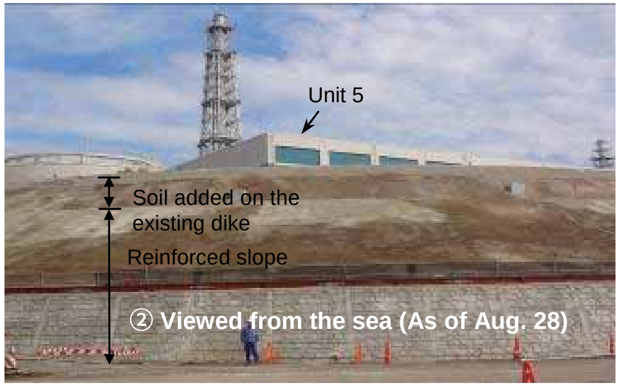
⇒Main body construction completed as of Aug. 29

- Soil mixed with cement was added with a height of about 3 m at the site about 12 m above sea level, and the slope on the sea side was reinforced.
- The peripheral areas will be improved within FY2012 as a target.





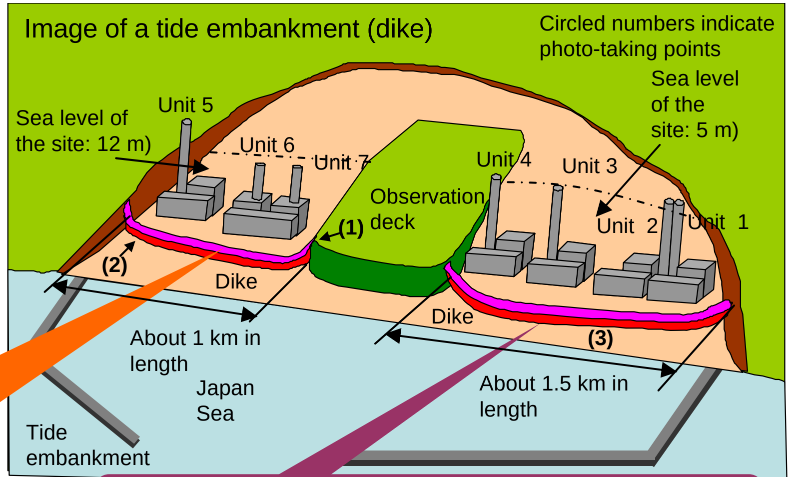
(1) Viewed from the observation deck (As of Aug. 28)



② Viewed from the sea (As of Aug. 28)

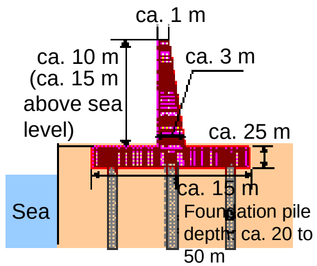
A water drainage system is also added against flooding within the tide embankment.

The tide embankment is designed to withstand the design earthquake ground motion of Ss and wave power equivalent to a tsunami of 15 m in height (or 3 times of static hydraulic pressure).



Tide embankment (dike) on the side of Unit 1 to 4

⇒Construction is progressing smoothly.



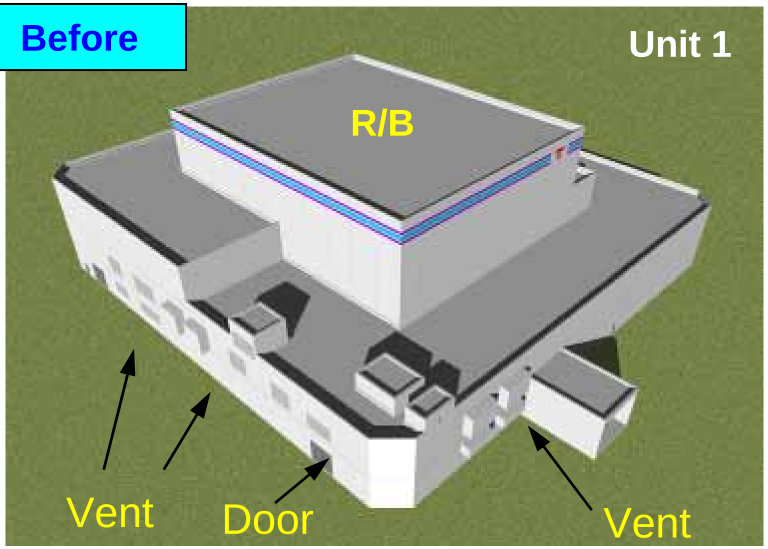

(3) viewed from the sea (As of Aug. 28)

- A iron bar reinforced dike of about 10 m in height is installed at the site 5 m above sea level. The dike is fixed in place firmly using foundation piles.
- On Aug. 28, driving in of a total of 891 foundation piles was completed on the dike. A part of the walls is also completed.

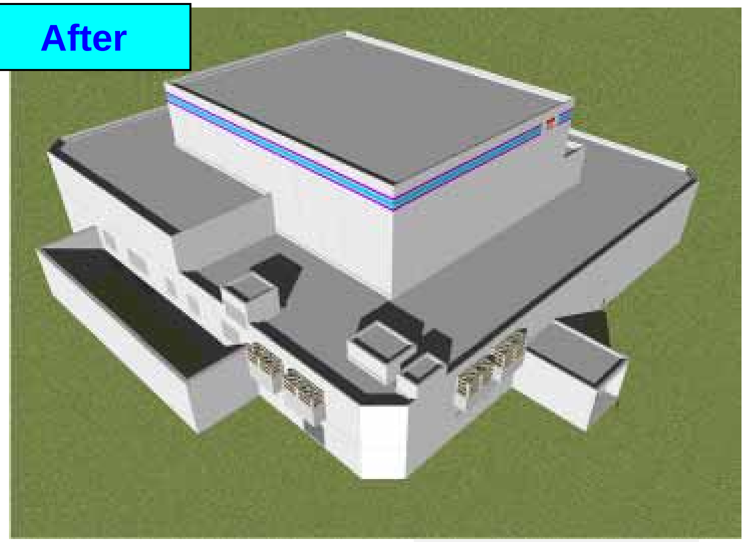
(1) Reducing Inundation and Avoiding Aftermath by Installing a Tide Levee <Tsunami Countermeasures>

A tide embankment of 15 m above sea level and vertical damp proof barriers are installed to prevent water coming into the R/B when the site is inundated with seawater.

Before



After



[Installation of Tide Embankments and Vertical Damp Proof Barriers]
- Tide embankment: Done- Unit 1 Under construction – Unit 2 to 4
- Vertical damp proof barrier: Done – Unit 1 Under construction – Unit 2 to 4

Vertical damp proof barrier

Tide embankment

Unit 1 building
(As of June 29)

* These tide embankments and vertical damp proof barriers are installed in Unit 1 to 4 only as they have an opening below T.P. 15 m.

Design condition
- They shall function well against the design earthquake ground motion (Ss).
- They shall function well against 3 times of static hydraulic pressure as wave power (same as that for tide embankment).

(1) Preventing Flooding of Critical Areas by Installing Water-tight Doors, etc. <Tsunami Countermeasures>

In addition, a water-tight door is installed in rooms where critical devices are installed, to prevent flooding in the case where seawater enters the building for some reasons.

Installing Water-tight Doors (Ex. Pump Room of RCIC in Unit 1)

A watertight door is installed at:
- RCIC room
- ECCS rooms (A)
- MUWC room
- Emergency electric room
- Others

Design conditions (water-tight door)

Water-tightness
- ca. 0.2 m³/m² • h

Hydraulic head pressure
- Floor height of each floor
  Ex.: K1 B5 – 18 m

Through holes for piping, cable trays and conduits

Example of waterproofing piping

Example of waterproofing for cable trays

Waterproofing using silicone rubber

Waterproofing done at:
- Through holes for piping
- Cable trays
- Conduits
- Others

Design conditions (through holes)

[Water power of a tsunami (external)]
- Front: 3 times of static hydraulic pressure
- Sides: 1.5 times
- Inside building: 1.0 time

[Hydraulic head pressure]
Aboveground
- Tsunami height (15m)-Height of through hole (m)

(1) Water Drainage in Reactor Buildings <Tsunami Countermeasures>

Measures have been taken against a tsunami, such as tide embankments, tide barriers, water-tight external doors, waterproofing at through holes, water-tight doors in the critical device room, etc. Also, a emergency power sources-driven temporary and permanent water drainage system is being installed at each R/B to avoid adverse impact on critical devices due to unexpected inundation. (Until a permanent water drainage system is installed, a temporary engine pump will be used to drain water as shown below.)

The plant water draining procedures drain from the bottom floor using a temporary engine pump.

Specifications:
- Weight: 30 kg
- Capacity of a fuel tank: 3.6 liter
- Pump head: ca. 30 m (Flow rate: 100 L/min.)
- Max. pumping vol.: 1,000 L/min

In preparation for inundation when an RCIC is manually starting under SBO conditions, a permanent water drainage system is being installed.

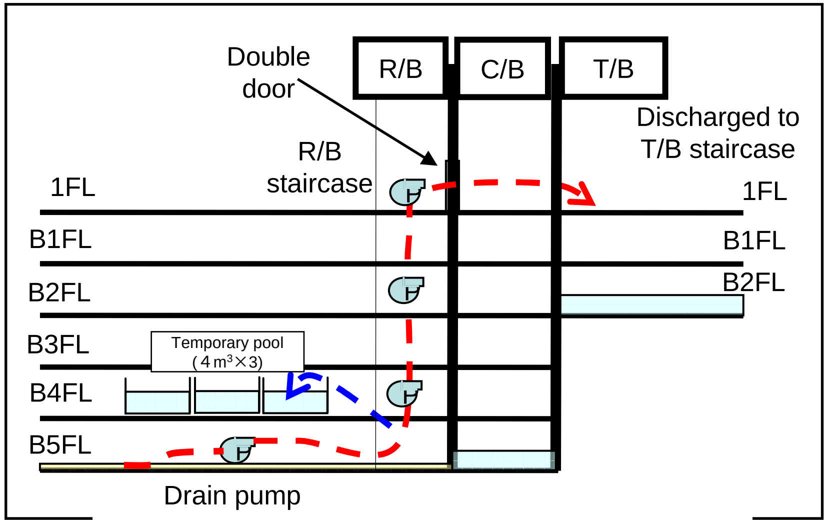
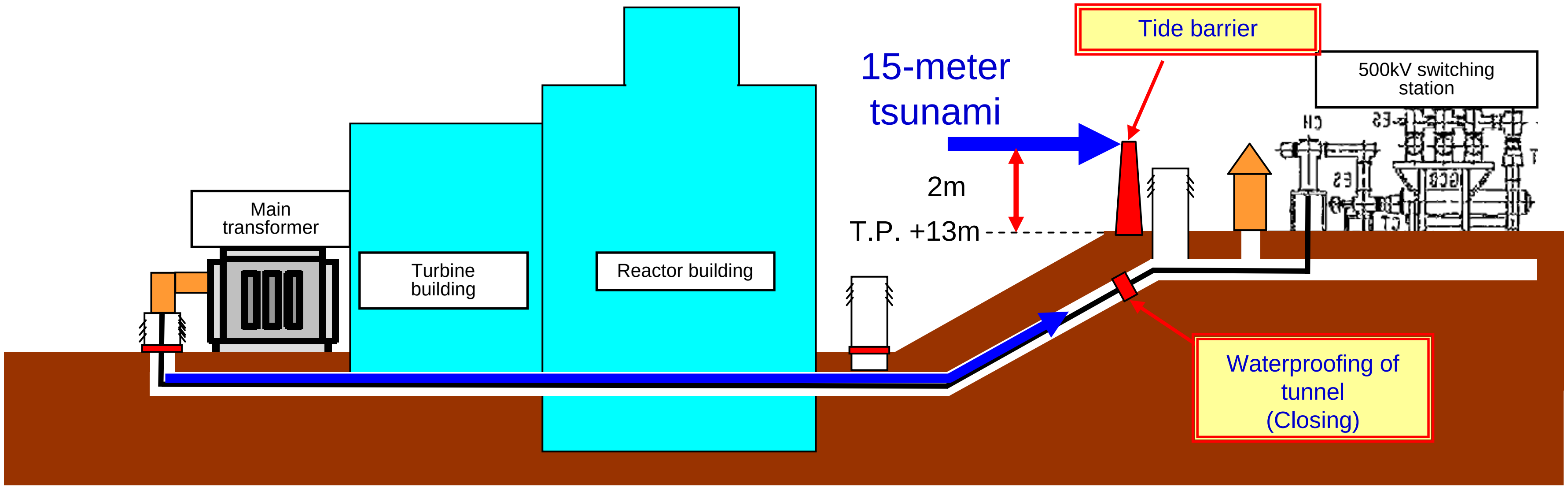


Figure: An Image of the Water Drainage

(1) Switching Station <Tsunami Countermeasures>

Waterproofing measures will be done to protect switching rooms and devices installed therein against inundation by a tsunami of 15 m in height.

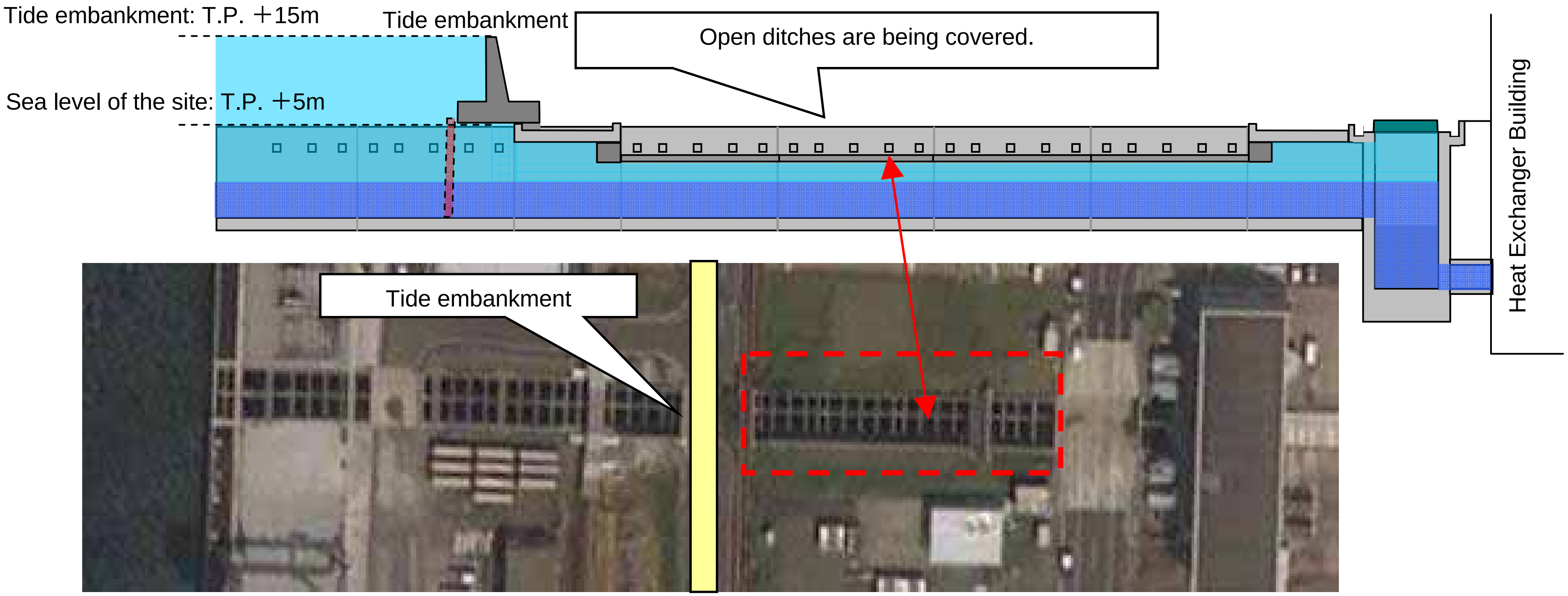
- Assuming a tsunami of 15 m in height, a tide barrier of about 2.0 m in height will be installed in the switching station at 13 m above sea level.
  (Design conditions): Can function against vibration of Ss. Assuming a tsunami of 15 m in height (a wall of 2 m in height).
  Tsunami wave power: Considering dynamic hydraulic pressure (1.5 times of static hydraulic pressure)
  * The 1.5–times hydraulic pressure is used for calculation of a tide barrier that is derived from 'Use 1.5 times as the static hydraulic pressure of a tide barrier if it is more than 500 m away from the seaside,' which is the condition for setting a coefficient to be used in the tsunami load calculation formula for structures. This is found in a technical finding document on designing tsunami-withstanding structures, issued by MLIT to prefectural governors. (A tide barrier should be installed more than 500 m away from the seaside.)
- Waterproofing will be done within the underground tunnel to prevent seawater from coming up through the tunnel.



(1) Covering Auxiliary Machine Water-Intake Channel <Tsunami Countermeasures>

To reduce the amount of seawater coming into the plant and to alleviate the impact of a tsunami, a tide embankment of 15 m in height is under construction. Even after completion of the levee, it is possible that a tsunami seawater could flow into the site through an open ditch such as a water-intake channel and damage the power generation facilities. To prevent this, openings including open ditches are being closed.

Ex. Emergency Auxiliary Machine Water-Intake Channel for K1

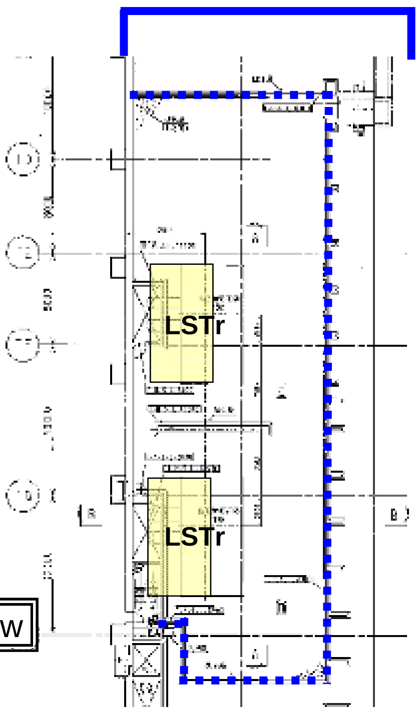


(1) Protecting Transformers from Inundation <Tsunami Countermeasures>

Measures against inundation of low starting voltage transformers are being implemented to increase the reliability of external power sources.

As a means to prevent inundation of low starting voltage transformers expected after the completion of the tide embankment, an impervious wall will be installed.

Ex. Image of an impervious wall to Unit 1

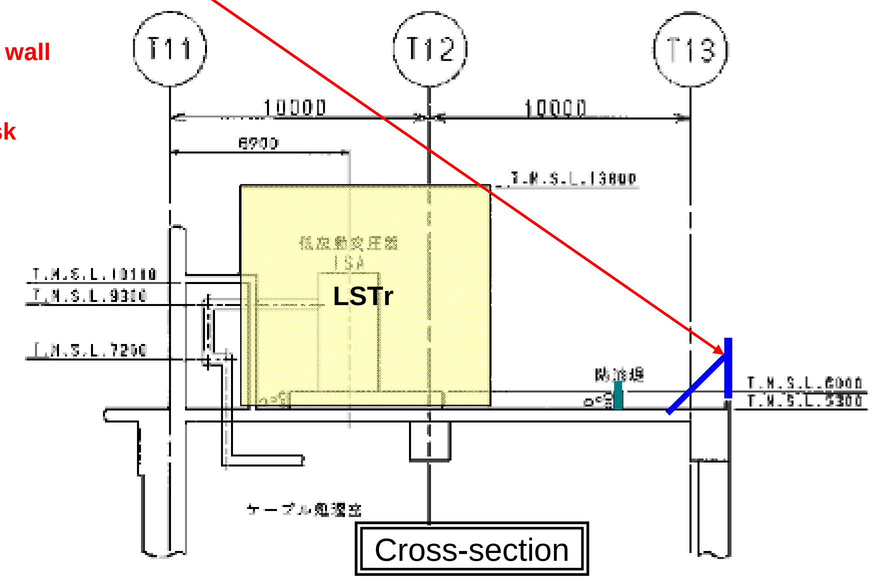


Plain view

Impervious wall

- Impervious wall
- Existing disk

* Heights and specifications will be determined based on the inundation assessment.

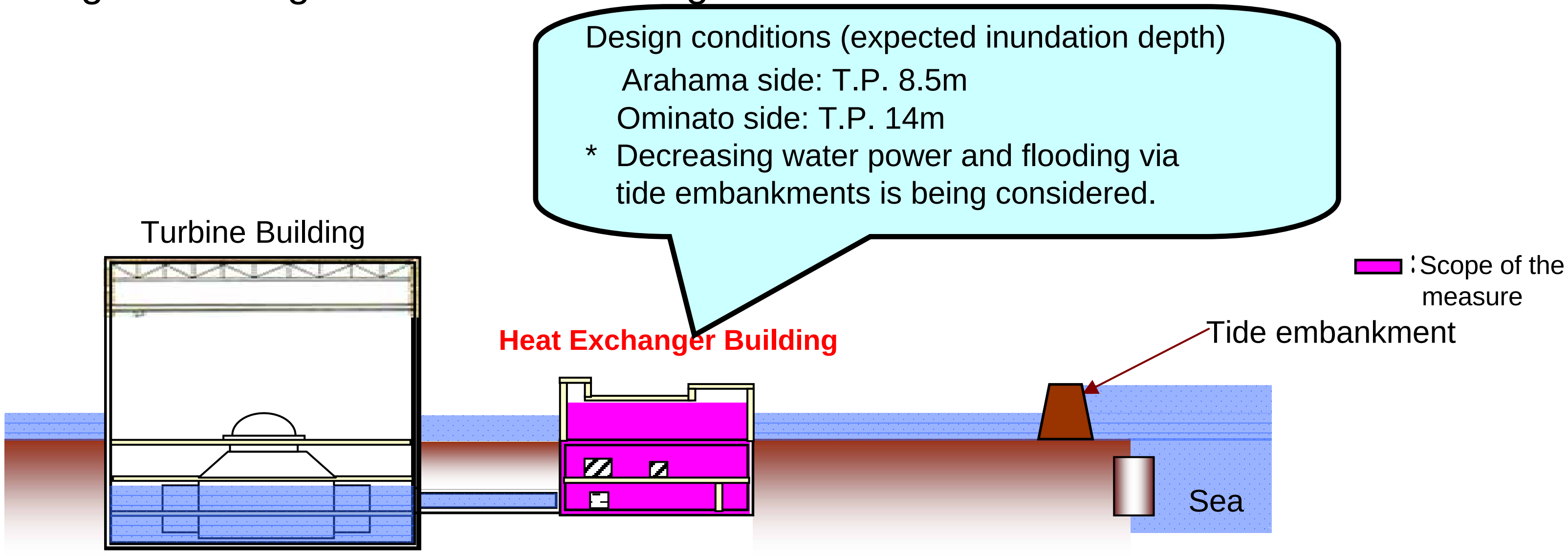


Cross-section

(1) Protecting the Heat Exchanger Building, etc. from Inundation <Tsunami Countermeasures>

In order to ensure early cold shutdown for reactors, the heat exchanger building has been waterproofed so that a tsunami won't damage the function of the system of sea-water heat exchangers.

- Reinforcing the seawater pump room water-intake channel hatches within the heat exchanger building (adding reinforcement to the hatch cover)
- Installing a water stop at external openings
- Reinforcing the building structure
- Installing a water-tight door in the building



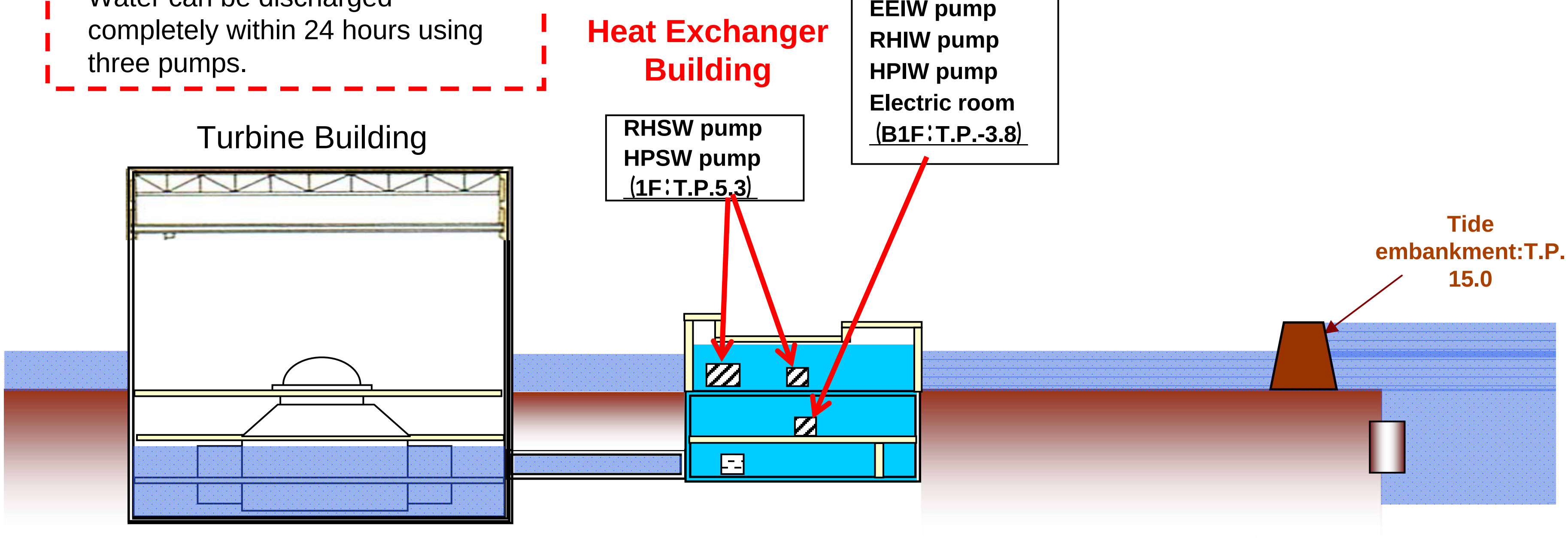
(1) Drain Pump in the Heat Exchanger Building <Tsunami Countermeasures>

When a tsunami of unexpected size hits and inundates the heat exchanger building, the sea-water pump in the building supporting the power source, cooling down, and water supply can be restored as soon as possible by removing water quickly.

(For the two plants) 6 water discharge pumps (8 in. in water discharge diameter, 300m^3/h in discharge volume and 26 m in max pumping height), 6 sets of hose (8 in. in diameter) are stored as emergency response materials (for 2 plants).

Ex. Unit 1 (Assuming water discharge of 20,000 m^3)

* Water can be discharged completely within 24 hours using three pumps.



Layer 3 Preventing Core Damage when an Accident Occurs

Issues (Lessons)

Alternative power sources weren't sufficient in preparation for the total loss of all power sources (AC and DC)

Policy
- Expect existing power sources after waterproofing
- Secure new measures against protracted total power loss. Protect AC power sources against tsunamis by installing them on higher ground.

Legend:
- (Pink) Measures (mid- to long activities) based on the Fukushima Daiichi Plant accident
- Red: Measures (short-term) based on the Fukushima Daiichi accident (ongoing)
- Black: Measures (short-term) based on the Fukushima Daiichi accident (done)
- (Yellow) Measures against the Niigata Prefecture Chuetsu Off-shore Earthquake
- (Light blue) Accident management measures set up before the Fukushima Daiichi Plant accident
- (White) Facilities employed under the basic design

Note: Actions in the blue bold frame refer to facilities where tsunami prevention measures using tide embankments can be effective.

* As short-term reinforcement, emergency power generators and DC power sources will be installed at high ground. As a long-term measure, existing DC power sources will be reinforced.

Classification of measures	AC power sources	AC power sources	DC power sources	Fuel
Stage V	Reinforcement incl. installing power sources in higher places			
Stage IV	Deployment of power source cars at high ground		Reinforcement of batteries (DC power sources), etc. [Long-Term Measure]	
Stage III	Deployment of air-cooling gas turbine power generation cars at high ground	Installing power source facilities (distributors, etc.) at high ground	Reinforcement of batteries (DC power sources), etc. [Short-Term Measure] *	Fuel procurement from outside the power plant, such as local
Stage II	Emergency D/G (A),(B),(H)	Supply of power from reactors nearby	Battery charging by power supply interchange from adjacent units	Installation of underground light oil tanks
Stage I	External power sources		DC power sources (A),(B),(H) (Batteries)	Light oil tank (A),(B) (DI tanks)

(2) Power Source

(2) Early Power Restoration by Deploying Air-Cooling GTGs and Power Source Cars at High Ground <Securing Power Supply>

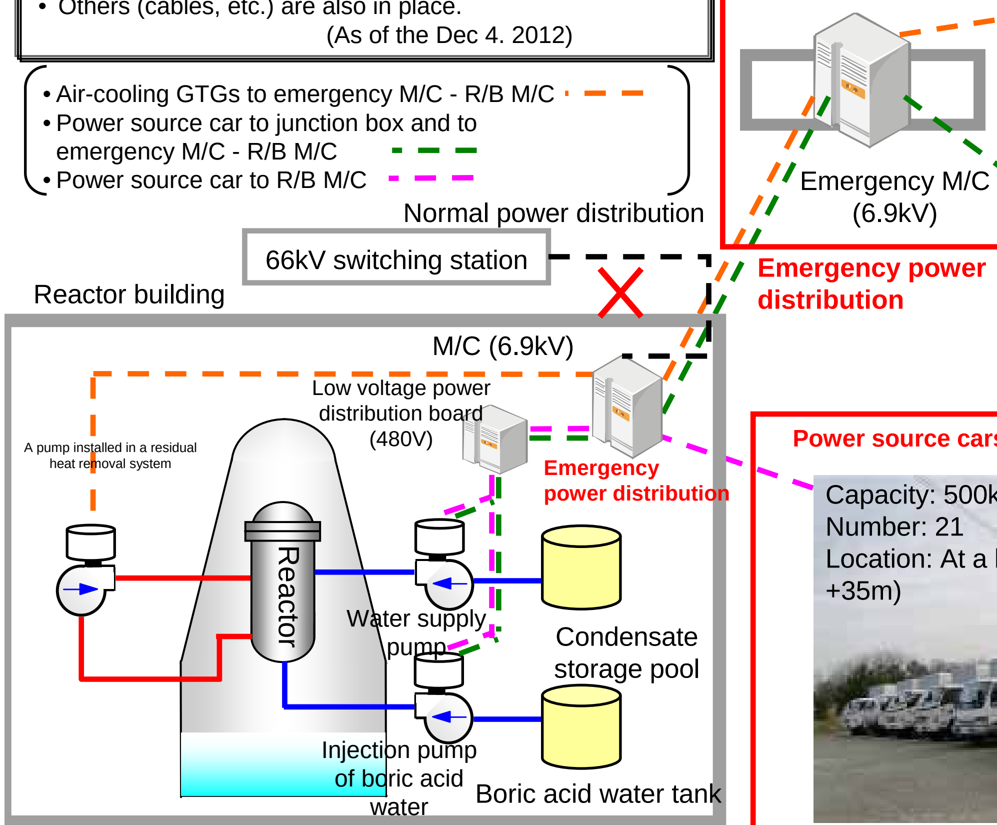
In preparation for unexpected total power loss of the plant, large air-cooling gas turbine power generation cars (air-cooling GTGs) are now deployed at high ground so that power can be supplied to critical devices. In addition, underground light oil tanks have been installed for fuel supply purposes. Emergency high tension power distribution boards (M/C) are installed to supply electricity swiftly, with permanent cables laid to each reactor. Many power source cars are deployed at high ground.

- Two air-cooling GTGs have already been deployed.
- 23 power source cars have already been deployed. (The number will eventually be increased to 23.)
- A power generator with an engine has already been deployed.
- Others (cables, etc.) are also in place.

(As of the Dec 4. 2012)

- Air-cooling GTGs to emergency M/C - R/B M/C
- Power source car to junction box and to emergency M/C - R/B M/C
- Power source car to R/B M/C

Power supply routes



Junction box

An air-cooling GTG installed at high ground

Capacity: 4,500kVA
Number: 2 (Can operate RHR(A) in 7 plants)
Location: At a high place (T.P. +35m)

Power source cars deployed at high ground

Capacity: 500kVA
Number: 21
Location: At a high place(T.P. +35m)

Underground light oil tanks

Location: T.P. +35m
Capacity (nominal):144 kL
Capable of storing fuel equivalent to those consumed by these air-cooling GTGs, power source cars and fire engine in about a day (for 24 hours)

Existing light oil tanks for 7 plants

Existing light oil tanks (Reactor o. 1 to 7)
Total capacity: 5700kl
Transportation means being examined.

Fuel procurement agreements have been signed with the local oil distributor, we can refuel 120kl within 6 hours from the disaster.

As a backup facility for gas turbine power generation cars, junction boxes capable of connecting up to 15 power source cars easily are now in place to strengthen the plant's emergency power supply system for swift restoration of the facilities.

(2) Early Power Restoration Drills Using Air-Cooling GTGs and Power Source Cars at High Ground <Securing Power Supply>

A procedure for restoration of power supply using air-cooling GTGs and power source cars is set up, and training for early securing of power supply in a situation of total power loss situations is conducted repeatedly so as not to cause damages to cores. This confirms the effectiveness of the system and the procedures. These procedures and systems are continuously improved.

Power source car training

Target	170 min.
Training done	ca. 70 min.

Station blackout → Securing power sources → Securing power supply using existing facilities (First priority) → Air-cooling GTGs (Second priority) → Power source cars (Third priority) → Power supply is secured

Major drills	How the drills are done
•Supply of power from power source cars Move power source cars at the side of the affected reactor. Lay and connect cables. Then, turn on the power source cars.	<Power Source Securing Drill>
• In addition, the following types of training are held. • GTG and power source car operation training • Emergency high tension power distribution board and high tension power distribution operation training using power source cars • Cable connection training • Night-time training • Others	

(1) Laying cables
(2) Connecting cables
(3) Connecting cables to power source cars
(4) Starting power source cars

GTG

(2) Reinforcing Batteries (DC) <Securing Power Supply> (1/2)

The DC power supplies used for controlling critical devices and monitoring instruments are being reinforced. Movable standby batteries are also installed.

Current

Location: K1→C/S B1F
K7→C/B B1F
Capacity of existing DC power sources (K1)
(A): 4000Ah
(B): 1600Ah
(H): 500Ah
* A series (RCIC, etc.) can be powered for 8 hours (with no load).

The water-tightness of existing DC power supply room is enhanced.

Waterproofing is added to the battery room to avoid inundation of the room.

Power supply (with no load)
ca. 8 hours

Images of strengthening batteries

Charging

Location:
K1 →C/S rooftop
K7→C/B rooftop
•Power can be supplied to RCIC and monitoring instruments (with load cut).

Emergency power generators will be installed at high ground of at least 15 m above sea level within the plant dedicated for recharging batteries.

Location: K1→R/B M3F
K7→R/B 4F
Capacity of additional DC power supply:
(A): 3000Ah (eq. 75% of existing capacity

DC power source facilities will be added at high ground of at least 15 m above sea level within the plant, separate from the existing DC power facility.
(Scattering and increased number of batteries installed.)

Added batteries

[Supplied to:]

- ◆ RCIC (high pressure water injection system)
- ◆ SRV (pressure reducing system)
- ◆ Critical monitoring instruments

(2) Reinforcing Batteries (DC) <Securing Power Supply> (2/2)

○ Standby Batteries

Application		Number of movable standby batteries (unit)								Location
		Reactor No.1	Reactor No.2	Reactor No.3	Reactor No.4	Reactor No.5	Reactor No.6	Reactor No.7	total	
Monitoring instruments	**Monitoring Instruments**	2	2	2	2	2	2	2	14	Unit 1: Computer room Unit 5 to 7: Central control room
	Monitoring radiation level	4	**Supplied by permanent AC power supply**※1						4	Computer room
SRV		10	10	10	10	10	10	10	78	Operating the SRV Ex. Reactor 1 lower central control room
Diesel-driven fire extinguisher pump		4								
Monitoring water level of reactors		4								

Movable standby batteries deployed
(for operating SRV, etc.)

* 1: The radiation monitors in Reactors 2 to 7 are powered by a permanent AC power supply. In the case of AC power loss, they get electricity from UPS batteries.

○ Limiting Loads for AC Power Supply

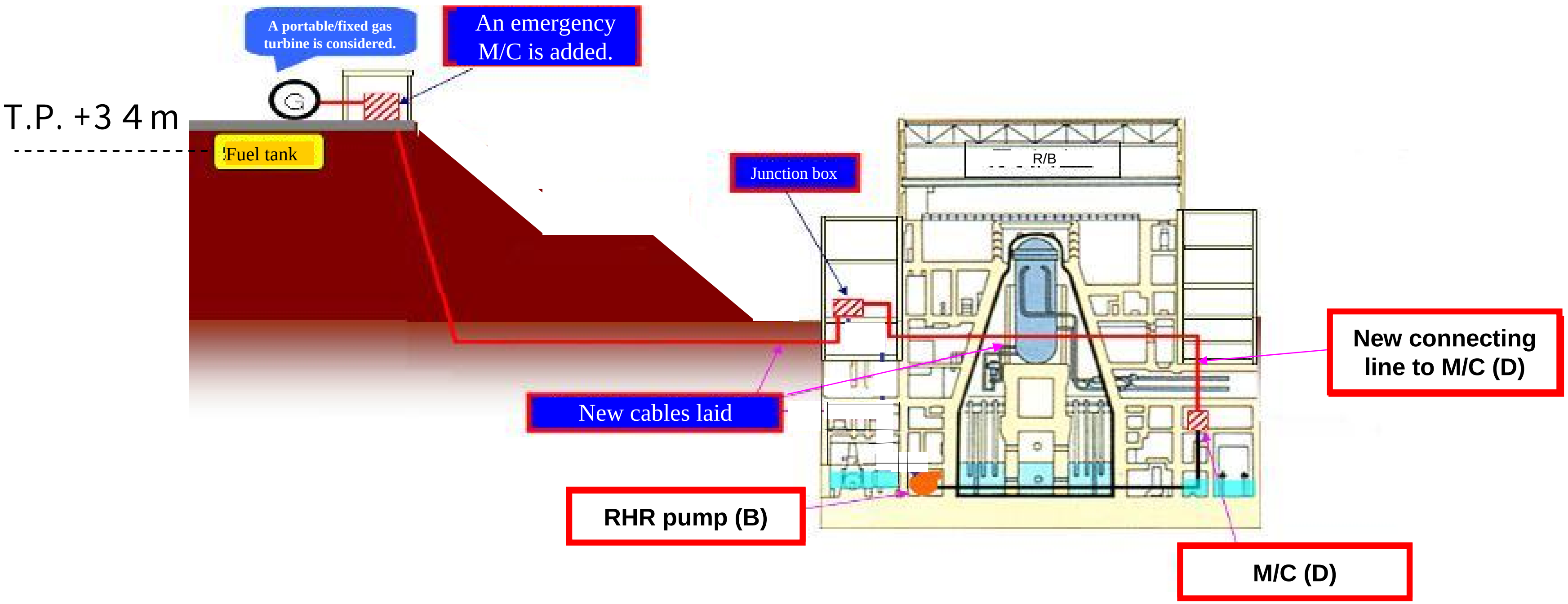
- After SBO, loads will be limited to minimum required DC loads only (i.e. RCICs, lighting equipment and monitoring instruments).
- After 8 hours, lighting equipment will also be disconnected from the batteries.

(2) Installing Additional Power Sources at High Ground <Securing Power Supply>

Considering the diversity of these emergency AC power sources, air-cooled AC power sources will be installed at high ground that would not be affected by a tsunami. As a measure to ensure redundancy of the power supply system, a new power supply system will be installed to supply energy from the emergency M/C to the emergency high tension bus bar (D) system to run RHR (B).

Image of a High Place Power Supply System (Ongoing)

(1. Addition of a building for M/C)
2. Addition of M/C and electric facility
3. Installing a generator (air-cooling type) at a high place
4. Installing fuel tanks
5. Installing conduits from the emergency M/C to a junction box
6. Installing conduits from a junction box to D-series M/C



Layer 3 Preventing Core Damage when an Accident Occurs

Issues (Lessons)

There were insufficient water sources and water injection means to prevent core damages and alleviate the aftermath.

Policy

- Expect existing power sources after waterproofing.
- Secure various water sources, including the installation of water reservoirs and wells as well as the use of seawater, and improve the methods of injecting water from these water sources.

Classification of measures	
Stage IV	Seawater
Stage III	Water reservoir and wells
Stage II	Pure water tanks and filtrated water tanks
Stage I	Condensate storage pool (CSP) Emergency condensate storage pool (ECSP)

- (Pink) Measures (mid- to long activities) based on the Fukushima Daiichi Plant accident
- Red: Measures (short-term) based on the Fukushima Daiichi accident (ongoing)
- Black: Measures (short-term) based on the Fukushima Daiichi accident (done)
- (Yellow) Measures against the Niigata Prefecture Chuetsu Off-shore Earthquake
- (Light blue) Accident management measures set up before the Fukushima Daiichi Plant accident
- (White) Facilities employed under the basic design

Note: Actions in the blue bold frame refer to facilities where tsunami prevention measures using tide embankments can be effective.

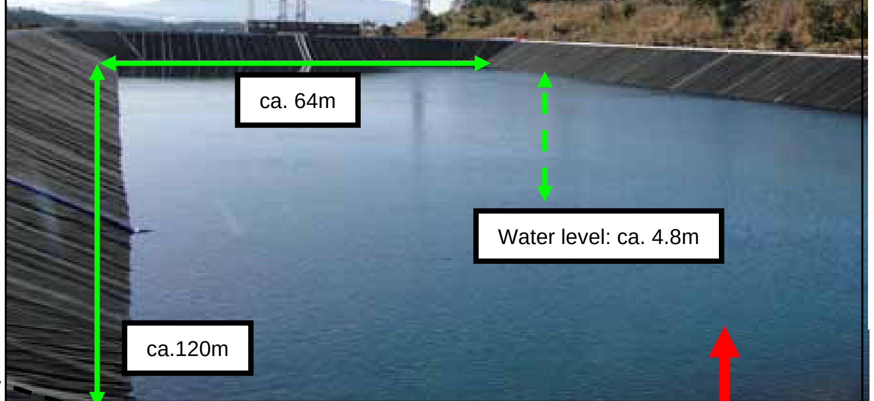
(3) Water source

(3) Stably Securing Freshwater by Installing a Water Reservoir and Wells in the Plant <Securing Water Sources>

In addition to the existing freshwater tanks, a reservoir capable of storing about 20,000 tons of freshwater is installed so that freshwater can be stably injected into R/B and SFP at a height of 45 m above sea level. Two wells are dug to supply water to the reservoir.

Water Reservoir

- Maintains function against the design earthquake ground motion of Ss.
- Uses a free fall system to supply water to the tank; no energy used.
- Installed to a height of T.P. 45 m), outside the reach of a tsunami.
- Sends water to the tank facilities:1,500m^3/day
- Effective water reserving volume:18,000m^3
  (Even if all 7 plants are damaged simultaneously, the reservoir is capable of supplying water to RPV and SFP for about 7 days after all water tanks become empty.)

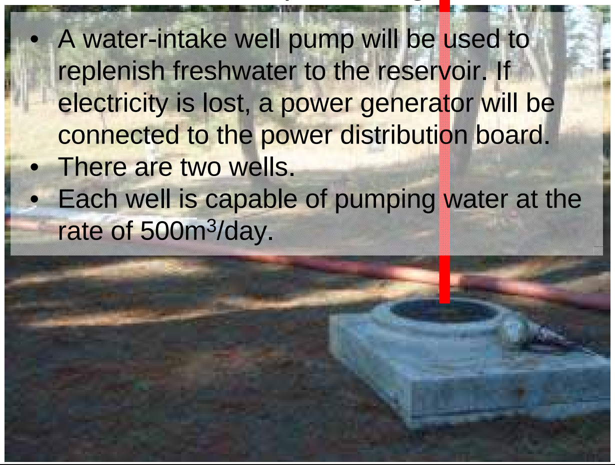


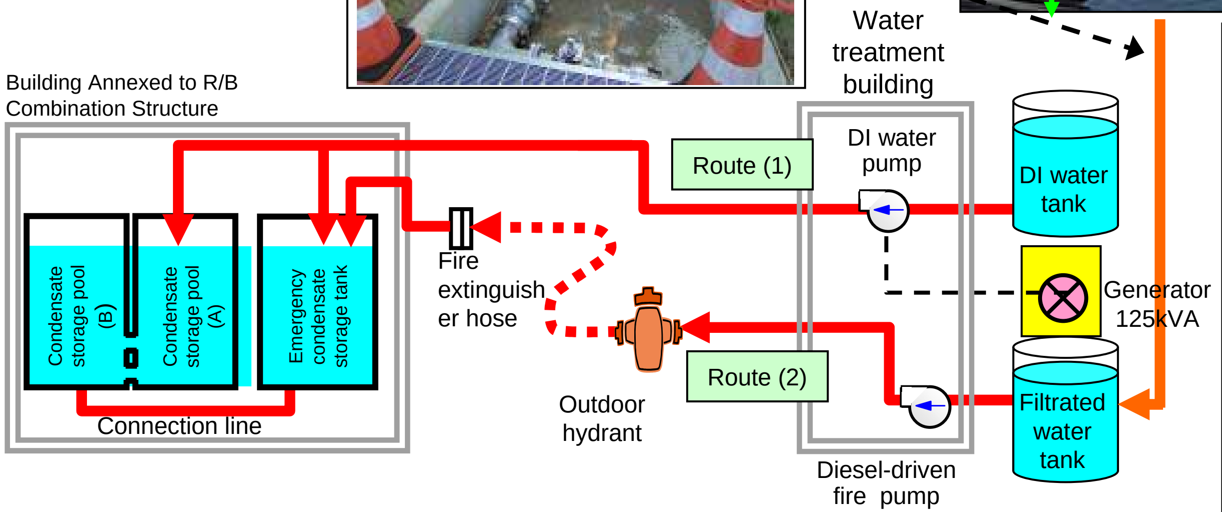
Water distribution lines have a flexible design so that they won't be affected by an earthquake.

Water line to the reservoir

Wells for Replenishing Water

- A water-intake well pump will be used to replenish freshwater to the reservoir. If electricity is lost, a power generator will be connected to the power distribution board.
- There are two wells.
- Each well is capable of pumping water at the rate of 500m^3/day.

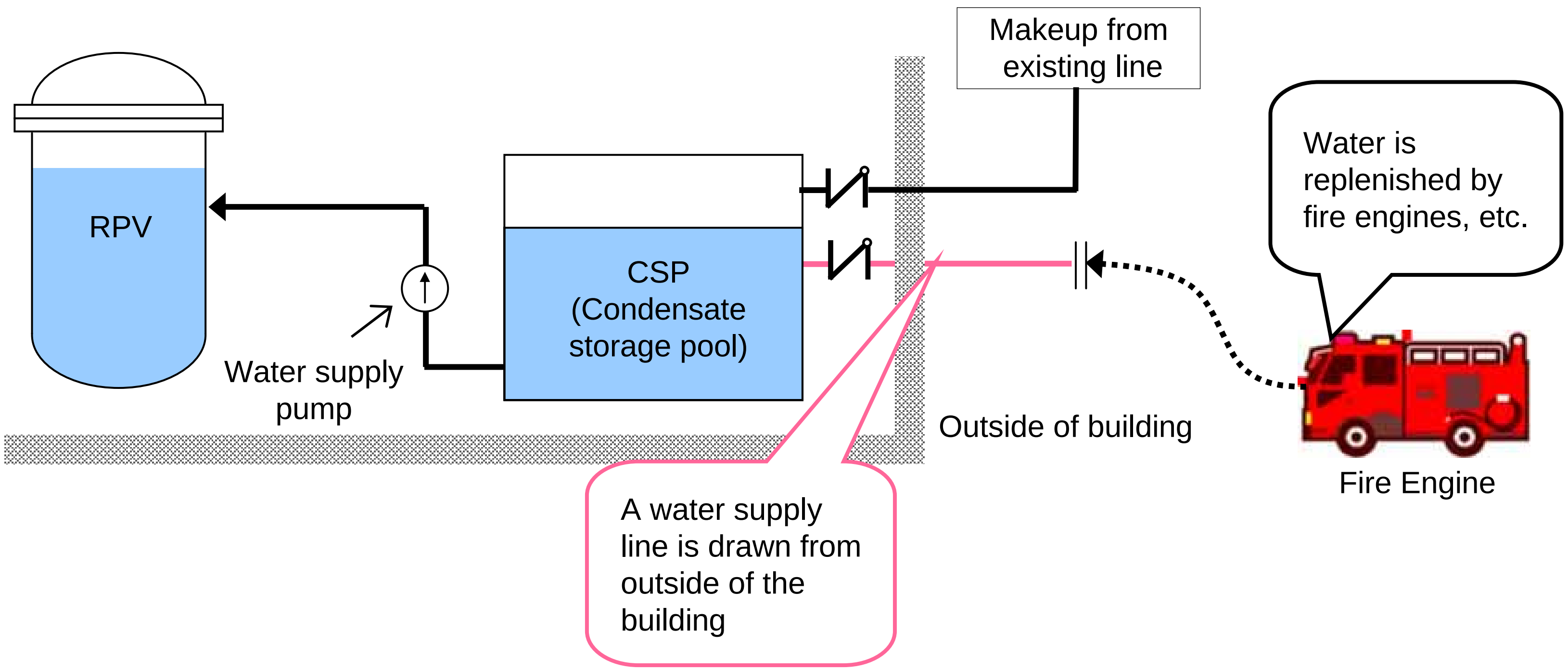




(3) CSP Water Injection Lines from Outside of the Buildings <Securing Water Source>

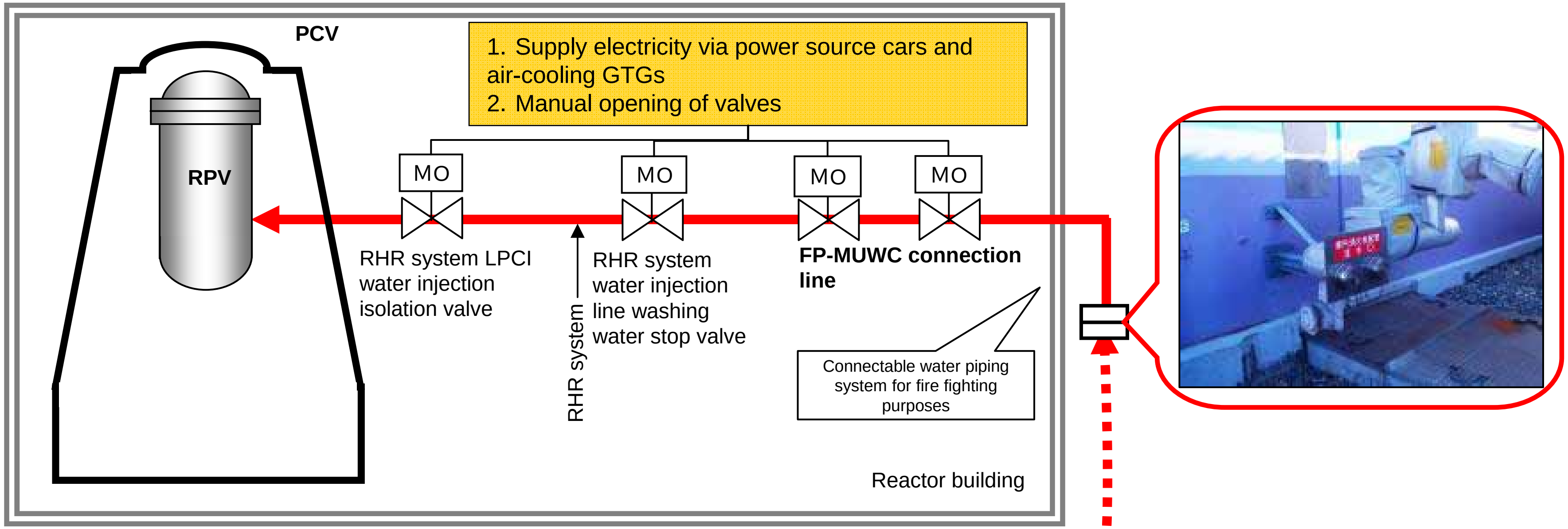
There is a water supply line is there from outside of the buildings to CSP (condensate storage pools), a major water source for RPV to make it possible to get water from outside areas.

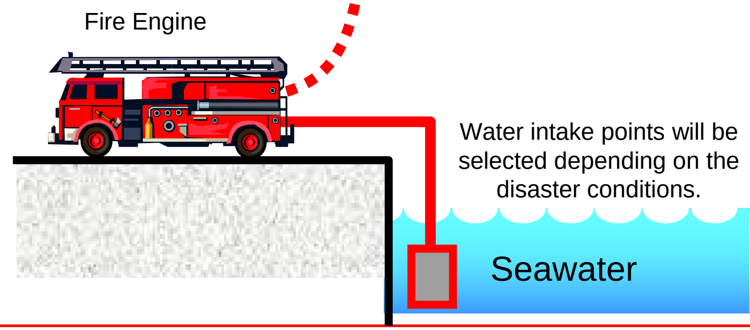
A water supply line is installed from outside of the Buildings



(3) Establishing Procedures for Using Seawater <Securing Water Sources>

When water injection using MUWC and D/DFP has failed, or when their water source (freshwater) is out, fire engines will be used to pump seawater to inject it into the affected RPV. The procedure for this is now in place through the Tsunami AMG.





○ Required Tools

- A fire engine (at least Class A II) * Class A II refers to a fire engine capable of injecting water at 84 m^3/h @ 1.4MPa.
  * 84m^3/h is equivalent to the decay heat generated for about 60 min. after the stoppage of RPV.
- 16 water distribution hoses of 20 m in length to be mounted to fire engines
- Fire engines are parked at a temporary stock yard (T.P.+35m) and at the Self Defense Fire Fighting Center.

Layer 3 Preventing Core Damage when an Accident Occurs

Issues (Lessons)

The plant had insufficient means of high pressure water injection, pressure reduction, low pressure water injection, removal of heat and securing water sources when the total power loss occurred. The workers had to cope with the problems in an ad hoc manner.

Policy

Each means is strengthened (incl. high pressure water injection, pressure reduction, low pressure water injection, and heat removal to and from the affected RPV and PCV)

*1 Though decay heat generated from a nuclear reactor just after it stops cannot be totally cooled down with the volume of water supplied by this facility, it is expected to use this as an auxiliary measures of injecting water at a high pressure. For this purpose, a procedure is set up (CRD(30m³/h)).

*2 Even in a case of a severe accident and water level in RPV cannot be accurately measured, a thermometer will be installed at the reference water level container to understand that the water level in the reactor is lower than the effective fuel area.

*3 It is provision for BWR plant, and we operate alternative water injection using HPCF when RCIC fails to start at ABWR plant. So, in the case of ABWR, the layer of countermeasure is increased by one at 「(4)High pressure water injection」 and decreased at 「(6)Low pressure water injection」.

Classification of measures	(4) High pressure water injection	(5) Pressure reduction: Valve body	(5) Pressure reduction: Air	(5) Pressure reduction: Power Source	(6) Low pressure water injection	(7) Cool-down of RPV and PCV (heat removal): RPV	(7) PCV (Spray)	(7) PCV (Heat removal)	(4) - (7) Measuring instruments
Stage VII					Reinforcing D/D pumps				
Stage VI	Installation of alternative high pressure water injection system				Alternative water injection using LPCS when RCIC is in a single point failure*3	Installation of standby motors for seawater pumps			
Stage V	Setting up a procedure for emergency use of water pressure system for moving control rods *1				Deploying fire engines at high ground (for water injection); Installation of an external port for MUWC	Installation of alternative immersion pumps			
Stage IV	Setting up a procedure for emergency use of boric acid water injection system *1		Installation of an air compressor for driving SRVs		Diesel-driven fire fighting system (D/DFP)	Installation of alternative heat exchanging facilities			
Stage III	Setting up a procedure to manually start RCIC		Setting up standby cylinders for driving SRVs		Electricity-driven fire fighting system	Residual heat removing system (A) and (B) (Removal of heat from RPV)	Setting up a procedure for spraying water to PCVby fire engines	Installation of a handle for manual ventilation of PCVs	Reinforcing plant condition monitoring function (Measuring water level in RPV)*2
Stage II	Steam-driven high pressure water injection system (RCIC)	Automatic pressure reducing system	Cylinders (A) and (B) for driving SRVs	Installation of standby batteries for SRVs	MUWC (A), (B) and (C)	RPV coolant purification system (A) and (B)	Alternative spraying (MUWC and FP)	Containment PCV vent facility	Reinforcing plant condition monitoring function (Measuring water level in RPV)*2
Stage I	Electricity-driven high pressure water injection system (HPCS)	SRV (A), (B) (SRV)	LN_2 facility	Batteries (A) and (B) for operating SRVs	Electricity-driven low pressure water injection system (A),(B) and (C) LPCS	Condenser (Removal of heat from RPV)	D/W spraying	S/C cooling (A) and (B) (PCV vent)	Existing measuring systems

Legend:

- (Pink) Measures (mid- to long activities) based on the Fukushima Daiichi Plant accident
- Red: Measures (short-term) based on the Fukushima Daiichi accident (ongoing)
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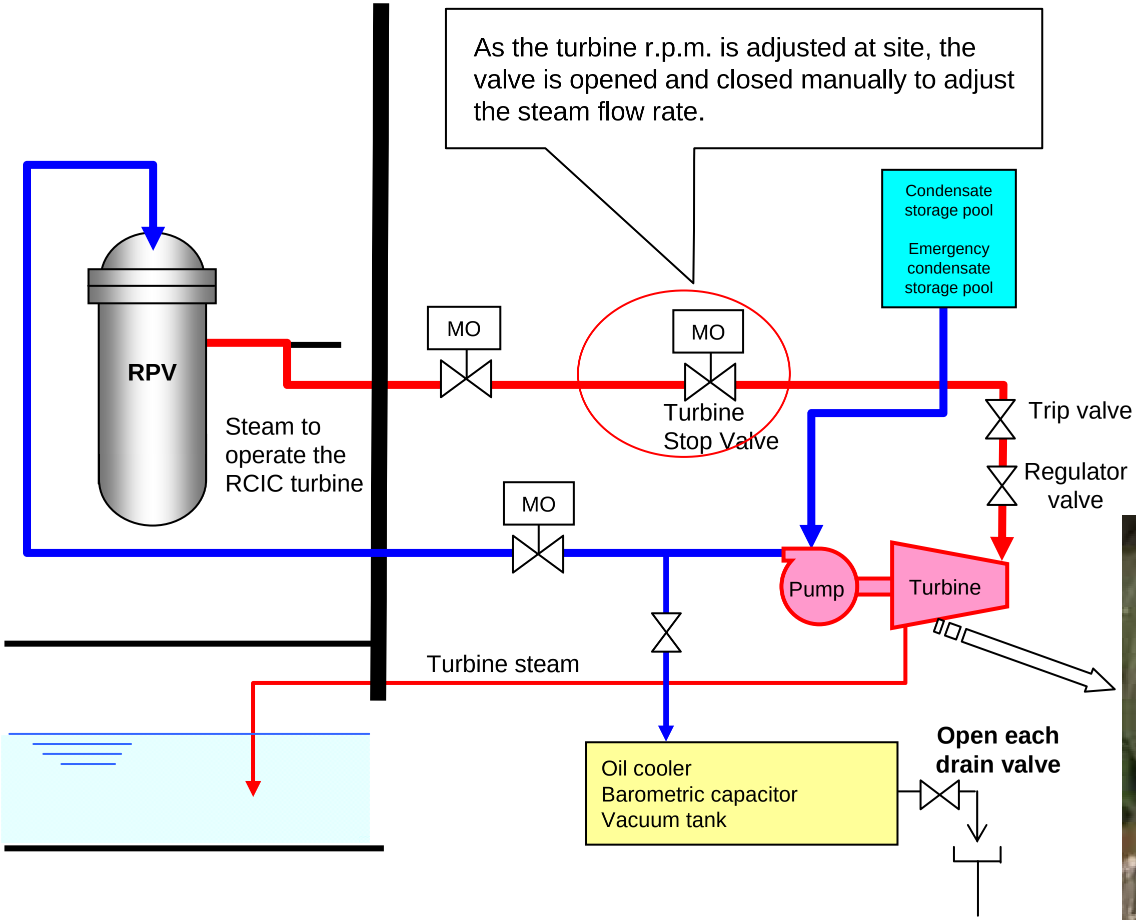
- (Light blue) Accident management measures set up before the Fukushima Daiichi Plant accident
- (White) Facilities employed under the basic design

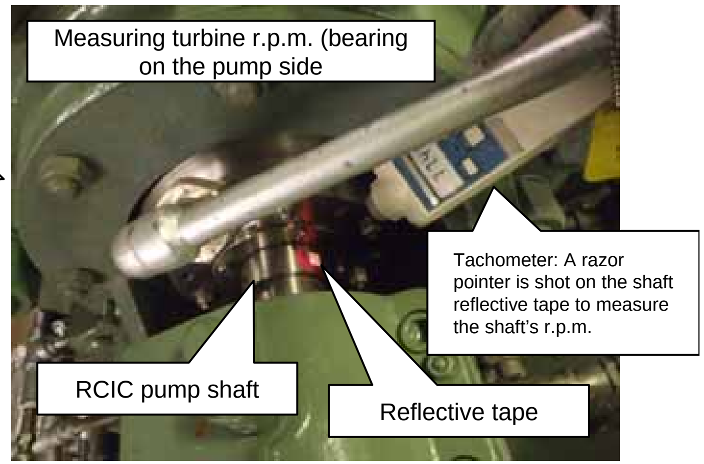
Note: Actions in the blue bold frame refer to facilities where tsunami prevention measures using tide embankments can be effective.

(4) Establishing Procedures for Manually Starting a RCIC <High Pressure Water Injection>

A procedure for manually operating valves is in place so that the reactor core isolation cooling system (RCIC), which starts using steam generated by the reactor, can be started even if DC is lost for starting and controlling the cooling system. The effectiveness of the system has been confirmed through training.

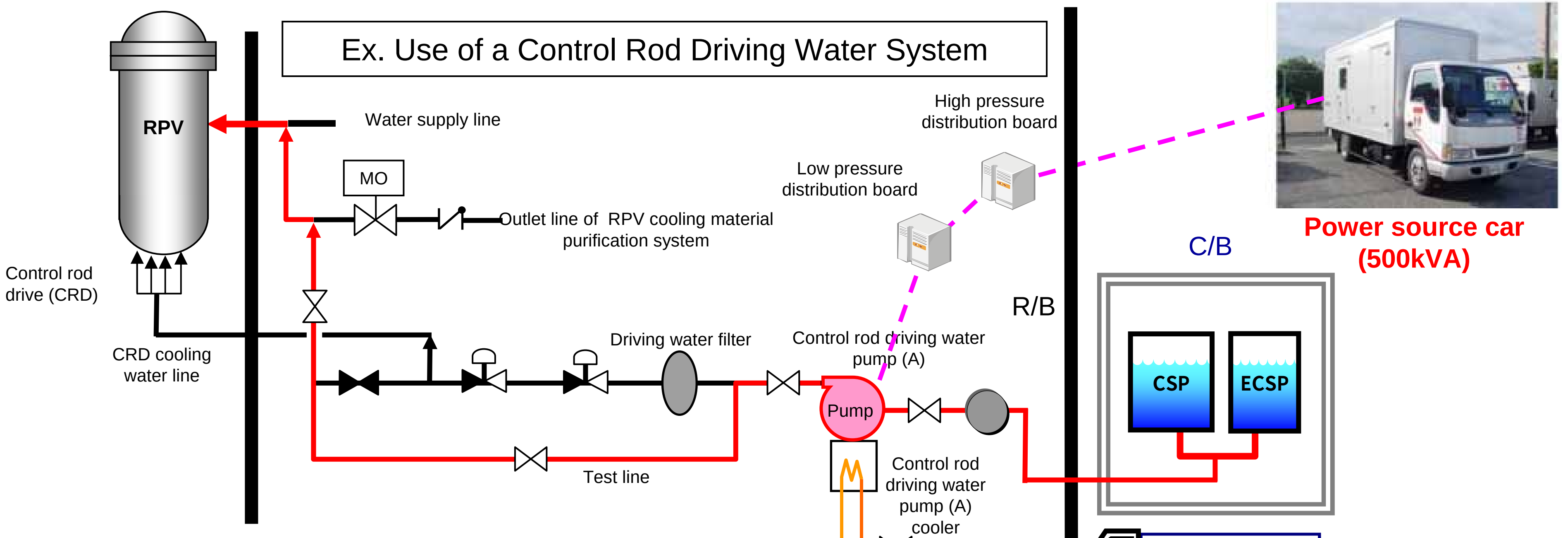


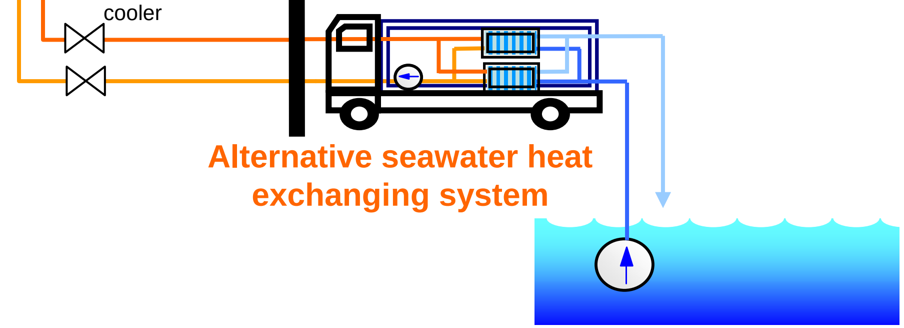
<A Training Scene>



(4) Establishing Procedures for Emergency Use of Control Rod Driving Water Pressure System <High Pressure Water Injection>

As a mean to inject high pressure water, power and cooling water are supplied to a control rod driving water to inject water to cool down RPV.





* Though the flow of water through the CRD is smaller than that through the RCIC, it could be used in the case where water is injected at a high pressure after continuous operation of the RCIC.

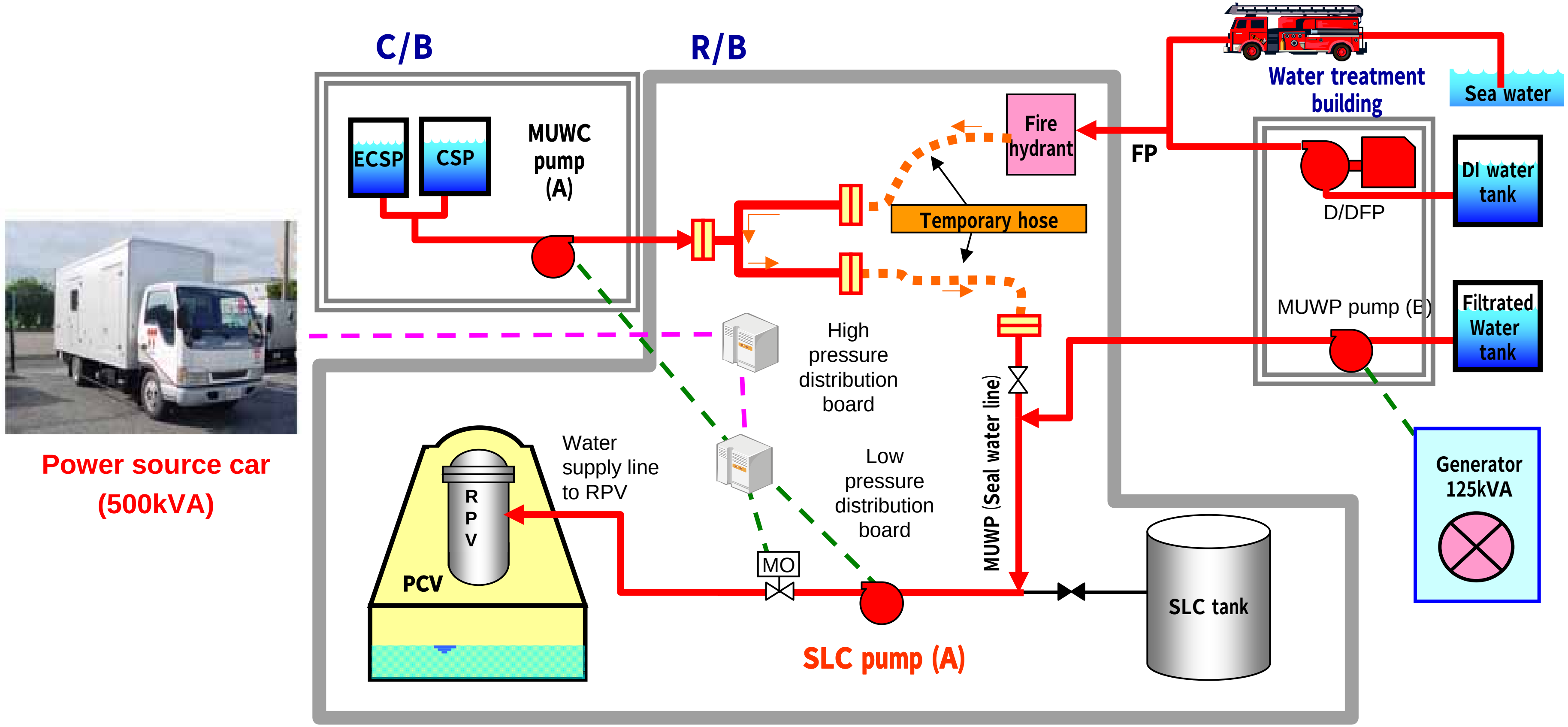
Reference:

CRD ca. 30m^3/h ⇉ Equivalent to the decay heat generated for 16 hours after the stoppage of RPV

RCIC ca.140m^3/h ⇉ Equivalent to the decay heat generated for 15 min. after the stoppage of RPV

(4) Establishing Procedures for Emergency Use of Boric Acid Water Injection System <High Pressure Water Injection>

As a mean to inject high pressure water, power and cooling water are supplied to a boric acid water injection pump to inject water to cool down RPV.



※Though the flow of water through the SLC is smaller than that through RCIC, it could be used in the case where water is injected at a high pressure after continuous operation of the RCIC.

Reference： SLC ca. 10m³/h

(4) Alternative Water Injection Using the High Pressure Core Water Injection System during RCIC Failure (Unit 7) <High Pressure Water Injection>

An alternative method of injecting water using the high pressure core flooding system (HPCF) will be set up to prevent damages to cores in the case of RCIC failure.

When SBO+LUHS occurs, water is injected using RCIC. Additional methods of core protection will be designed in so that the core can be cooled down even in the case of RCIC failure.

Non-RCIC Methods of Water Injection

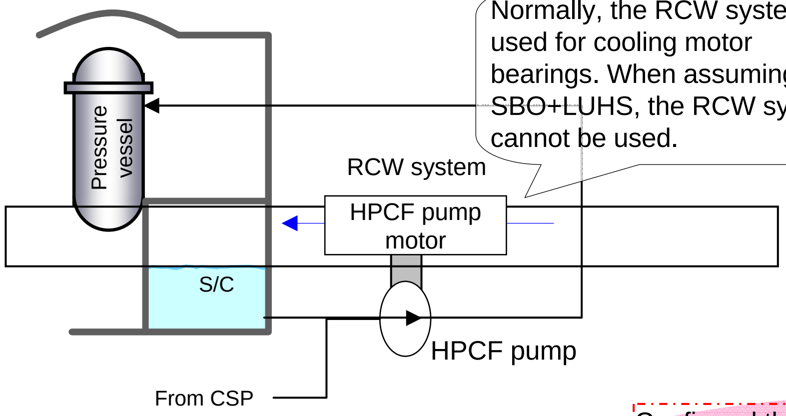
Water injection method	System	Remarks
High pressure water injection	HPCF	Power can be supplied by an air-cooling GTG. An air-cooling GTG can be ready for operation in 40 min.
Low pressure water injection after pressure down	RHR (LPFL function)	Water source is S/C only. Power supply from an air-cooling GTG should start within 20 min, During this time, no power supply can be available.
	D/DFP	Unacceptable, as water volume is insufficient to make an early stage water injection to the affected RPV.
	MUWC	Unacceptable, as water volume is insufficient to make an early stage water injection to the affected RPV.

It is effective to remove decay heat occurring within about an hour.

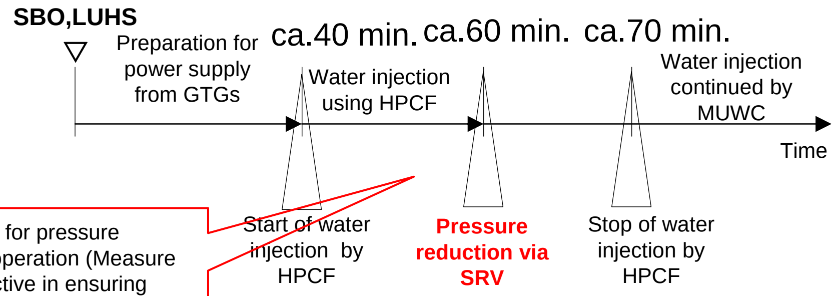
Outline of the System

Water injection using HPCF is examined.

Normally, the RCW system is used for cooling motor bearings. When assuming SBO+LUHS, the RCW system cannot be used.



Time course action after an accident (example)



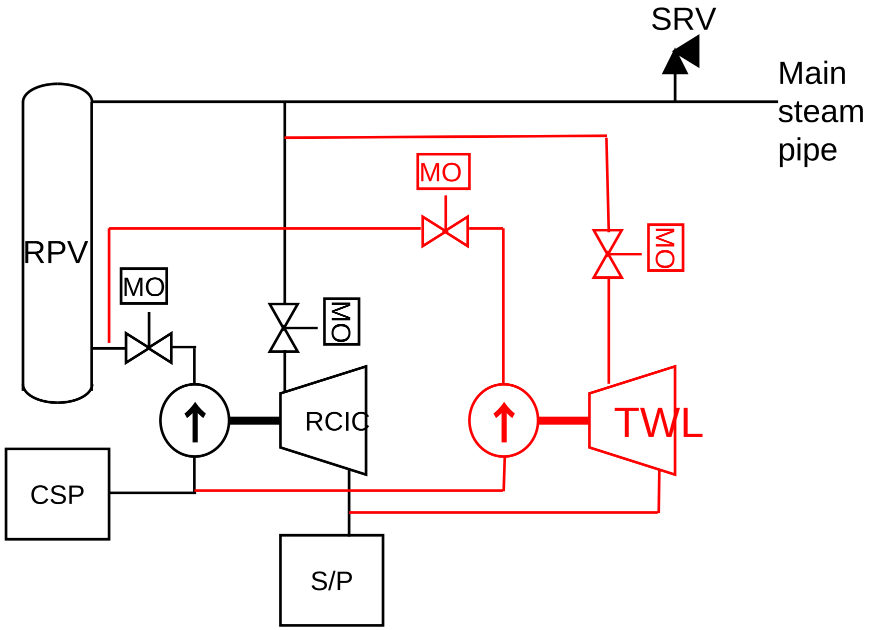
A measure for pressure reduction operation (Measure (5)) is effective in ensuring operations in a reliable manner.

Confirmed that the RCIC can be operated for about 30 min. without cooling motor bearings and that by decompression after HPCF for 20 min and MUWC injection after HPCF for 30 min can be continued without causing any core damage.

(4) Alternative High Pressure Water Injection Facility (TWL) <High Pressure Water Injection>

A TWL (Turbine Water Lubricant) pump, a steam turbine driven pump, is being added as an alternative high pressure water injection system to be used if the RCIC has lost function.

A steam-driven TWL pump is being installed for high pressure water injection at a place higher than the RCIC room. There is also steam piping, water injection piping, DC power source, and other incidental facilities.



An image of RCIC/TWL system construction

An image of a TWL pump

Layer 3 Preventing Core Damage when an Accident Occurs

Issues (Lessons)

The plant had insufficient means of high pressure water injection, pressure reduction, low pressure water injection, removal of heat and securing water sources when the total power loss occurred. The workers had to cope with the problems in an ad hoc manner.

Policy

Each means is strengthened (incl. high pressure water injection, pressure reduction, low pressure water injection, and heat removal to and from the affected RPV and PCV)

*1 Though decay heat generated from a nuclear reactor just after it stops cannot be totally cooled down with the volume of water supplied by this facility, it is expected to use this as an auxiliary measures of injecting water at a high pressure. For this purpose, a procedure is set up (CRD(30m^3/h)).

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Classification of measures	High pressure water injection (4)	(5) Pressure reduction: Valve body	(5) Pressure reduction: Air	(5) Pressure reduction: Power Source	(6) Low pressure water injection		(7) Cool-down of RPV and PCV (heat removal): RPV	(7) PCV (Spray)	(7) PCV (Heat removal)	Measuring instruments (4) - (7)
Stage VII					Reinforcing D/D pumps					
Stage VI	Installation of alternative high pressure water injection system				Alternative water injection using LPCS when RCIC is in a single point failure※3		Installation of standby motors for seawater pumps			
Stage V	Setting up a procedure for emergency use of water pressure system for moving control rods *1				Deploying fire engines at high ground (for water injection)	Installation of an external port for MUWC	Installation of alternative immersion pumps			
Stage IV	Setting up a procedure for emergency use of boric acid water injection system *1		Installation of an air compressor for driving SRVs		Diesel-driven fire fighting system (D/DFP)		Installation of alternative heat exchanging facilities			
Stage III	Setting up a procedure to manually start RCIC		Setting up standby cylinders for driving SRVs		Electricity-driven fire fighting system		Residual heat removing system (A) and (B) (Removal of heat from RPV)	Setting up a procedure for spraying water to PCVby fire engines	Installation of a handle for manual ventilation of PCV	Reinforcing plant condition monitoring function (Measuring water level in RPV)*2
Stage II	Steam-driven high pressure water injection system (RCIC)	Automatic pressure reducing system	Cylinders (A) and (B) for driving SRVs	Installation of standby batteries for SRVs	MUWC (A), (B) and (C)		RPV coolant purification system (A) and (B)	Alternative spraying (MUWC and FP)	Containment PCV vent facility	Reinforcing plant condition monitoring function (Measuring water level in RPV)*2
Stage I	Electricity-driven high pressure water injection system (HPCS)	SRV (A), (B) (SRV)	LN_2 facility	Batteries (A) and (B) for operating SRVs	Electricity-driven low pressure water injection system (A),(B) and (C) LPCS		Condenser (Removal of heat from RPV)	D/W spraying	S/C cooling (A) and (B) (PCV vent)	Existing measuring systems

Legend:
- (Pink) Measures (mid- to long activities) based on the Fukushima Daiichi Plant accident
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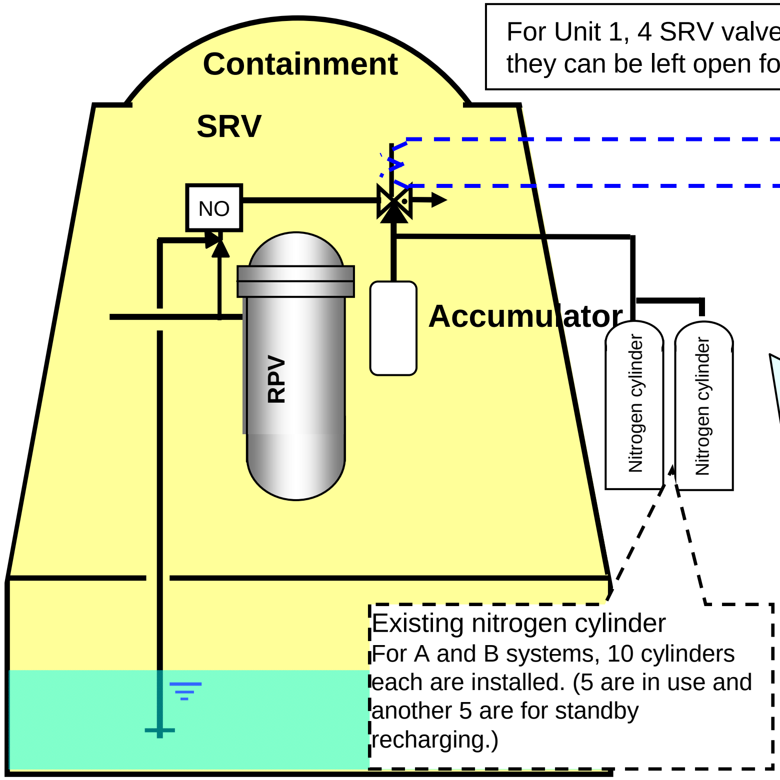
(5) Standby Batteries and Standby Nitrogen Cylinders for the SRV Operation <Pressure Reduction>

Backup DC power sources (standby batteries) and nitrogen cylinders are deployed to ensure that the main relief valve can be opened even when all AC power supplies and DC power supplies are lost. In addition, a procedure to supply DC power directly at affected sites is set up and the effectiveness has been confirmed through training. The existing nitrogen pump can operate the SRV at least 200 times.



For Unit 1, 4 SRV valves are connected to a battery and they can be left open for 2 days with the batteries.

Existing nitrogen cylinder
For A and B systems, 10 cylinders each are installed. (5 are in use and another 5 are for standby recharging.)

Each plant has 10 standby cylinders, 5 for A system and remaining for B system.

Location

In the case of Unit 1, they are installed on the 2nd FL of the reactor building (Non-controlled area;T.P.12.8m)

Standby Batteries
(12V×10 units/plant)
Location: Under the central control room (Unit 1)

Temporary operation switch and temporary cables

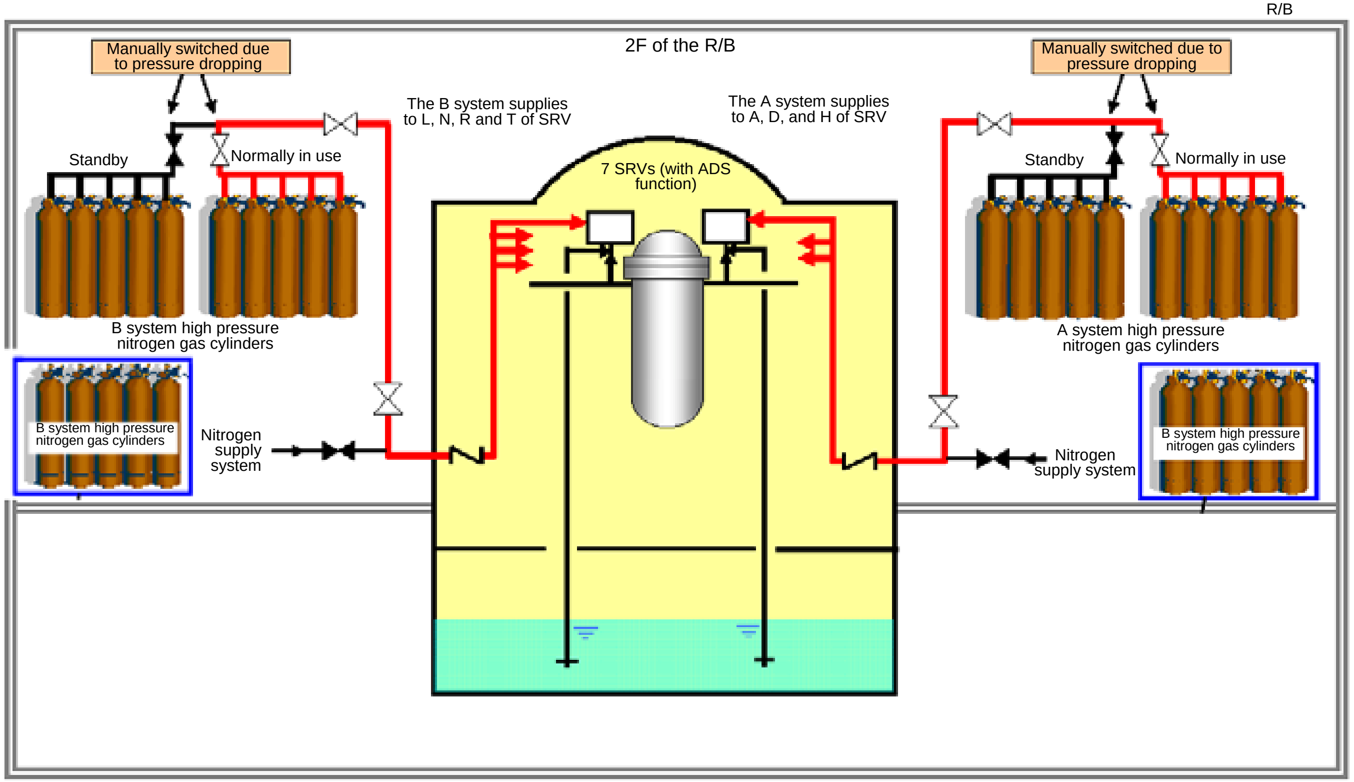
(For Unit 1, a set of temporary operation switches and a 30-m long temporary cable are installed.)

Standby batteries and standby nitrogen cylinders are installed as the sources of operation of the main steal relief valve. Procedures for using them are now in place as well.

(5) Air Compressor for the SRV <Pressure Reduction>

A temporary air compressor is deployed in addition to the standby high pressure nitrogen cylinders to be used to operate the SRV.

A temporary air compressor is deployed as backup for the standby cylinders



Temporary Air Compressor (Image)
(Detailed specifications are under examination.)

[Driven System]
Diesel engine

Safety Measures at Kashiwazaki-Kariwa Nuclear Power Plant <Layer 3>

Layer 3 Preventing Core Damage when an Accident Occurs

Issues (Lessons)

The plant had insufficient means of high pressure water injection, pressure reduction, low pressure water injection, removal of heat and securing water sources when the total power loss occurred. The workers had to cope with the problems in an ad hoc manner.

Policy

Each means is strengthened (incl. high pressure water injection, pressure reduction, low pressure water injection, and heat removal to and from the affected RPV and PCV)

Classification of measures	High pressure water injection (4)	Valve body (5) Pressure reduction	Air (5) Pressure reduction	Power Source (5) Pressure reduction	Low pressure water injection (6)	RPV (7) Cool-down of RPV and PCV (heat removal)	PCV (Spray) (7)	PCV (Heat removal) (7)	Measuring instruments (4) - (7)
Stage VII	Installation of alternative high pressure water injection system				Reinforcing D/D pumps				
Stage VI	Alternative water injection using HPCF when RCIC is in a single point failure				Alternative water injection using LPCS when RCIC is in a single point failure	Installation of standby motors for seawater pumps			
Stage V	Setting up a procedure for emergency use of water pressure system for moving control rods *1				Deploying fire engines at high ground (for water injection); Installation of an external port for MUWC	Installation of alternative immersion pumps			
Stage IV	Setting up a procedure for emergency use of boric acid water injection system *1		Installation of an air compressor for driving SRVs		Diesel-driven fire fighting system (D/DFP)	Installation of alternative heat exchanging facilities			
Stage III	Setting up a procedure to manually start RCIC		Setting up standby cylinders for driving SRVs		Electricity-driven fire fighting system	Residual heat removing system (A) and (B) (Removal of heat from RPV)	Setting up a procedure for spraying water to PCVby fire engines	Installation of a handle for manual ventilation of PCV	Reinforcing plant condition monitoring function (Measuring water level in RPV)*2
Stage II	Steam-driven high pressure water injection system (RCIC)	Automatic pressure reducing system	Cylinders (A) and (B) for driving SRVs	Installation of standby batteries for SRVs	MUWC (A), (B) and (C)	RPV coolant purification system(A) and (B)	Alternative spraying (MUWC and FP)	Containment PCV vent facility	Reinforcing plant condition monitoring function (Measuring water level in RPV)*2
Stage I	Electricity-driven high pressure water injection system (HPCS)	SRV (A), (B) (SRV)	LN_2 facility	Batteries (A) and (B) for operating SRVs	Electricity-driven low pressure water injection system (A),(B) and (C) LPCS	Condenser (Removal of heat from RPV)	D/W spraying	S/C cooling (A) and (B) (PCV vent)	Existing measuring systems

*1 Though the volume of water supplied by this facility cannot totally cool down the decay heat generated by the RPV just after it stops, it is expected to use this as an auxiliary measure for high-pressure water injection. A procedure is set up for this purpose (CRD(30㎥/h)).

*2 Even in a case of a severe accident where the water level in the RPV cannot be accurately measured, a thermometer will be installed at the reference water level container to understand whether the water level in the reactor is lower than the effective fuel area.

Legend:
- Pink: Measures (mid- to long activities) based on the Fukushima Daiichi Plant accident
- Green, Red: Measures (short-term) based on the Fukushima Daiichi accident (ongoing)
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- Light blue: Accident management measures set up before the Fukushima Daiichi Plant accident
- White: Facilities employed under the basic design

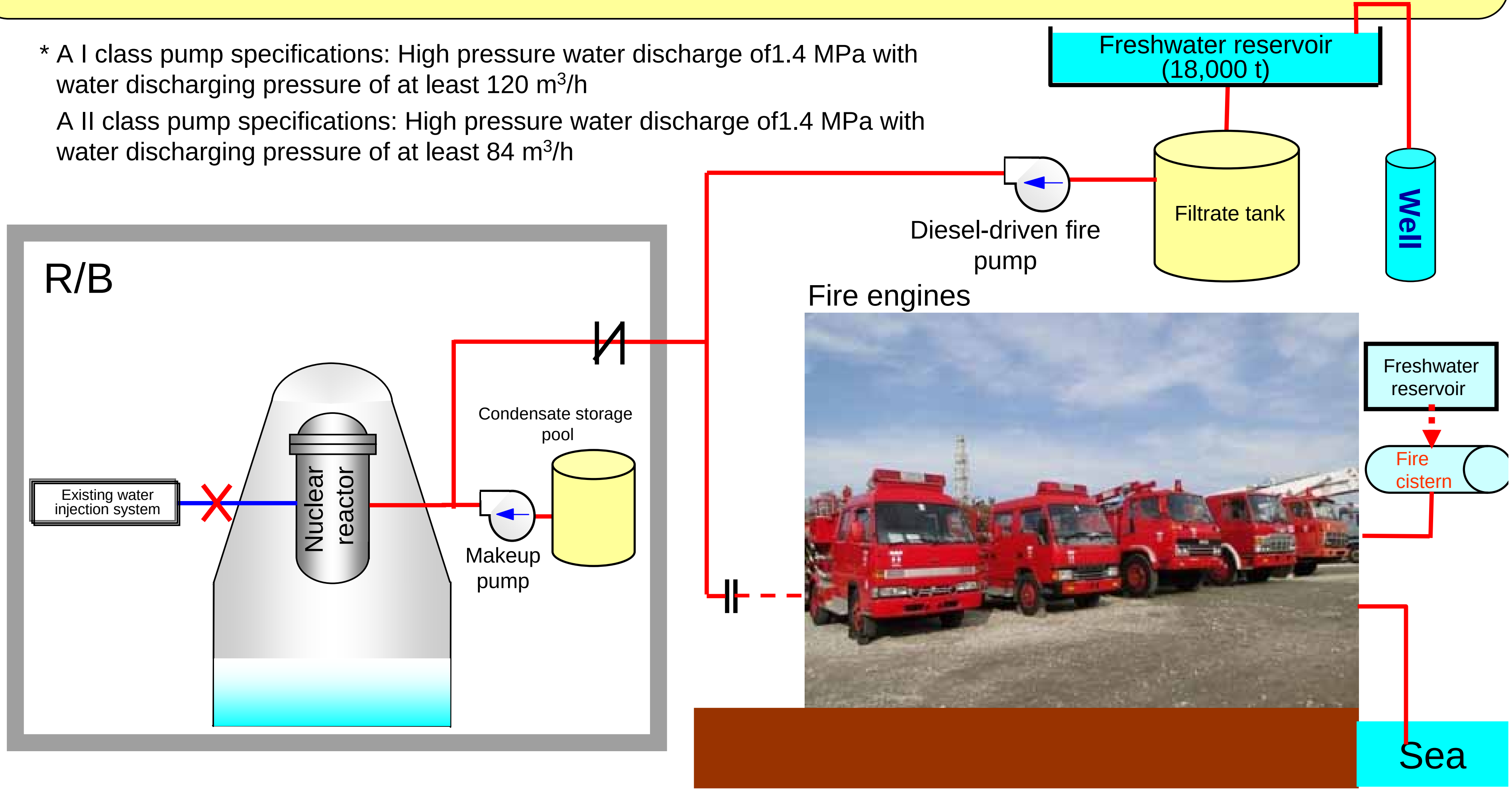
Note: Actions in the blue bold frame refer to facilities where tsunami prevention measures using tide embankments can be effective.

(6) Securing Redundancy and Diversity of RPV Water Injection Methods by Deploying Fire Engines to High Ground <Low Pressure Water Injection>

Eight fire engines (2 for A I class and 6 for A II class) are scattered and deployed at high ground of T.P. 35 m in order to ensure water injection to affected reactors in the case of SBO caused by the loss of all electricity-driven low pressure water injection systems. The fire engines can be connected to the ports installed in the buildings for discharging water.

* A I class pump specifications: High pressure water discharge of1.4 MPa with water discharging pressure of at least 120 m^3/h

A II class pump specifications: High pressure water discharge of1.4 MPa with water discharging pressure of at least 84 m^3/h



(6) RPV Water Injection Drills Using Fire Engines and Hoses <Low Pressure Water Injection>

In the case where the electricity-driven system to inject water to RPV is lost, the fire engines can be swiftly mobilized from a height of T.P. 35 m, and hoses can be swiftly laid and connected to secure water lines. For continuous improvement, drills for injecting seawater are conducted repeatedly to check the accuracy of the procedure and its effectiveness.

Fire Engine Drills

	Water injection	SFP injection
Target	60 min.	60 min.
Actual	ca. 25 min.	ca. 25 min.

LUHS, SBO

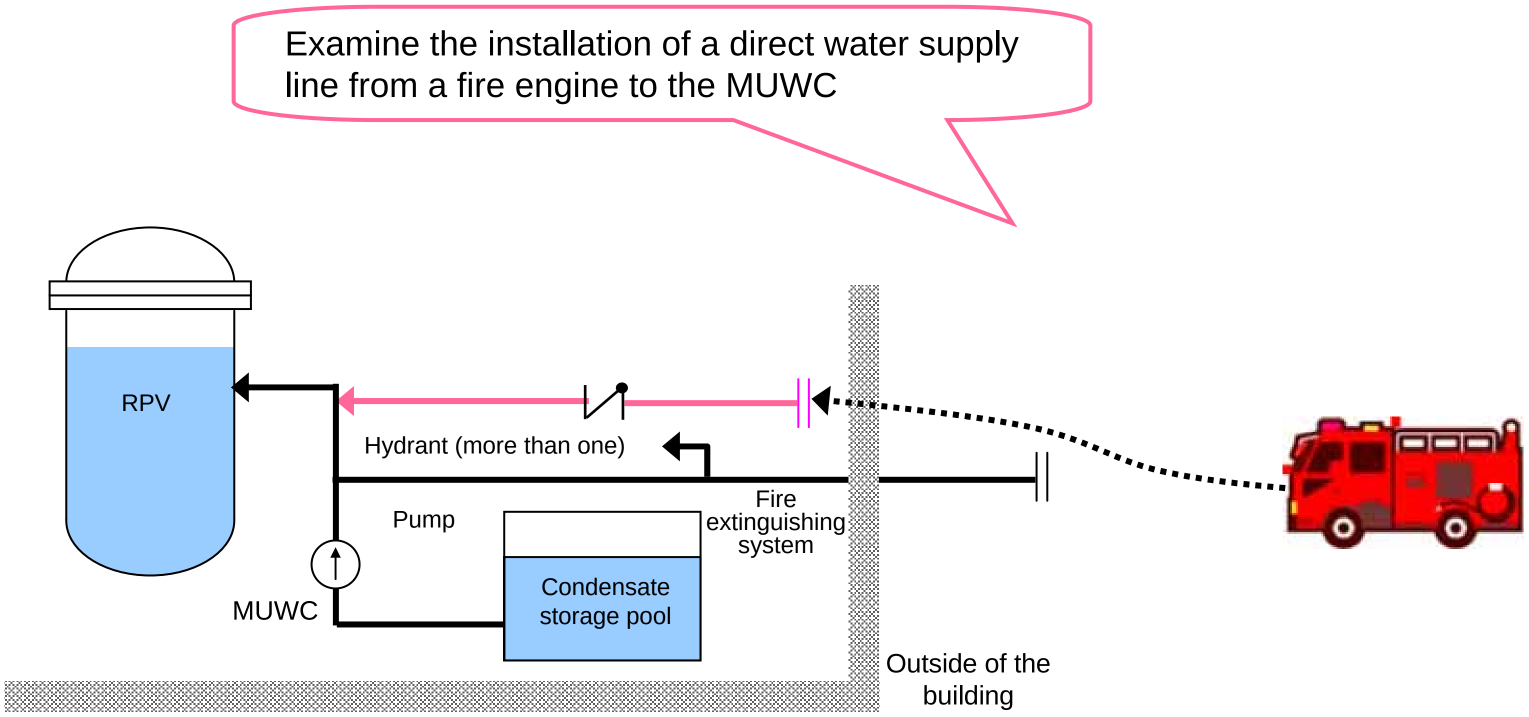
Water injection to RPV → Water injection via the RCIC → Pressure reduction by opening the SRV → (First Priority) Seawater injection using existing facilities → (Second Priority) Seawater injection using fire engines → Maintaining water level in RPV

Water injection to SFP → (First Priority) Freshwater injection using existing facilities → (Second Priority) Seawater injection using fire engines → Maintaining SFP water level

Main Drills	How the Drills are Done
▪ Seawater injection using a fire engine (RPV and SFP) Mobilize a fire engine near the water intake port. Lay hoses and connect it to the water injection line. ▪ In addition to the seawater injection drill using a fire engine (comprehensive training), the following drills have been done: laying and connecting fire engine hoses at night in preparation for a disaster occurring at night, etc.	<Water Injection Drill using a Fire Engine>  A fire engine is parked at the water intake port and hoses are laid.  A hose is laid.  A hose from the fire engine is connected to the water line.

(6) External Connection Ports for the MUWC <Low Pressure Water Injection>

The idea of laying a line that supplies water directly from a fire engine to a highly anti-seismic MUWC is under examination.



(6) Alternative Water Injection Using the LPCS to Protect Cores from Damaged when RCIC Startup Fails (Unit 1) <Low Pressure Water Injection>

An alternative method of injecting water using low pressure core-spray (LPCS) system will be introduced to protect cores from being damaged in the case that the RCIC fails to start.

When SBO+LUHS occurs, water is injected using the RCIC. Additional methods of core protection will be designed so that the core can be cooled down even in the case of RCIC failure.

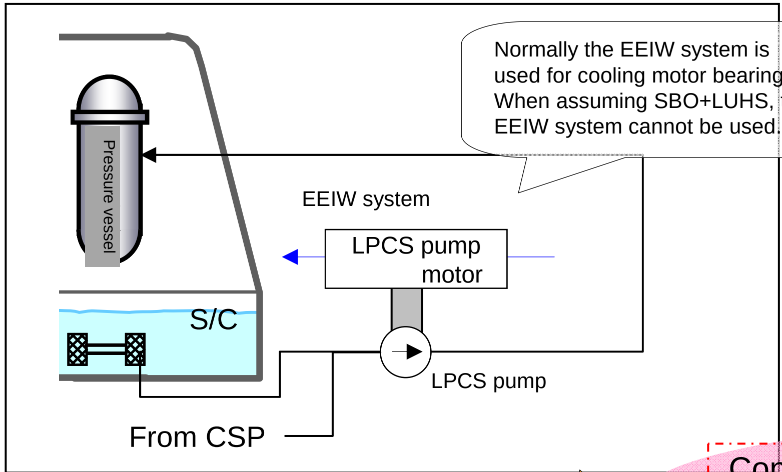
Non-RCIC Methods of Water Injection

Water injection method	System	Remarks
High pressure water injection	HPCS	The power capacity of the air-cooling GTGs currently in use is too low to supply electricity.
Low pressure water injection after pressure down	**LPCS**	Two air-cooling GTGs are deployed for use if an accident happens. These can be used for supplying electricity. These GTGs can be ready for power supply within 60 min.
	RHR	Except for the viewpoint of protecting devices, the SHC function of RHR system should be operated continuously after restoring the power supply and heat sink.
	D/D FP	Unacceptable, as water volume is insufficient to make an early stage water injection to the affected RPV.
	MUWC	Unacceptable, as water volume is insufficient to make an early stage water injection to the affected RPV.

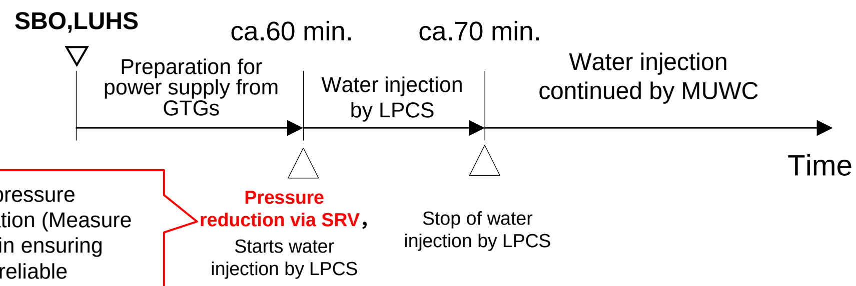
It is effective to remove decay heat occurring within about an hour.

Outline of the System

Examine water injection using LPCS



Time course action after an accident (example)



A measure for pressure reduction operation (Measure (5)) is effective in ensuring operations in a reliable manner.

Confirmed that the LPCS can be operated for about 10 min. without cooling motor bearings, and that after water injection by LPCS for 10 min., water injection using MUWC doesn't lead to core damage.

(6) Reinforcing Diesel Pumps <Low Pressure Water Injection>

In preparation for more than one reactor being damaged by a disaster and/or fire, D/D pumps will be installed so that water can be injected to all affected reactors at a low pressure, even if low pressure water injection other than D/D-FP cannot be utilized.

[Current D/D-FP Specifications]

Water Treatment Building (for Unit 1 to 4: Arahama Side)
D/D-FP: 1 unit
Rated capacity: 350 m^3/h
Total pump head: 66 m
Shutoff head: 79 m

Water Supply Building (for Unit 5 to 7: Ominato Side)
D/D-FP: 1 unit
Rated capacity:177 m^3/h
Total pump head: 75 m
Shutoff head: 81 m

[D/D Pump Design Requirements **(To be Updated)**]

- D/D pumps shall satisfy the following conditions and shall be able to inject water into 4 plants for the Arahama side and 3 plants for the Ominato side simultaneously.
- The flow rate shall be enough to absorb all decay heat generated for 8 hours after the stoppage of RPV.
(Unit 1 to 5: ca. 50 m^3/h; Reactor 6 and 7: ca. 60 m^3/h)
- The pump head shall be enough to inject water shown above, considering water injection after pressure reduction by SRV.

Safety Measures at Kashiwazaki-Kariwa Nuclear Power Plant <Layer 3>

Layer 3 Preventing Core Damage when an Accident Occurs

Issues (Lessons)

The plant had insufficient means of high pressure water injection, pressure reduction, low pressure water injection, removal of heat and securing water sources when the total power loss occurred. The workers had to cope with the problems in an ad hoc manner.

Policy

Each means is strengthened (incl. high pressure water injection, pressure reduction, low pressure water injection, and heat removal to and from the affected RPV and PCV)

Classification of measures	High pressure water injection (4)	Valve body (5) Pressure reduction	Air (5) Pressure reduction	Power Source (5) Pressure reduction	(6) Low pressure water injection	RPV (7) Cool-down of RPV and PCV(heat removal)	PCV (Spray) (7) Cool-down of RPV and PCV(heat removal)	PCV (Heat removal) (7) Cool-down of RPV and PCV(heat removal)	Measuring instruments (4) - (7)
Stage VII	Installation of alternative high pressure water injection system				Reinforcing D/D pumps				
Stage VI	Alternative water injection using HPCF when RCIC is in a single point failure				Alternative water injection using LPCS when RCIC is in a single point failure	Installation of standby motors for seawater pumps			
Stage V	Setting up a procedure for emergency use of water pressure system for moving control rods *1				Deploying fire engines at high ground (for water injection) / Installation of an external port for MUWC	Installation of alternative immersion pumps			
Stage IV	Setting up a procedure for emergency use of boric acid water injection system *1		Installation of an air compressor for driving SRVs		Diesel-driven fire fighting system (D/DFP)	Installation of alternative heat exchanging facilities			
Stage III	Setting up a procedure to manually start RCIC		Setting up standby cylinders for driving SRVs		Electricity-driven fire fighting system	Residual heat removing system (A) and (B) (Removal of heat from RPV)	Setting up a procedure for spraying water to PCVby fire engines	Installation of a handle for manual ventilation of PCV	Reinforcing plant condition monitoring function (Measuring water level in RPV)*2
Stage II	Steam-driven high pressure water injection system (RCIC)	Automatic pressure reducing system	Cylinders (A) and (B) for driving SRVs	Installation of standby batteries for SRVs	MUWC (A), (B) and (C)	RPV coolant purification system(A) and (B)	Alternative spraying (MUWC and FP)	Containment PCV vent facility	Reinforcing plant condition monitoring function (Measuring water level in RPV)*2
Stage I	Electricity-driven high pressure water injection system (HPCS)	SRV (A), (B) (SRV)	LN_2 facility	Batteries (A) and (B) for operating SRVs	Electricity-driven low pressure water injection system (A),(B) and (C) LPCS	Condenser (Removal of heat from RPV)	D/W spraying	S/C cooling (A) and (B) (PCV vent)	Existing measuring systems

*1 Though the volume of water supplied by this facility cannot totally cool down the decay heat generated by the RPV just after it stops, it is expected to use this as an auxiliary measures of injecting water at a high pressure. For this purpose, a procedure is set up (CRD(30m³/h)).

*2 Even in a case of a severe accident where the water level in RPV cannot be accurately measured, a thermometer will be installed at the reference water level container to understand whether the water level in the reactor is lower than the effective fuel area.

Legend:
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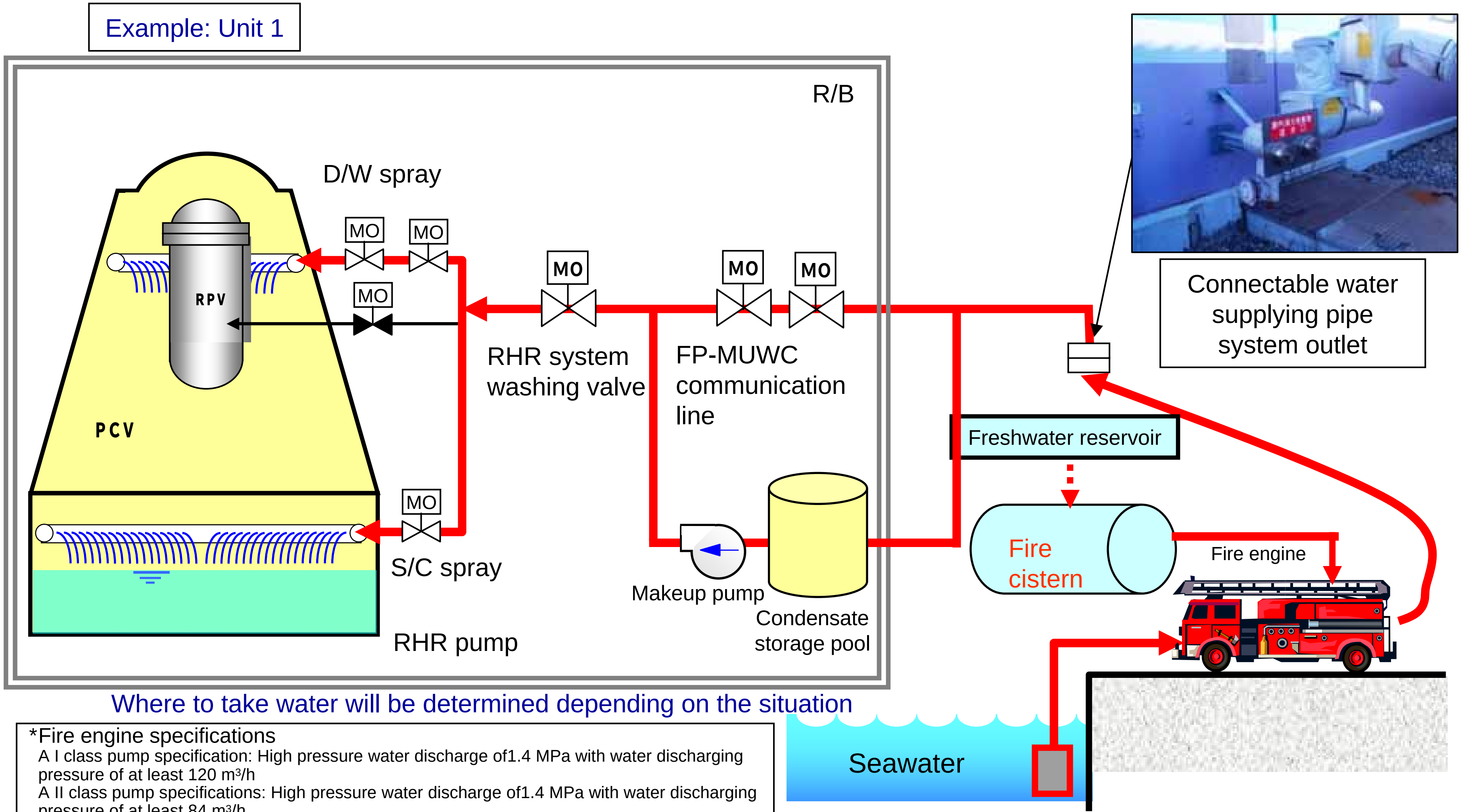
- (White) Facilities employed under the basic design

Note: Actions in the blue bold frame refer to facilities where tsunami prevention measures using tide embankments can be effective.

(7) Establishing a Method for Spraying into PCV without Using AC Power Supply <Cooling of RPV>

A procedure for spraying water into a containment using a fire engine is in place in order to prevent pressure and temperature surge in the containment even if AC power supply is totally lost.

Example: Unit 1



Where to take water will be determined depending on the situation

*Fire engine specifications
A I class pump specification: High pressure water discharge of1.4 MPa with water discharging pressure of at least 120 m³/h
A II class pump specifications: High pressure water discharge of1.4 MPa with water discharging pressure of at least 84 m³/h

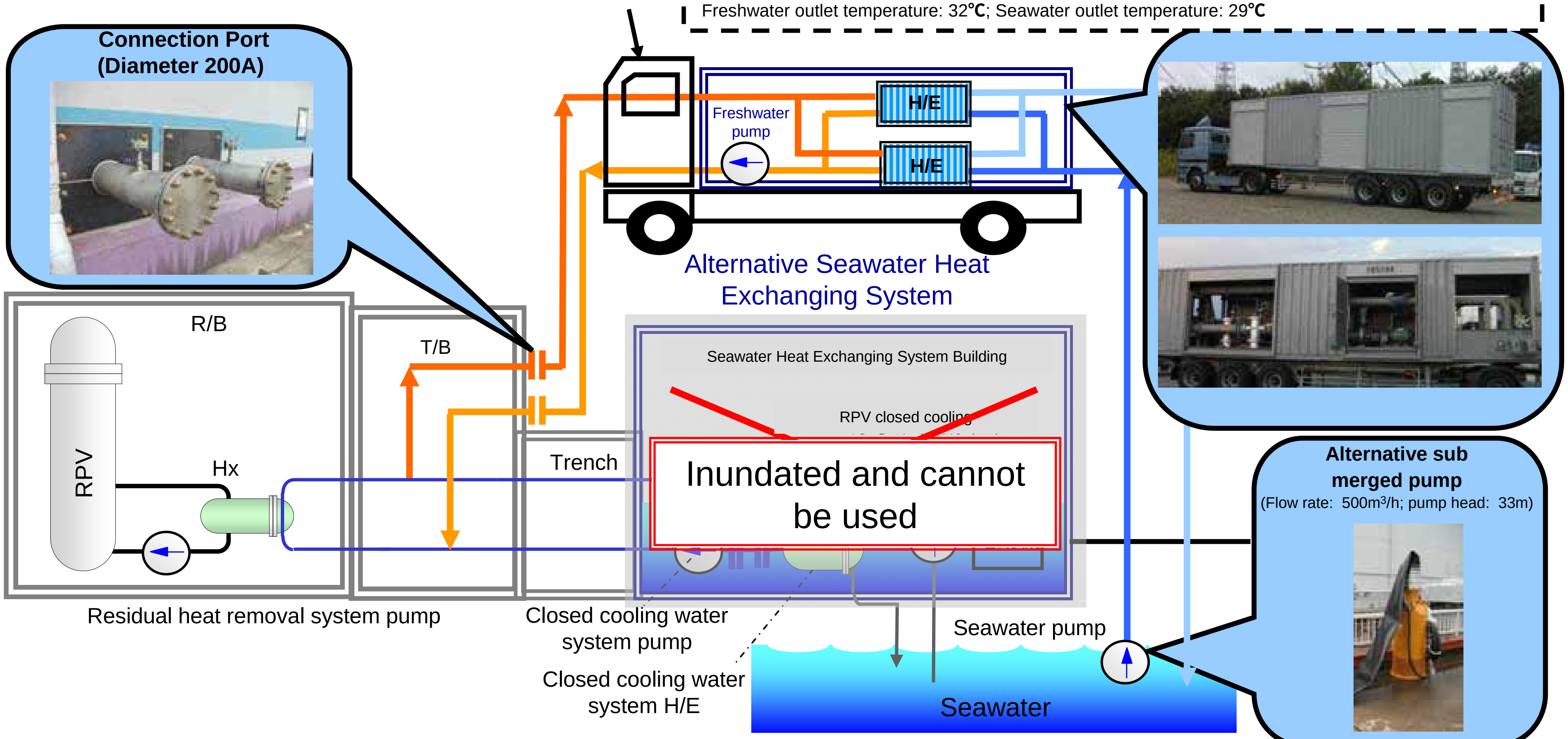
(7) Stable Cooling Using Alternative Seawater Heat Exchanging System <Cooling of RPV>

Highly mobile large capacity seawater heat exchanging systems are installed at various places at the height of T.P. 35 m in order to cool down RPV and SFP stably even if devices in the heat exchanging building have all failed. In the case of Unit 1, it can reach cold stop within 48 hours when the alternative heat exchanger begins operation within 24 hours after total power loss due to a tsunami, etc.

[Freshwater Pump Specification]
Quantity: 1; Flow rate: 420m³/h; Pump head: 40m

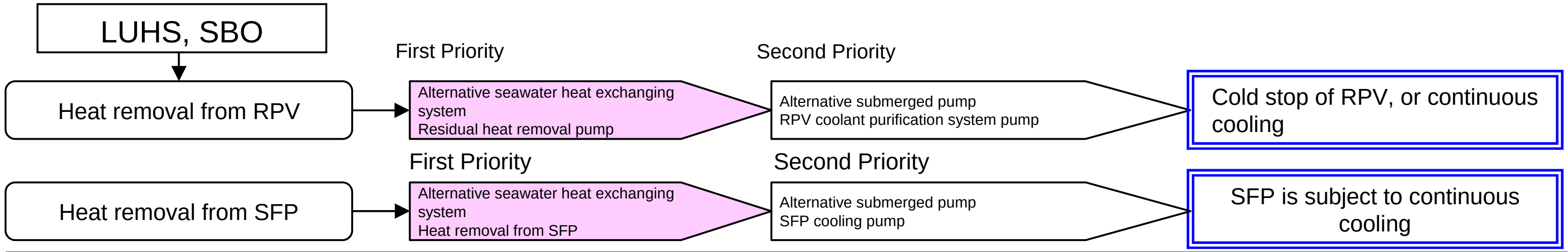
[Heat Exchanger Specifications] Type: Plate type× 2

[Plate heat exchanging condition]
(Cold stop in 48 hours from reactor stop; Decay heat and other heat loads can be removed.)
Heat exchanging capacity: 18.6MW; Freshwater flow rate: 420m³/h; seawater flow rate: 500m³/h;
Freshwater outlet temperature: 32℃; Seawater outlet temperature: 29℃



(7) Alternative Seawater Heat Exchanging System Connection Drill <Cooling of RPV>

For continuous improvement, comprehensive safety drills are conducted repeatedly using an alternative seawater heat exchanging system and an alternative submerged pump to confirm the effectiveness of the procedure and structure.



Main Drills	How the Drills are Done
・Training on removing removal from nuclear reactors and SFP using a seawater heat exchanging system A power source car, a transformer, an alternative seawater heat exchanging system and other devices are set up, cables are laid and connected, and then power is supplied by the power source car. Water injection hoses are laid and connected to the hydrant. In addition to the training on removing heat from RPV and from SFP using a seawater heat exchanging system, the following drills are done individually. ・Supplying power to an alternative seawater heat exchanging system ・Laying and connecting freshwater hoses ・Others	<Alternative Seawater Heat Exchanging System Connection Drill>  

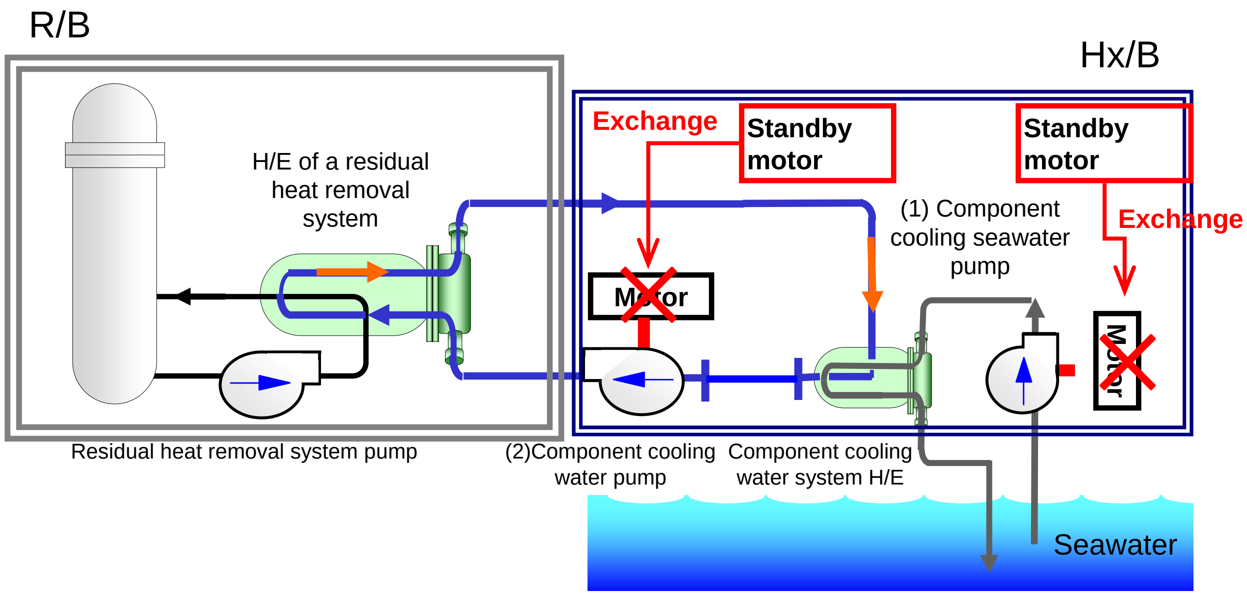
(7) Deploying Standby Motors for Seawater Pumps <Cooling of RPV>

In preparation for the loss of motors that support pumps used for power supply, heat removal, and water injection due to a tsunami of unexpected size, standby motors will be deployed for early system restoration.

(1) Motors for RPV closed cooling water system: 7 units
(Ex.) Standby motor for Unit 7: Output: 280 kW, Voltage: 440 V

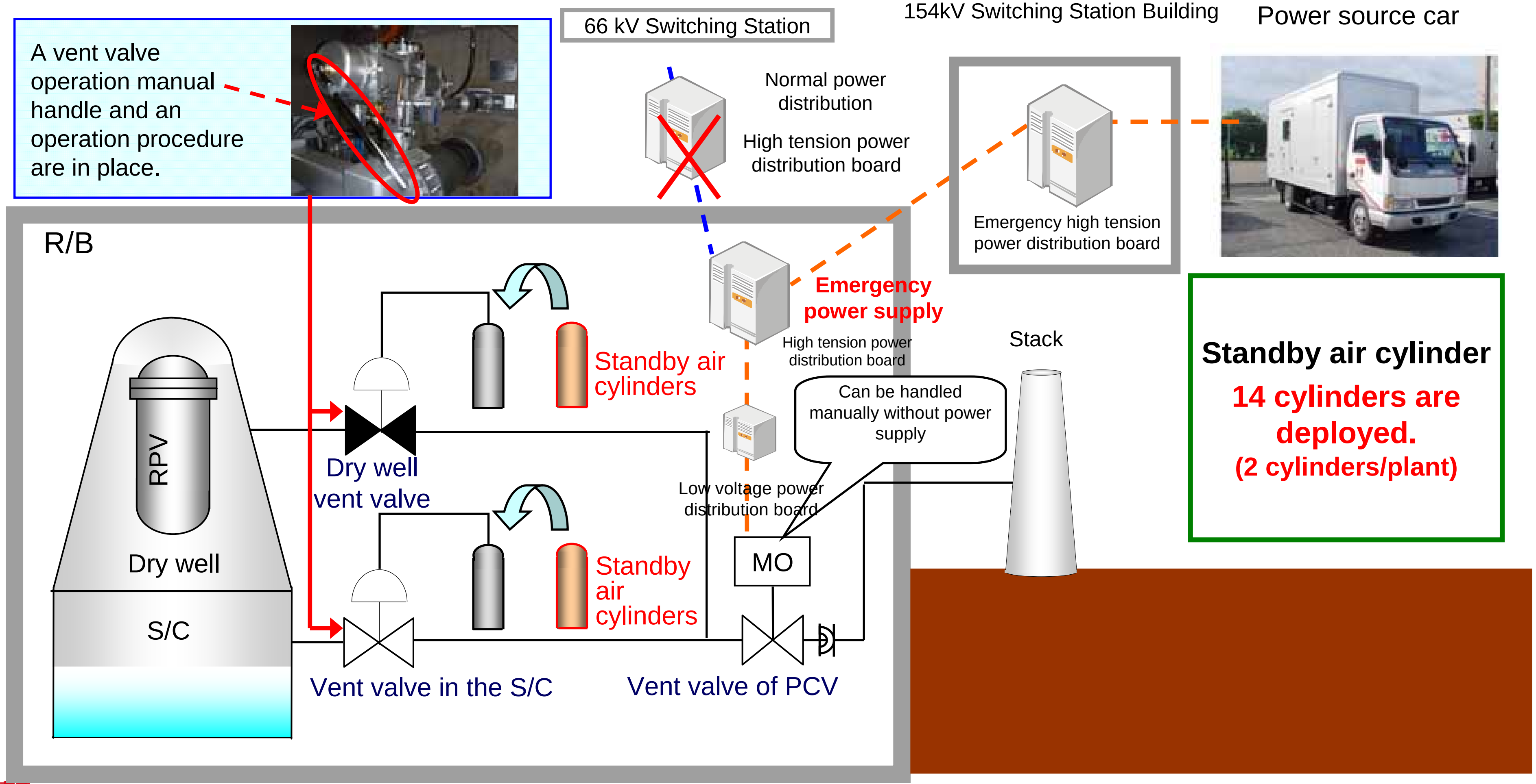
(2) Motors for RPV closed cooling water system: 7 units
(Ex.) Standby motor for Unit 7: Output: 370 kW, Voltage: 6600 V

A standby motor is deployed to each reactor.



(7) Maintaining Cooling and Confinement Using Containment Vent <Cooling of PCV>

Even when a heat sink has lost function, pressure and temperature in PCVcan be controlled to maintain good condition by injecting water to reactors and ventilation of PCV. Standby air cylinders are deployed for operating valves to ensure continuous ventilation, and a manual handle is also in place so that the valves can be opened without a power supply.



Standby air cylinder

14 cylinders are deployed.
(2 cylinders/plant)

Layer 3 Preventing Core Damage when an Accident Occurs

Issues (Lessons)

The plant had insufficient means of high pressure water injection, pressure reduction, low pressure water injection, removal of heat and securing water sources when the total power loss occurred. The workers had to cope with the problem in an ad hoc manner.

Policy

Each mean is strengthened (incl. high pressure water injection, pressure reduction, low pressure water injection and heat removal to and from the affected RPV and PCV)

Stage	(4) High pressure water injection	(5) Pressure reduction: Valve body	(5) Pressure reduction: Air	(5) Pressure reduction: Power Source	(6) Low pressure water injection	(7) Cool-down of RPV and PCV (heat removal): RPV	(7) PCV (Spray)	(7) PCV (Heat removal)	(4) - (7) Measuring instruments
Stage VII	Installation of alternative high pressure water injection system				Reinforcing D/D pumps				
Stage VI	Alternative water injection using HPCF when RCIC is in a single point failure				Alternative water injection using LPCS when RCIC is in a single point failure	Installation of standby motors for seawater pumps			
Stage V	Setting up a procedure for emergency use of water pressure system for moving control rods *1				Deploying fire engines at high ground (for water injection); Installation of an external port for MUWC	Installation of alternative immersion pumps			
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Stage III	Setting up a procedure to manually start RCIC		Setting up standby cylinders for driving SRVs		Electricity-driven fire fighting system	Residual heat removing system (A) and (B) (Removal of heat from RPV)	Setting up a procedure for spraying water to PCVby fire engines	Installation of a handle for manual ventilation of PCV	Reinforcing plant condition monitoring function (Measuring water level in RPV) *2
Stage II	Steam-driven high pressure water injection system (RCIC)	Automatic pressure reducing system	Cylinders (A) and (B) for driving SRVs	Installation of standby batteries for SRVs	MUWC (A), (B) and (C)	RPV coolant purification system(A) and (B)	Alternative spraying (MUWC and FP)	Containment PCV vent facility	Reinforcing plant condition monitoring function (Measuring water level in RPV) *2
Stage I	Electricity-driven high pressure water injection system (HPCS)	SRV (A), (B) (SRV)	LN_2 facility	Batteries (A) and (B) for operating SRVs	Electricity-driven low pressure water injection system (A),(B) and (C) LPCS	Condenser (Removal of heat from RPV)	D/W spraying	S/C cooling (A) and (B) (PCV vent)	Existing measuring systems

Classification of measures: (4) High pressure water injection; (5) Pressure reduction (Valve body, Air, Power Source); (6) Low pressure water injection; (7) Cool-down of RPV and PCV(heat removal) (RPV, PCV (Spray), PCV (Heat removal)); (4) - (7) Measuring instruments

*1 Though the volume of water supplied by this facility cannot totally cool down the decay heat generated by the RPV just after it stops, it is expected to use this as an auxiliary measures of injecting water at a high pressure. For this purpose, a procedure is set up (CRD(30m³/h)).

*2 Even in the case of a severe accident where the water level in RPV cannot be accurately measured, a thermometer will be installed at the reference water level container to understand whether the water level in the reactor is lower than the effective fuel area.

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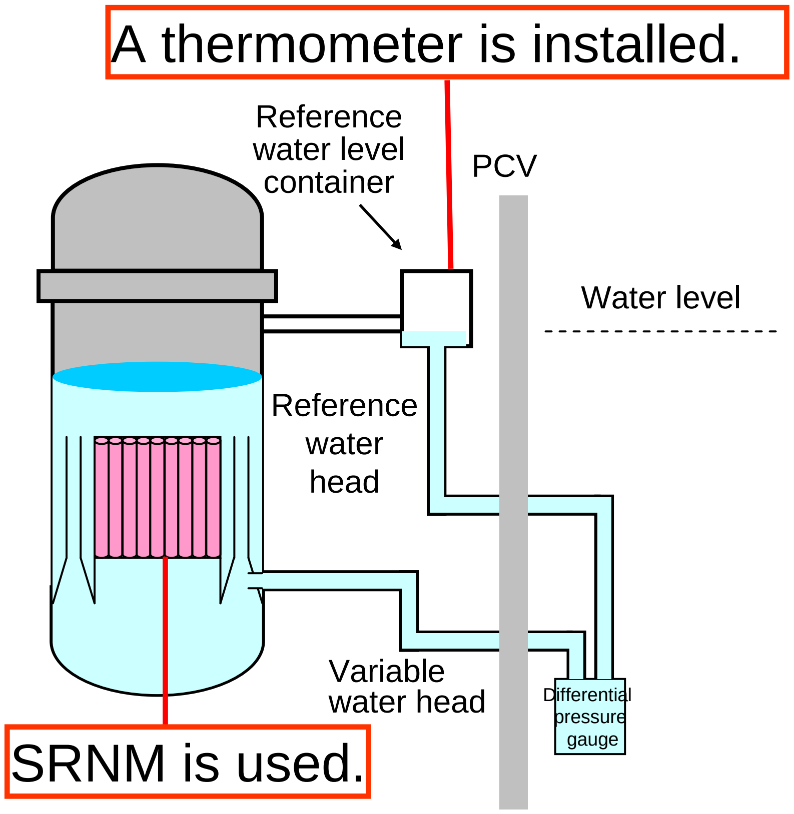
(4) - (7) Strengthening Plant Status Monitoring (Measuring the RPV Water Level)

A thermometer will be installed at the reference water level container to understand whether the water level in the reactor measures accurately in the case of a severe accident. To understand whether the water level in the reactor is lower than the effective fuel level, at the same time, the water supply nozzle temperature and discharge air temperature from the SRV , and the count of the SRNM (Startup Range Neutron Monitor) will also be monitored for this purpose



When the water level of the cores is approaching the bottom of the effective fuel level, water will be evaporated from the reference water level container due to a temperature surge. The temperatures of the water supply nozzle and SRV will go up as well.

In the reference water level container to monitor the water supply nozzle and the SRV to grasp when the water level is approaching the bottom of the effective fuel level.

Exposing fuel to the air decreases the SRNM count. This is a sign that fuel is exposed to the air due to a dropping water level.

Layer 4 Alleviating the Aftermath after an Accident

Issues (Lessons)

There were no means in place to alleviate the aftermath of the damaged core (including preventing damages to PCV, hydrogen control, measures against dropping of melted cores, and mass discharge of radioactive substances to the environment).

Policy

Measures to alleviate aftermath of damaged cores are strengthened (incl. hydrogen control, monitoring of hydrogen concentration, and suppression of core concrete reactions).

Hydrogen control

Hydrogen generated by reaction of Zr and water after cores are damaged will be discharged appropriately.

Suppression of core concrete reaction

After RPV pressure vessel is damaged and melted cores is dropped on the pedestal, the melted cores are appropriately retained and cooled down.

* The FCS' objective is to take an action against LOCA, and it doesn't have sufficient capacity to remove massive volume of hydrogen generated.

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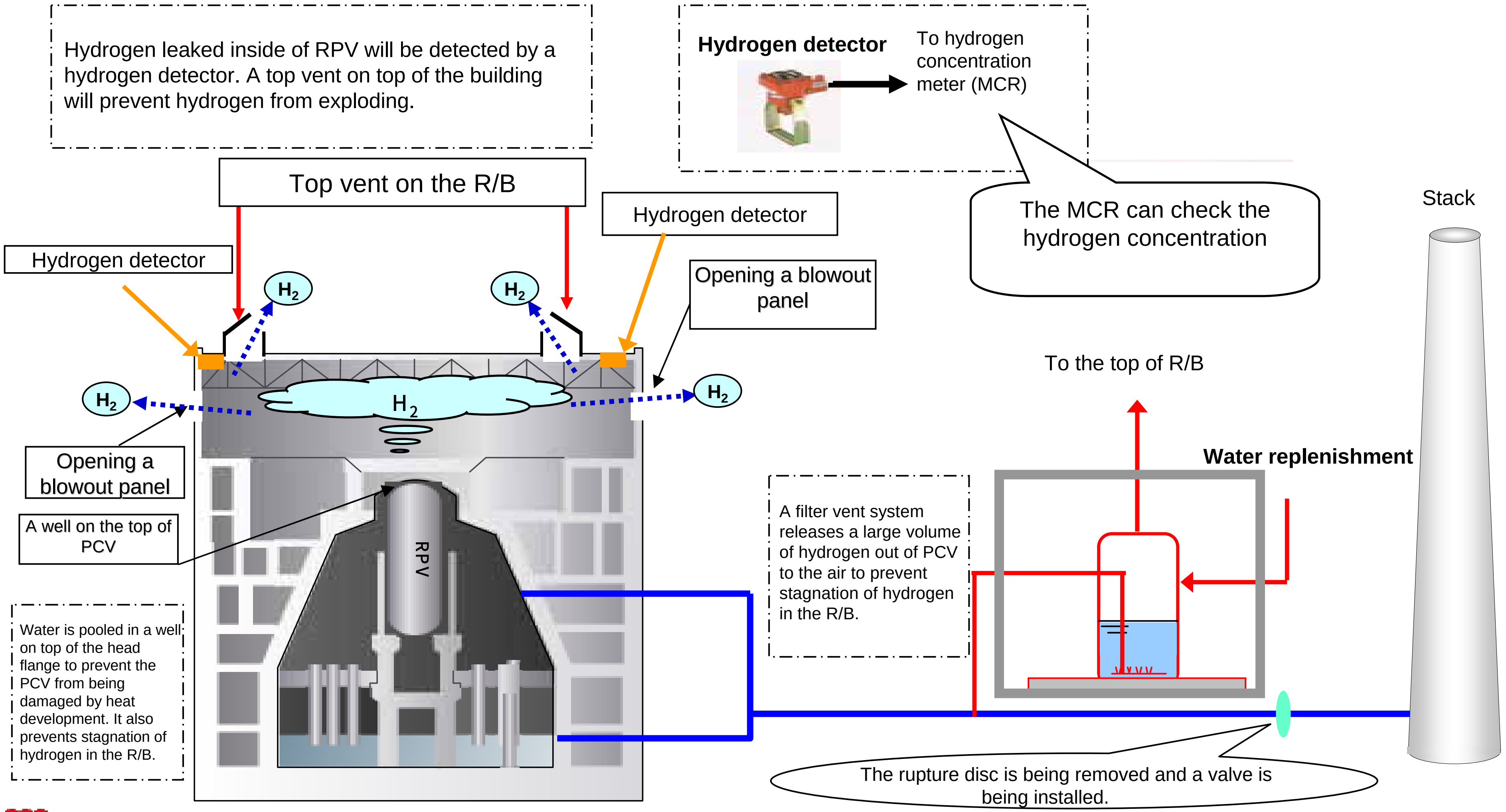
Classification of measures	Hydrogen control and monitoring hydrogen concentration			Suppressing core concrete reaction
Stage III	Top vent system on the R/B, hydrogen concentration meter at each building and blow out panel			Measures against falling of melted cores
Stage II	Hydrogen treatment system in R/B	Water pool at the top of PCV	Filter vent system	Water injection to pedestal using a fire engine
Stage I	FCS*			Water injection to pedestal using an MUWC

(8) Alleviation of aftermath of damaged cores

(8) Installing a Top Vent System in the R/B

Lessons Learned and Measures (Done)
Filtered vent is ongoing.

A filter vent system is in place to reduce the emission of radioactive substances after cores are damaged. The filter vent system is capable of releasing a large quantity of hydrogen out of the PCV; therefore, stagnation of hydrogen in the R/B can be avoided. In the case that a filter vent cannot discharge hydrogen from the building sufficiently, a top vent on the building will be used to avoid explosion of stagnant hydrogen.



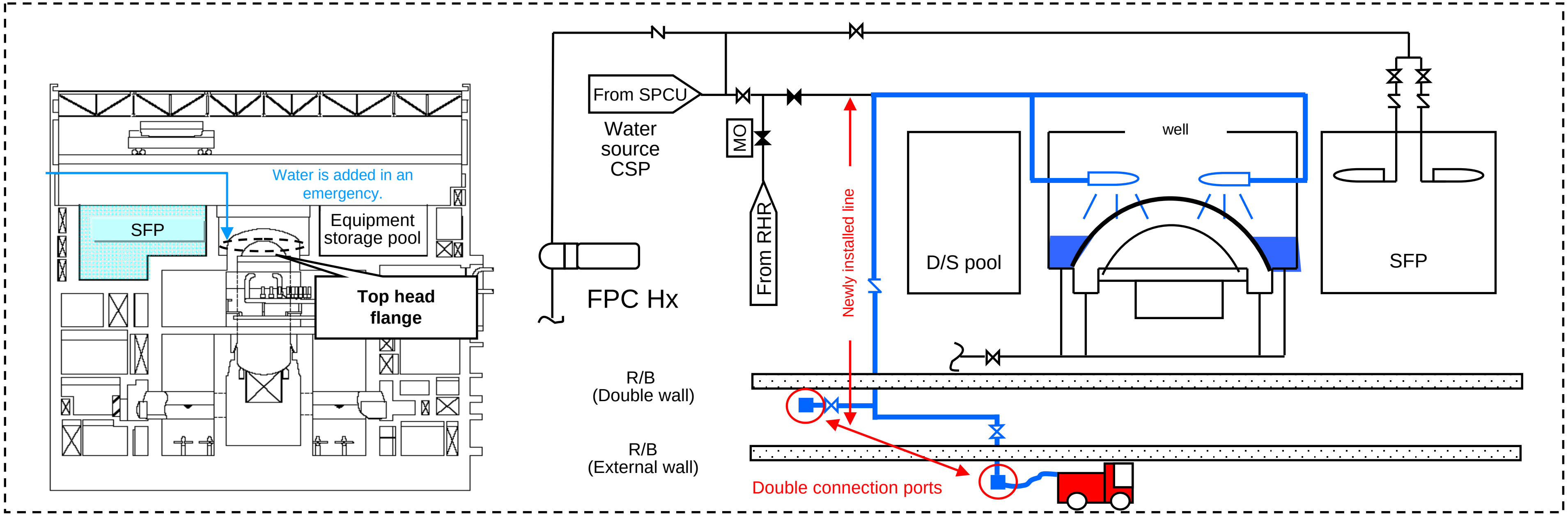
(8) A Well on the Top of the PCV

In order to prevent PCV from being damaged due to heat development after an accident, the idea of installing an emergency well water injection system to add water to the RPV well to cool down the top of the PCV is being examined.

A water supply line is installed from outside of the R/B to a well inside of the building by way of an FPC system to provide water to the well when an accident occurs (to cool down the top flange to avoid high temperature steam if generated in the PCV from flowing out to R/B).

* A simple assessment of PCV cool-down indicates that adding about 50 m^3 of water into the well can lower the temperature of the top head to max. 200°C. In the future, examination will be made as to the volume, timing, and target volume of water to be added.

Image of an Emergency Well Watering Line (Under Examination)

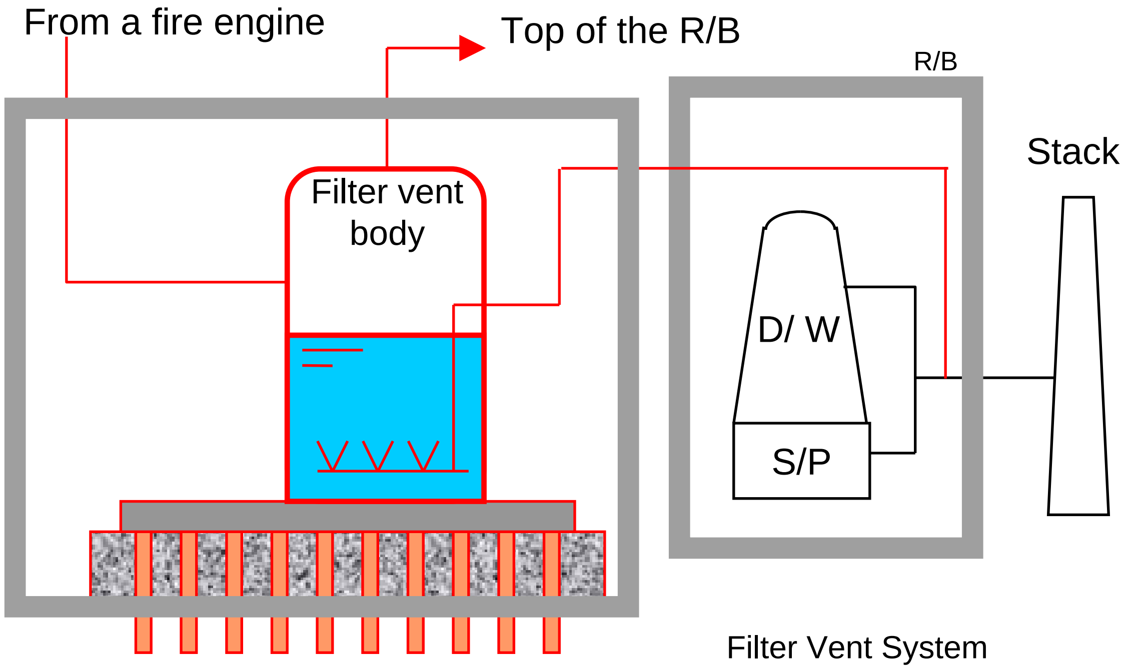


(8) Filter Vent

A filter vent is installed to reduce the release of radioactive substances when cores are damaged.

○ It reduces the release of iodine and cesium to ca. 1/1000.

Filter Vent System (Image)

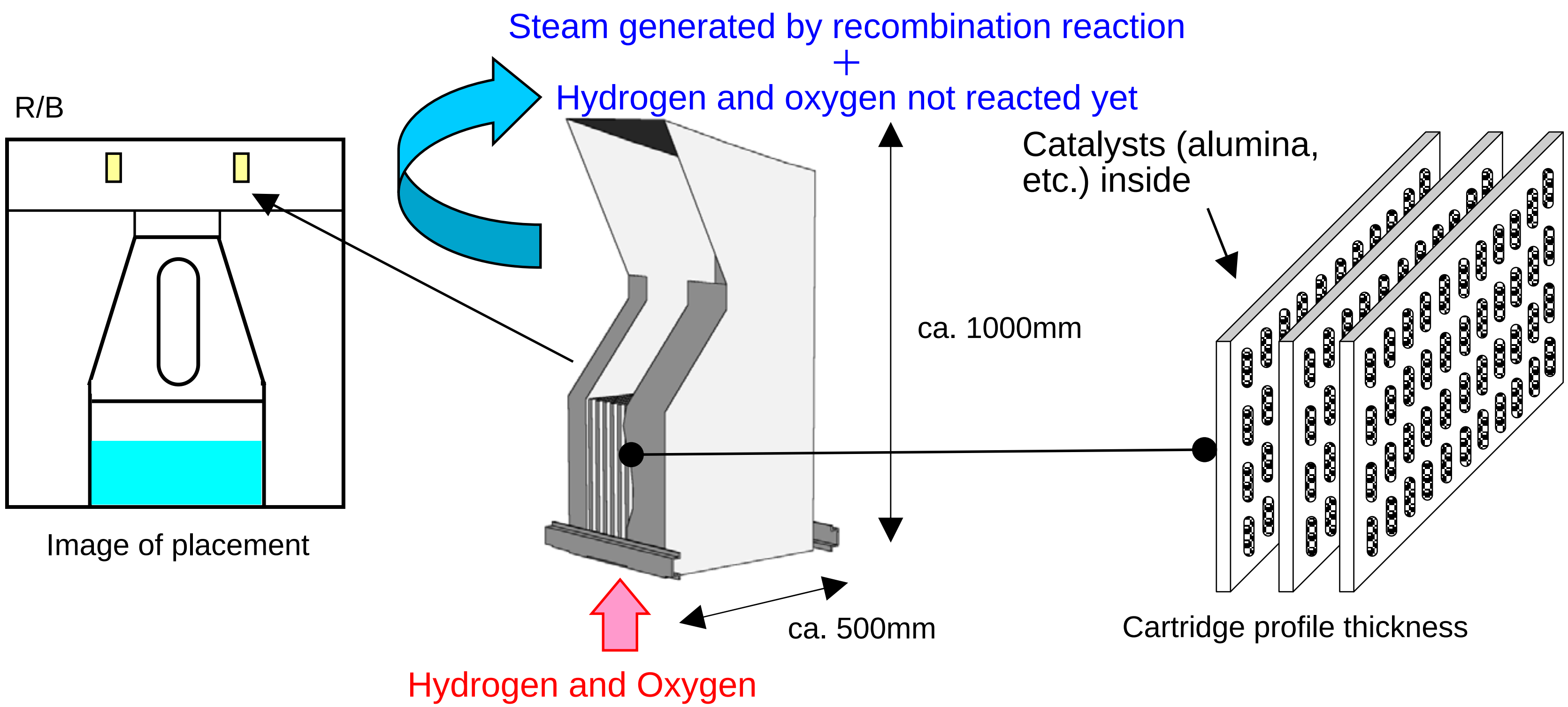


Filter Vent System

(8) Hydrogen Treatment System in the R/B

A passive autocatalytic recombiner (PAR) is installed to process hydrogen leaked inside of a building.

Image of a PAR (Under Examination)



PAR Specifications (Under Examination)
Processing capacity: Though the capacity of processing varies depending on the conditions of how hydrogen flows out inside of the nuclear reactor building, about 2 kg/h of hydrogen can be processed by a PAR unit.
Number: TBD, depending on where a PAR should be placed and what stagnant hydrogen is like in the R/B.

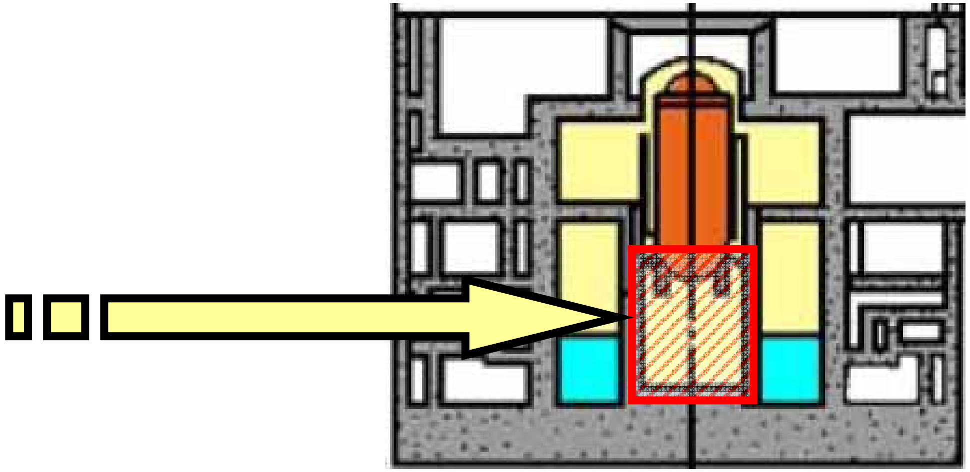
(8) Strengthening Temperature Monitoring in the PCV (Actions against Falling of Melted Cores)

The existing measurement system did not show how melted fuels behave.

- ✓ The thermometer in the RPV could not check the condition of melted cores.
- ✓ Temperature monitoring wasn't designed considering that the inside of the PCV could reach several hundred degrees Celsius.
- ✓ Whether an RPV is damaged can be assumed from the RPV and PCV pressure and the ambient temperature of a pedestal. No temperature that can directly detect (by measuring the temperature of hot pedestal bottoms in contact with melted fuels and fuels themselves) was used.

- ➢ **A thermometer capable of measuring high temperatures of more than 1,000°C will be introduced** so that melted cores can be detected.
- ➢ **Redundant temperature measurement systems** are employed for assured detection and from the viewpoint of space distribution of the system
- ➢ **A thermometer is installed at the bottom of an RPV and/or at the bottom of a pedestal.**

To ensure the accuracy of measurement under the severe accident condition, thermometers, cables and connectors are made with heat-withstanding.



(8) Anti-Corrosion in the PCV (Actions against Falling of Melted Cores)

Corrosion of PCV due to melted cores could not be avoided.

✓ Structure and materials used for PCVweren't designed in a way that a pedestal could be protected from high temperatures if water is couldn't be injected to the pedestal.

The PCV concrete is corroded by melted cores vertically and horizontally.

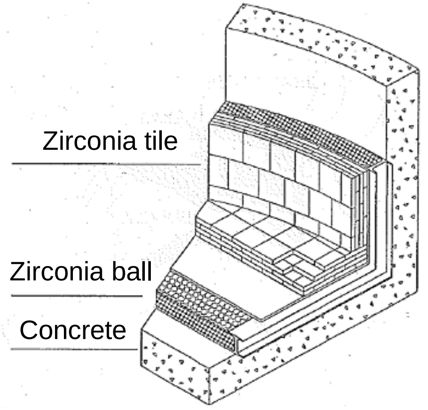
- **A corrosion prevention measure is installed** that catches melted cores to delay the start of corrosion.
- The materials and structures used will be determined based on past joint studies and existing technologies (incl. heat-withstanding properties, low thermal conductivity, chemical compatibility with corium, load intensity, etc.)

[Reference] Examples of existing technologies related to thermal-withstanding materials
Melting points of each material found in past joint studies and experienced in the other industries of iron milling, chemicals, aerospace, etc.)

Al_2O_3 (ca. 2,000**℃**) ; ZrO_2 (ca. 2,700**℃**) ;
MgO (ca. 2,800**℃**) ; SiC (ca. 2,700**℃**)

* In addition to melting points, it is necessary to determine which technologies to use after considering cracks that appear at high temperatures and corrosion by melted fuels.

* An example of a core catcher using ZrO_2



Corrosion of PCV by melted cores could not be avoided.

✓ When melted fuels are deposited in a certain depth by flowing into a drain sump at the bottom of a pedestal, water injection from the top cannot be sufficient to stop corrosion from developing.

In particular, in the case of a Mark II PCV (K-1 to K-5), there is an S/P under a pedestal sandwiching a concrete floor of less than 2 m in thickness. If they are heavily corroded, melted fuels will drop further.

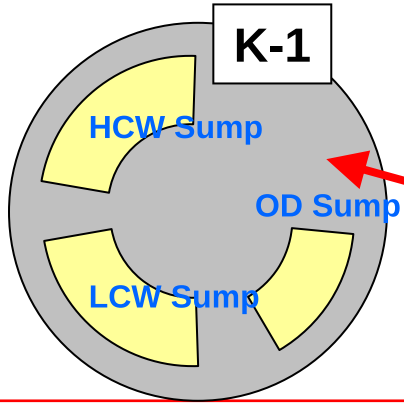
→ Melted fuels could drop through the sump at an early stage, as there is less than 1 m between the bottom of the sump and the S/P.

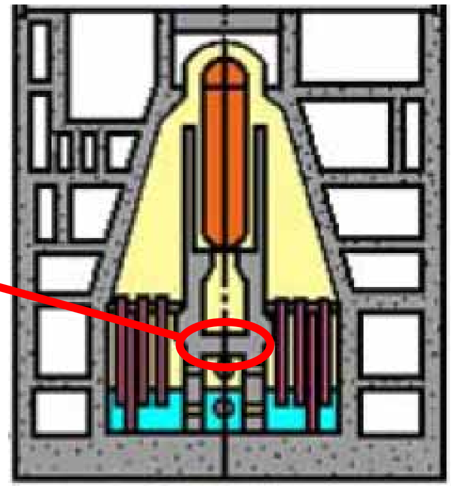
- **<u>The sump lid is changed to one made with thermal-withstanding materials</u>** (or laying thermal-withstanding tiles)
- A coolant leakage detection system in the PCV is secured using the sump drain line, and, considering the drain performance, **<u>the sump is bottomed up and/or the opening is reduced.</u>**

[Reference] Volume of Inflow into K-1 Drain Sump (Actual from April 2006 to May 2007)

- HCW
  Max.: 0.0027m³/hr (Sump volume: 2.0m³)
- LCW
  Max.: 0.2987m³/hr (Sump volume: 2.0m³)

* The OD drain sump isn't used currently and preparations to start a procedure to treat it as a letup facility are underway.





Safety Measures at Kashiwazaki-Kariwa Nuclear Power Plant <Others>

Others SFP cooling

Issues (Lessons)

Monitoring and measurement of water level and method of removing heat, water injection and securing water sources for fuel pools thereafter weren't set up sufficiently in the case of total loss of power sources.

Policy

Reinforced measures for injecting water and removing heat to and from fuel pool (water injection function, heat removing function, monitoring and measurement)

Colour / label	Meaning
Pink	**Measures (mid- to long activities) based on the Fukushima Daiichi Plant accident**
Red	**Measures (short-term) based on the Fukushima Daiichi accident (ongoing)**
Black	**Measures (short-term) based on the Fukushima Daiichi accident (done)**
Yellow	Measures against the Niigata Prefecture Chuetsu Off-shore Earthquake
Light blue	Accident management measures set up before the Fukushima Daiichi Plant accident
White	Facilities employed under the basic design

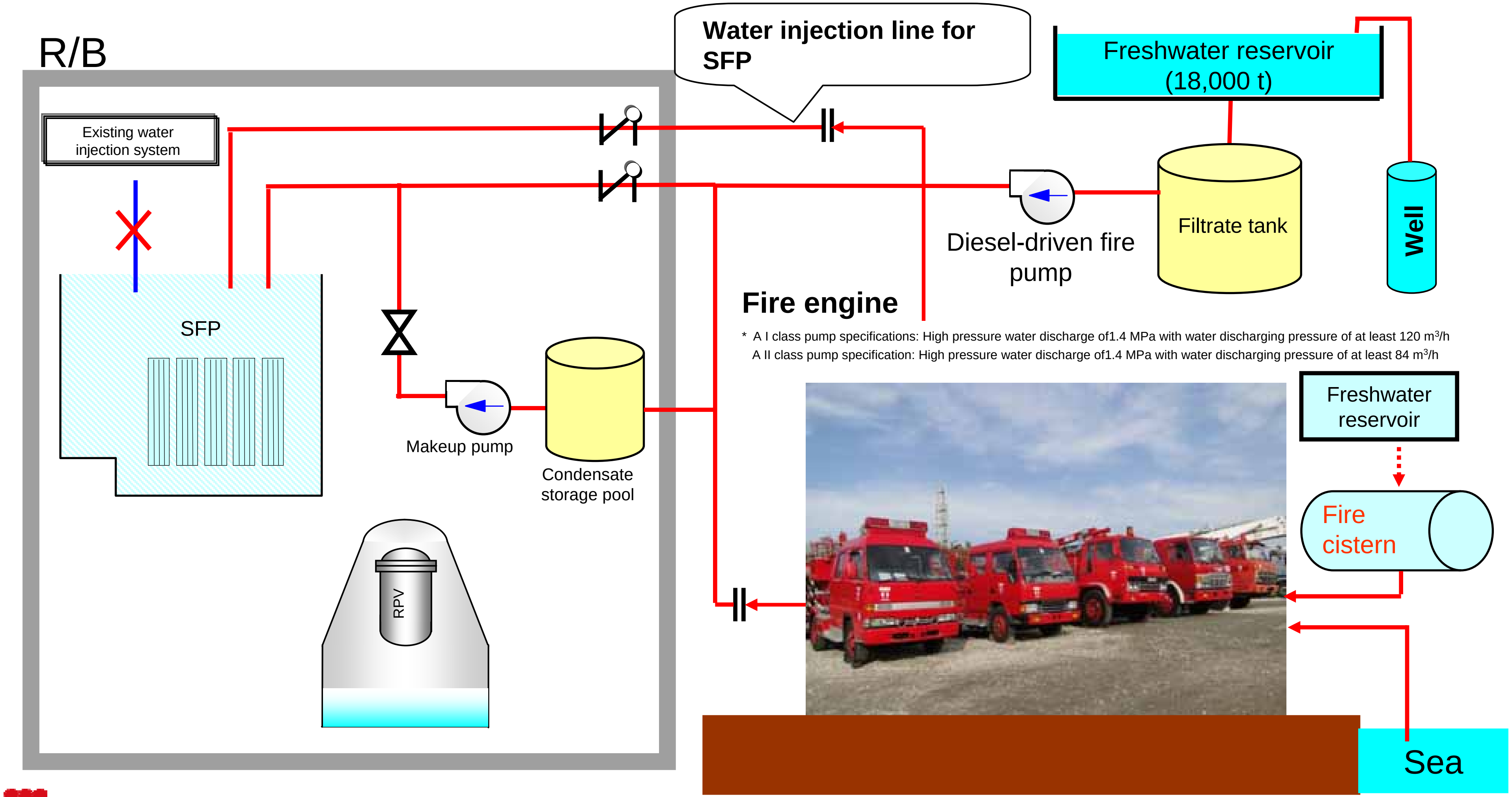
Note: Actions in the blue bold frame refer to facilities where tsunami prevention measures using tide embankments can be effective.

Classification of measures	Water injection function		Heat removal system	Monitoring and measurement
Stage V	**Reinforcing a D/D pump**			
Stage IV	**Deploying a concrete pump car**		Residual heat removal system A using alternative Hx (Heat removal from fuel pools)	Emergency monitoring camera
Stage III	**Deploying fire engines at high ground (for water injection)**	**Installing water pipe system from outside**	Fuel pool cooling and cleanup system A using alternative Hx	Emergency water level meter
Stage II	Condensate replenishment system		Residual heat removal system A and B(heat removal of fuel pools)	Monitoring from ITV
Stage I	Fuel pool water replenishment system		Fuel pool cooling and cleanup system A and B	Water level meter

(9) Fuel Pool

(9) Increasing Redundancy and Variations of Water Injection Means to SFP by Deploying Fire Engines at High Ground <Measures for SFP>

In order to ensure water injection to SFP even in the case that all electricity-driven water injection systems are unable to function due to a total loss of AC power sources, 8 fire engines (2 A I class cars and 6 A II class cars) are deployed at different places on high ground. The fire engines can be connected to the filling port installed at each building for spraying water to SFP. The number and size of diesel fire pumps are also increased.



(9) Adding Monitoring Cameras and Thermometers that Can Measure the Water Level <Measures for SFP>

Continuous monitoring of SFP is ensured from the central control room even when all AC power sources and the current monitoring function are lost.

- Monitoring cameras dedicated for SFP are installed.
- There are thermocouples installed that can measure temperature at 1 m intervals from the top of an SFP rack.

[Power Source]
- SFP thermometers → No power source required as they are thermocouples.
- Digital recorders → A built-in battery can operate the recorder for 7 hours.
- SFP monitoring camera → Power source cars are used to supply energy.

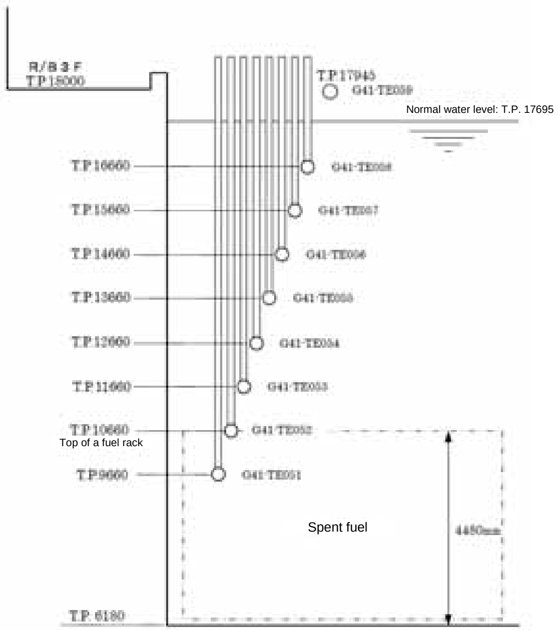
SFP Monitoring Camera (Unit 1)

Monitoring camera

Monitor (MCR)

SFP thermometer (Unit 1)

Central Control Room



(9) Deploying Concrete Pump Cars <Measures for SFP>

Concrete pump cars are deployed so that water can be injected directly to the SFP from outside of the R/B in the case of total loss of existing SFP water spraying and cooling functions due to loss of power supply and/or damages to the building.

- Concrete pump cars are deployed so that water can be sprayed to the SFP from outside of a R/B. (As of the end of July 2013)

A car with an arm length of 70 m

A car with an arm length of 52 m

Others Reinforcement against Earthquake of Facilities Routinely Used: A measure that is expected as one of the action when an accident occurs

Issues (Lessons)

The external power supply system was routinely used but hadn't been expected to operate when a massive earthquake occurs. In the case of Fukushima Daini, an external power supply that stayed online when the earthquake occurred played an important role in the restoration thereafter.

Policy

- Even routinely used facilities can be expected to be used in the case of an emergency. Such facilities will be subject to anti-earthquake reinforcement if possible.

Stage III

- Safety evaluation of foundation of transmission line towers
- Anti-earthquake reinforcement of switching stations and transformers
- Anti-earthquake reinforcement of condensate water makeup system pipes, etc.
- Anti-earthquake reinforcement of freshwater tanks

Stage II

- Additional anti-earthquake reinforcement by setting a conservative design earthquake ground motion Ss, taking into consideration the findings of the Chuetsu Off-shore Earthquake

Stage I

- Anti-seismic design in line with earthquake proof design guidelines

Classification of measures

(10) Earthquake

Legend:

- (Pink) Measures (mid- to long activities) based on the Fukushima Daiichi Plant accident
- Red: Measures (short-term) based on the Fukushima Daiichi accident (ongoing)
- Black: Measures (short-term) based on the Fukushima Daiichi accident (done)
- (Yellow) Measures against the Niigata Prefecture Chuetsu Off-shore Earthquake
- (Light blue) Accident management measures set up before the Fukushima Daiichi Plant accident
- (White) Facilities employed under the basic design

Note: Actions in the blue bold frame refer to facilities where tsunami prevention measures using tide embankments can be effective.

(10) Anti-earthquake Reinforcement of MUWC Pipes, etc. <Measures against Earthquakes>

At KK, Based on knowledge from the Niigata-Chuetsu-Oki Earthquake, conservatively configure the Design Basis Seismic Ground Motion Ss and strengthen earthquake resistance so that there is additional margin of resistance

Considering use of a condensate water makeup system to inject water to RPV and SFP so that in the event of an accident such as a tsunami hitting the plant, the makeup system is added with supports and its conduits and cables are reinforced against earthquakes.

■ When all ECCS have lost function, all three alternative water injection methods (i.e. MUWC, D/DFP and fire engines) should use the MUWC system line for injecting water to RPV.

MUWC system lines have been reinforced against earthquakes. The lines withstand design earthquake ground motion Ss, and the reliability of low pressure water injection is enhanced.

- Added supports at about 100 locations.
- Renewed cables
- Laid conduits (Route without the tray reinforced against earthquakes only)

Supports are added

[Before]

[After]

[Seismic Qualifications]

Secure redundancy of at least 1 against the earthquake movement for seismic retrofit of S1000 (envelopment of design earthquake ground motion Ss and amplified seismic wave generated by Niigata Prefecture Chuetsu Off-Shore Earthquake of1.5NCO).

* 1.5NCO refers to a seismic motion 1.5 times as large as that observed at the foundation of the Unit 1 building when the Niigata Prefecture Chuetsu Off-Shore Earthquake occurred.

(10) Anti-earthquake Reinforcement of fresh water tank <Measures against Earthquakes>

Of the thing that the soundness was secured in the case of Chuetsu-oki earthquake, pure water tank No.3,4 are reinforced against earthquakes by increasing the thickness of side plate and soleplate like other tank .

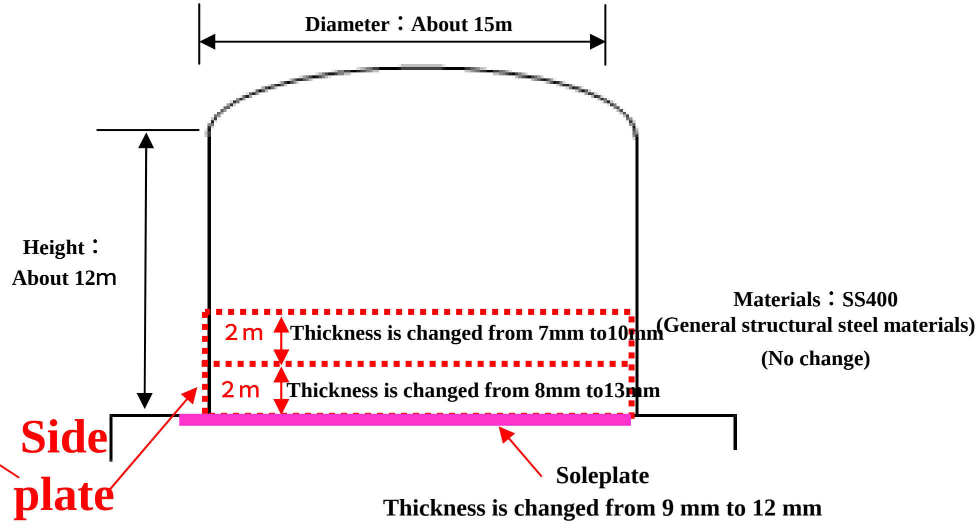
Filtrate water tank

		Anti-earthquake reinforcement after Chuetsu-oki earthquake
Arahama side	No.1	Rebuilding
	No.2	Rebuilding of side plate (deformity)
Ominato side	No.3	The thickness of side plate and soleplate were increased
	No.4	The thickness of side plate and soleplate were increased

Pure water tank

		Anti-earthquake reinforcement after Chuetsu-oki earthquake
Arahama side	No.1	Rebuilding (Increasing Self-respect)
	No.2	Rebuilding (Increasing Self-respect)
Ominato side	No.3	Because there was not meaningful injury, use continuously
	No.4	Because there was not meaningful injury, use continuously

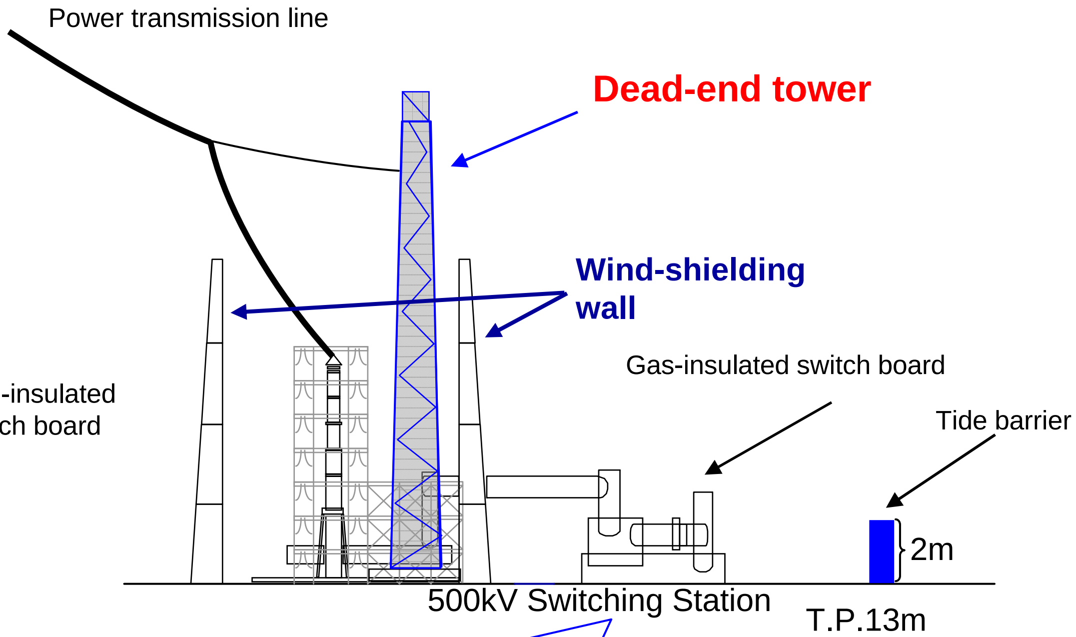
【Construction period】
- No. 3 tank ～Jun. 2013
- No. 4 tank ～Feb. 2013



(10) Enhancing Reliability of External Power Sources by Reinforcing Dead-end Towers of Switching Stations against Earthquakes <Measures against Earthquakes>

The dead-end tower that draws and fixes power transmission lines for a 500kV switching station will be replaced with a new one to enhance anti-seismic performance. At the same time, a tide barrier will be constructed at the switching station facility. Also, a wind-shielding wall will also be reinforced against earthquakes.

Gas-insulated switch board



[Facilities to be Replaced]

Minami-Niigata Trunk Line No. 1/No. 2

New Niigata Trunk Line No. 1/No. 2

Construction period: July 2012 to Dec. 2013 (planned)

The switching station installed in Kashiwazaki-Kariwa nuclear power plant uses gas-insulated switch board (GIS) with high quake resistant.
(It satisfies GIS:JEAG5003 'Anti-Seismic Guidelines of Electric Facilities,' whereas conformity with JEAC4601 'Anti-seismic Design Technology Regulation of Nuclear Power Plants' is being evaluated.

Others Safety Actions from Other Viewpoints

Issues (Lessons)

It was difficult to take actions against the accident due to significant deterioration of working environment, including poor accessibility to the affected sites and inferior workability caused by scattered debris.

Policy

Take actions for each function that should be used to support accident response activities.

* After the Chuetsu Off-shore Earthquake, access roads were repaired by improving the ground in areas where ground settlement and cracks were observed on the service roads.

As the short-term actions mainly for Fukushima Daiichi Nuclear Power Plant, there are tunnels that aren't earthquake resistant, for which an earthquake may cause deformation and above-ground road subsidence may occur. To alleviate the degree of subsidence and to allow emergency vehicles (power source cars and fire engines) to move along the road, the tunnels were reinforced along the area crossing with such above-ground roads with low seismic resistance.

Classification of measures	Emergency response headquarters	Central control room	Fire prevention	Securing access roads	Monitoring facilities	Communication system
Stage III			Reinforcing D/D pumps	Deployment of heavy machines to remove debris		
Stage II	Reinforcement of activity sites	Ventilation and air-conditioning system in the central control room To be powered by power source cars	Laying fire fighting pipes above-ground	Reinforcing access roads *	Reinforcing monitoring function	Reinforcing communication systems
Stage I	Construction of anti-seismic building	Ventilation and air-conditioning system in the central control room	Deployment of fire engines	Reinforcing access roads *	Existing monitoring facilities	Existing communication system

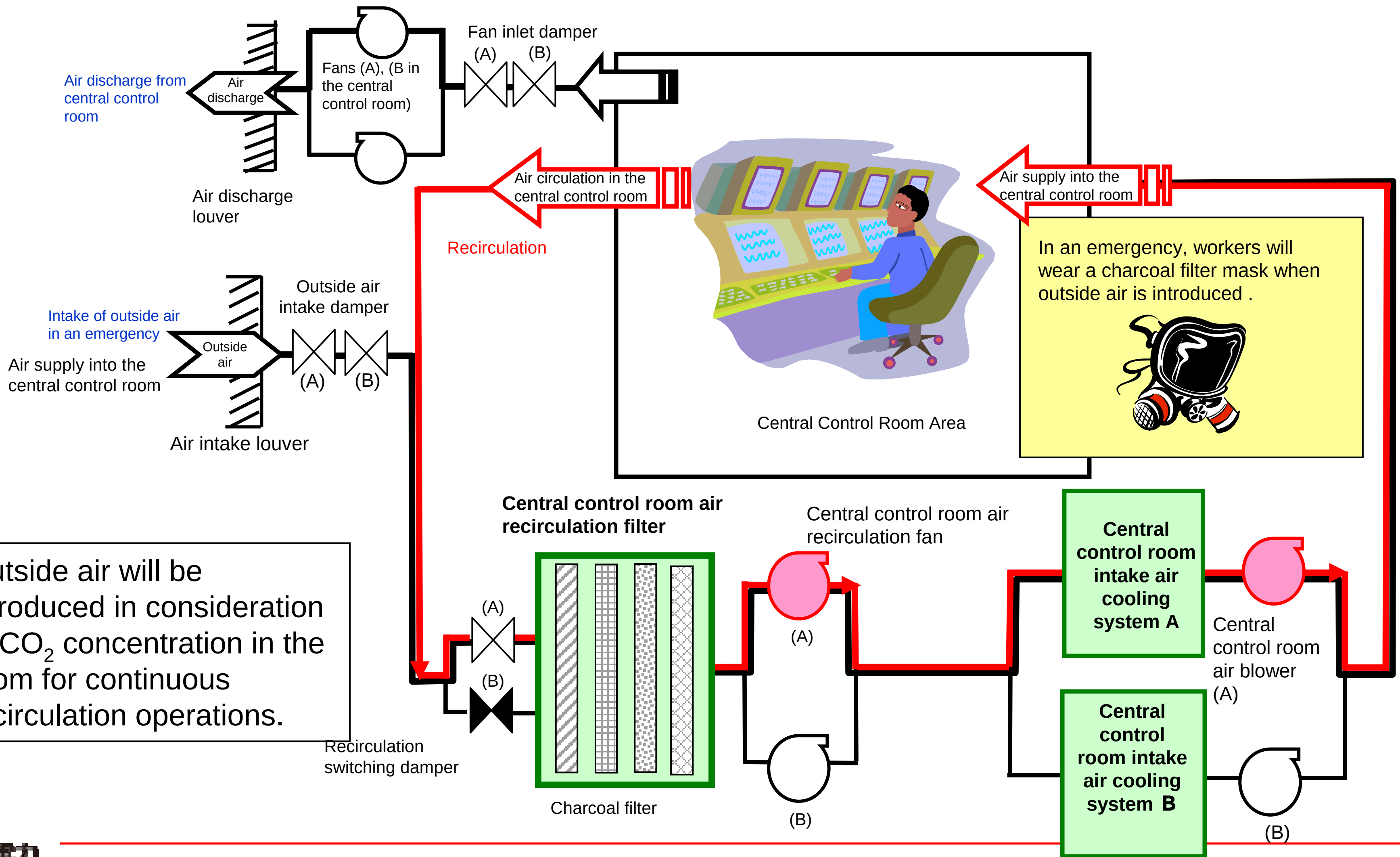
Legend:
- (Pink) Measures (mid- to long activities) based on the Fukushima Daiichi Plant accident
- Red: Measures (short-term) based on the Fukushima Daiichi accident (ongoing)
- Black: Measures (short-term) based on the Fukushima Daiichi accident (done)
- (Yellow) Measures against the Niigata Prefecture Chuetsu Off-shore Earthquake
- (Light blue) Accident management measures set up before the Fukushima Daiichi Plant accident
- (White) Facilities employed under the basic design

Note: Actions in the blue bold frame refer to facilities where tsunami prevention measures using tide embankments can be effective.

(11) Other Viewpoints

(11) Improving the Central Control Room <Other Viewpoints>

In the case where dose increases around the central control room, the dose within the room will be suppressed by operating an A/C system in the room to improve its air quality, using energy supplied by power source cars .



Outside air will be introduced in consideration of CO_2 concentration in the room for continuous recirculation operations.

(11) Reinforcing the Monitoring Function <Other Viewpoints>

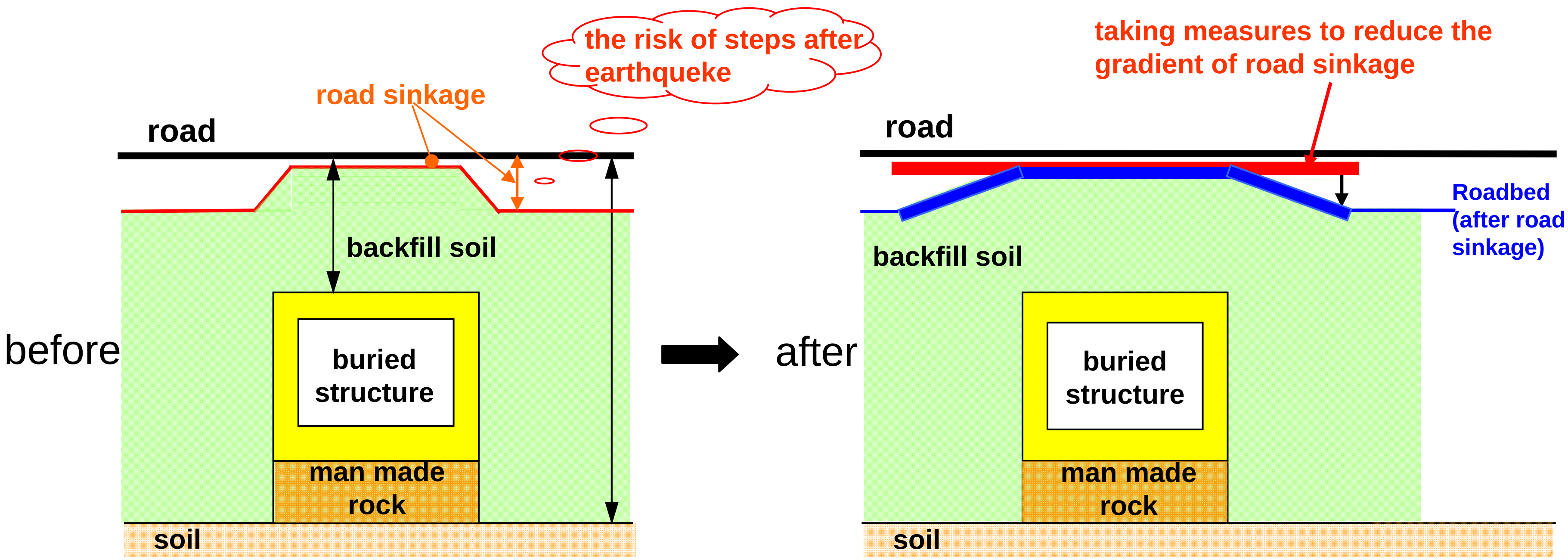
As a part of the reinforcing monitoring function, two KK monitoring cars will be deployed.

Systems in the Monitoring Cars
- External monitor chamber
- Dust sampler
- Dust monitor
- Iodine monitor
- Vane anemometer
- Power generator
- Satellite phone
- Transceivers
- Others

Monitoring car
Existing cars: 1 unit (see above)
Additional deployment: 2 units

⑪ Reinforcement of Access Roads ＜Other Viewpoints＞

- After the Niigataken Chuetsu-oki Earthquake, taking measures to reinforces yard access roads.
  → foundation improvement etc.
- Moreover, in order to ensure the rapid movement of vehicles, taking measures to reduce the gradient of road sinkage.



construction period：October 2012 ～ March 2013 (plan)

(11) Deploying Heavy Machines for Debris Removal <Other Viewpoints>

In order to secure access roads for power source cars and fire engines, etc., from high ground to the affected plant, heavy machines are deployed to swiftly remove scattered debris caused by an earthquake and/or a tsunami. The heavy machines are also used for removing gaps and repairing cracks on access roads.

[Loading shovels (3 units)]

[Wheel loaders (4 units)]

7 heavy machines for debris removal have already been deployed.
They can use 30m^3 of crushed stones to fill gaps on the route ahead of them.

In the case of a basic scenario* to use power source cars after the plant is hit by an earthquake and/or a tsunami, it is estimated that about 5 hours are required to completely secure an access route for a power source car from when the earthquake and the tsunami hit the area. When including restoration of power sources, the estimation is that it will take up to 8 hours.

* Occurrence of an earthquake/tsunami → Total loss of AC power source → Removal of debris → Mobilizing power source cars → RCIC → Heat removal via PCV vent → Securing water sources for CSP and fuel for power source cars

- ○ Place to mobilize heavy machines: At high ground of T.P.+35 m (Dispersed at Arahama side and Ominato side)
- ○ Place to stock crushed stones: As above
- ○ Operators
  - • Both the loading shovels and the wheel loaders will be handled by our employees to remove debris and to repair access roads. (Plural access routes are found)

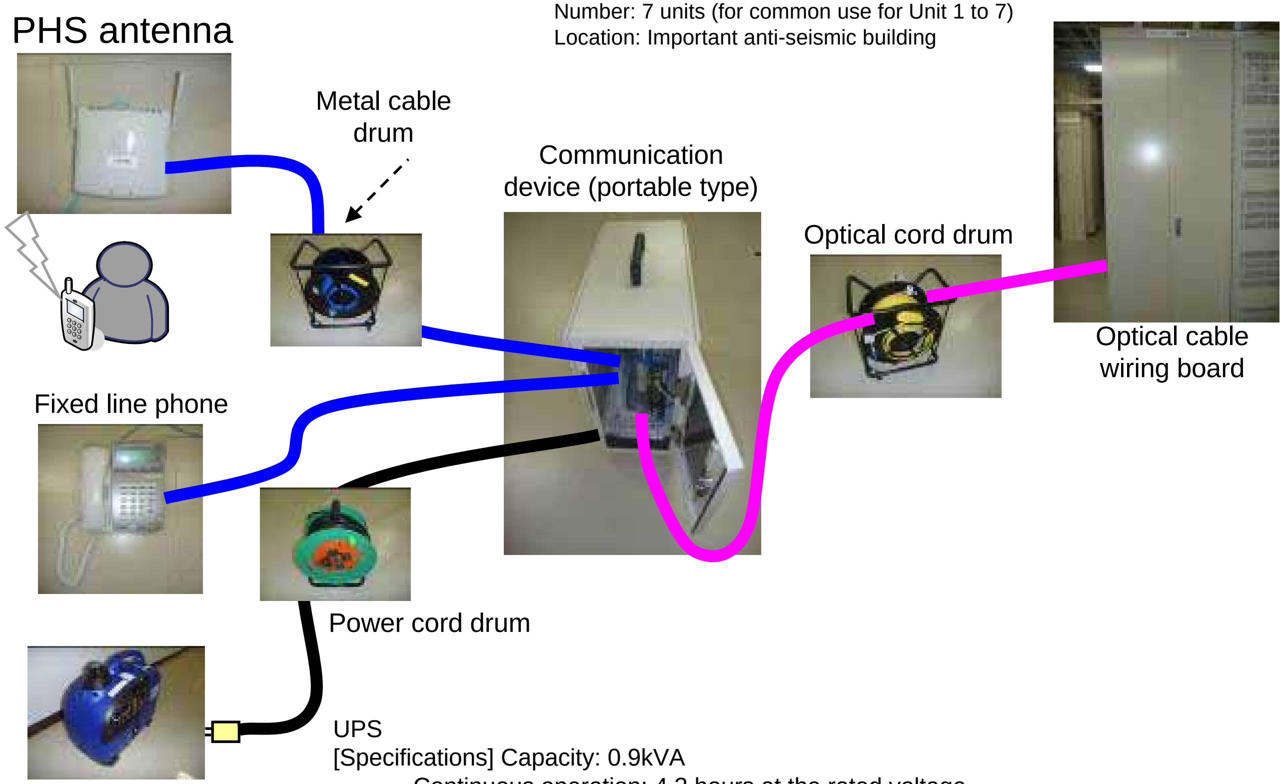
(11) Reinforcing Communication Systems <Other Viewpoints>

In order to ensure information collection and issuing commands at the central control room, sites and the important anti-seismic building, power sources for PHS switch boards and paging systems are reinforced, portable PHS antennas are deployed, and portable wireless machines are installed to reinforce communication systems.

Communication Systems (Example)

<Materials for Portable PHS Antennas>

Number: 7 units (for common use for Unit 1 to 7)
Location: Important anti-seismic building



UPS
[Specifications] Capacity: 0.9kVA
Continuous operation: 4.3 hours at the rated voltage
Fuel used: Gasoline
Gasoline tank capacity: 2.5L

<Training to use a Portable PHC>

(11) Reinforcing the Plant Status Monitoring Function <Other Viewpoints>

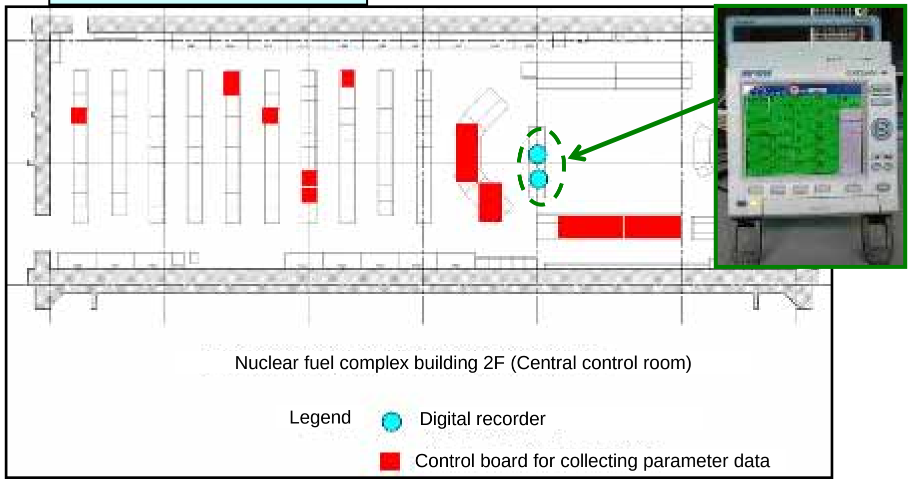
If the process calculator in the plant loses function due to an earthquake and loss of power supply, parameters cannot be monitored at the important anti-seismic building. The plant parameter monitoring function has been reinforced by transmitting the parameter to the building using digital recorders and the plant's LAN system in order to avoid such a situation.

- 14 digital recorders
- 7 PCs for monitoring
- A set of cables for temporary signals

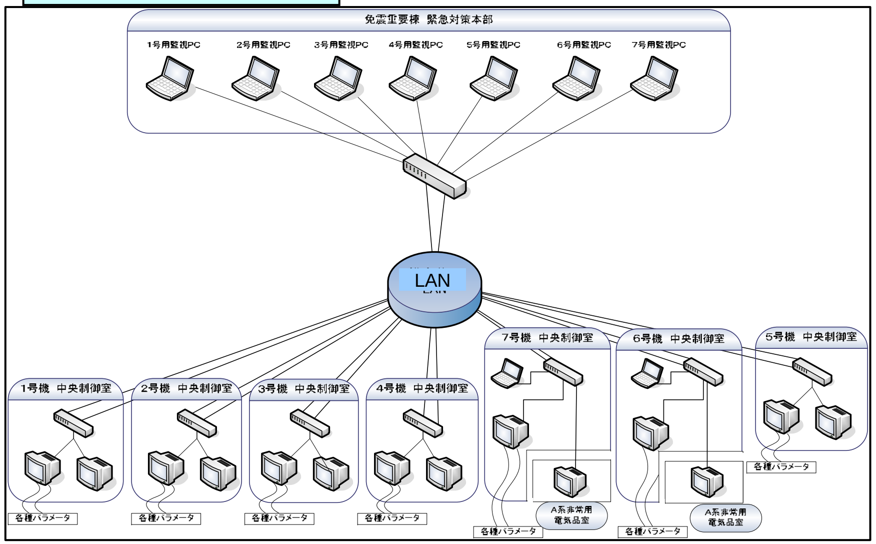
⊙ Major parameters

- Water level in RPV (fuel range)
- Pressure in RPV
- Pressure in PCV
- Others

Example (Unit 1)



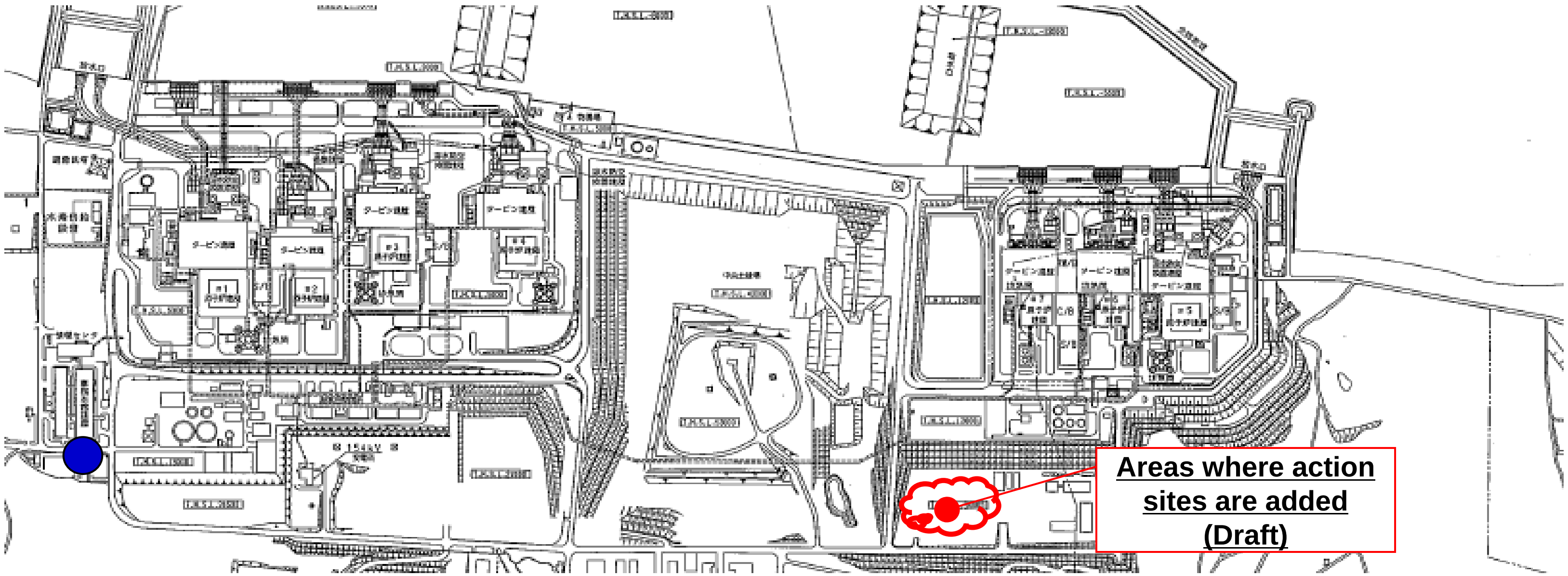
System Diagram



(11) Reinforcing Action Sites <Other Viewpoints>

The first floor of the important anti-seismic building served as the emergency response headquarters when the accident occurred. However, qualities and abilities above and beyond those originally designed for the building were required for the headquarters. Many issues were highlighted and it was revealed that the building must be redesigned. Therefore, emergency action sites for workers to work in the event of an emergency will be set up.

The existing anti-seismic building will be refurbished and reinforced. For this purpose, action sites whose functions and capacities are reinforced and for which prompt response activities can be made will be set up. (Size and the functions to be added are under examination.)



Measures at the Kashiwazaki Kariwa Nuclear Power Plant based on the lessons learned from the Fukushima Daiichi Nuclear Power Plant accident (Operational)

Legend	
(pink)	Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [medium- to long-term]
Red	Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (being implemented)
Black	Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (completed)
(yellow)	Measures based on the Niigataken Chuetsu-oki Earthquake
(light blue)	Accident management developed prior to accident at the Fukushima Daiichi Nuclear Power StationCountermeasures
(white)	Facilities adopted in the basic design

Note: Items in the blue thick frame are facilities in which effect is predicted with water stoppage measures by use of the seawall.

(12) Status of operational countermeasures of preparations for accidents

Problem (lessons learned)
Protection against unanticipated tsunami was insufficient.

Policy
- Preparing procedure for responding to the accident surpassing conventional anticipation, such as tsunami and loss of all power supplies.
- Implementing repeated education and training sessions for deployed response procedure.
- Making employees acquire necessary qualifications for driving heavy machinery

Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [medium- to long-term]
Red Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (being implemented)
Black Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (completed)
Measures based on the Niigataken Chuetsu-oki Earthquake, etc.
Accident management countermeasures developed prior to the accident at the Fukushima Daiichi Nuclear Power Station
Conventional responses being continued

Specific response (Countermeasures classification):

Preparation of response procedures
- Operation manual upon actuation of alarms
- Guidance for accident management (AM)
- Guidance for accident management (AM)
- Guidance for responding in the event that functions of the power supply are lost
- More improvement of guidance
- Emergency operating procedures
- Severe accident in emergency operating procedures
- Guidance of AM (accident management) for tsunami
- Flexible response guidance in case of emergency

Education and training
- Simulator training for operators
- Training regarding AM (accident management) for operators
- Training for operators regarding guidance of AM (accident management) for tsunami
- Training for response in case of loss of power supply functions, etc.
- Simulator training for operators Earthquakes + Tsunami + SBO
- Emergency response training
- Training regarding accident management
- Anticipation of a severe accident during emergency response training
- Reinforcement of emergency response training

Acquisition of training
- Acquisition of necessary qualifications for heavy machinery, etc.

(13) Operation status of countermeasures upon occurrence of complex disaster or simultaneous disaster at multiple plants

Problem (lessons learned)
The organization was confused when complex disaster and disaster occurred at multiple plants at the same time.

Policy
- Sharply increasing the number of personnel responding emergency at the power plant in order to respond to accidents that occur at multiple plants and long-term accident.
- Increasing the number of operators and personnel on duty for onsite response at initial phase.
- Increasing the number of personnel on duty and personnel for emergency response at the head office in order to support the power plant properly.
- Additional deployment of the alternative command post (alternative TSC)
- Introduction of ICS (Incident Command System)
- Clarifying the chain of instruction and command at the emergency countermeasures headquarters.
- Reinforcing the support system from cooperative firms and manufacturers, etc.
- Preparing the nuclear rescue unit equipped with remotely-operable robot, etc. in the Federation of Electric Power Companies.

Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [medium- to long-term]
Red Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (being implemented)
Black Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (completed)
Measures based on the Niigataken Chuetsu-oki Earthquake, etc.
Accident management countermeasures developed prior to the accident at the Fukushima Daiichi Nuclear Power Station
Conventional responses being continued

Specific response (Countermeasures classification):

Increase in number of personnel for response
- System of personnel on duty during night time and holidays
- Reinforcement of the number of personnel for radiation control in the system of personnel on duty during night time and holidays
- Increasing the number of personnel on duty during night time and holidays (personnel for external communication and personnel for collecting information)
- Increasing the number of personnel on duty during night time and holidays (personnel for onsite response)
- Personnel for emergency response
- Sharp increase of the number of personnel for emergency response
- Increasing the number of operators

Preparation of organization
- Clarification of the chain of instruction and command (arrangement of the person responsible for the unit)
- Introduction of ICS
- Preparation of the nuclear rescue unit
- Reinforcement of the support system
- Additional arrangement of the alternative command post

(14) Reinforcement of plant oversight, communication means, information sharing <communication and information sharing>

Problem (lessons learned)
Communication means, such as communication equipment, were restricted due to blackout, etc. and sharing information about the status became difficult; therefore plant states could not be smoothly determined and realized.

Policy
- Reinforcing monitoring and communication means, such as reinforcement of power supply and diversification of communication means.
- Formalizing information necessary at the accident in advance and preparation of guidance that is shared among operators, emergency countermeasures office and head office.
- National government dispatches members of the nuclear regulatory commission and director-general for emergency response measure. Also, cooperation is developed with the video conference system linking the national government and related organizations.

Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [medium- to long-term]
Red Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (being implemented)
Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (completed)
Black Measures based on the Niigataken Chuetsu-oki Earthquake, etc.
Accident management countermeasures developed prior to the accident at the Fukushima Daiichi Nuclear Power Station
Conventional responses being continued

Specific response (Countermeasures classification):

Reinforcement of monitoring of plant oversight
- Hot line between the main control room and the important seismic isolated building
- Satellite-based mobile phone equipped with the outdoor antenna
- Deployment of storage battery, etc. at the main control room
- Reinforcement of communication means in the main control room
- Satellite-based mobile phone
- Reinforcement of deployment of satellite-based mobile phone

Plant parameter
- Plant parameter transmission system (SPDS)
- Guidance for sharing plant information when at the time of shutdown of SPDS

Cooperation with the national government
- Video conference system
- Development of cooperation with the video conference system linking the national government
- Diversification of the report means to the local government

(15) Operation status of countermeasures for reinforcing procurement of materials and equipment and transportation system

Problem (lessons learned)
There was a shortage of materials and equipment for mitigating the accident.

Policy
- Storing food and beverages, which are necessary at the moment, in the power plant in consideration of deterioration of traffic situation.
- Making agreements with shipping companies and providing education regarding radiation protection to operators in order to transport necessary goods while a restricted area is set.
- Arranging logistic support bases (transportation base and access control base) reflecting lesson learned from the accident at the Fukushima Daiichi Nuclear Power Station.

Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [medium- to long-term]
Red Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (being implemented)
Black Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (completed)
Measures based on the Niigataken Chuetsu-oki Earthquake, etc.
Accident management countermeasures developed prior to the accident at the Fukushima Daiichi Nuclear Power Station
Conventional responses being continued

Specific response (Countermeasures classification):

Storage
- Storage of 7 days' worth food and beverage for personnel for emergency response
- Storage of fuel
- Agreement on procurement of fuel in emergency

Reinforcement of transportation system
- Transportation contract with shipping companies
- Transportation contract with shipping companies (including the restricted area)
- Education regarding radiation protection for operators in shipping companies

Logistic support base
- Logistic support bases

(16) Operation status of countermeasures for reinforcing the radiation control system at the time of an accident

Problem (lessons learned)
Dispersion of contamination and insufficient radiation control system made response to the accident difficult.

Policy
- Reinforcing the power supply at the monitoring post and reinforcing the monitoring car.
- Deploying additional radiation measuring device, materials and equipment for radiation protection at the emergency countermeasures office and the main control room. .
- Preparing the method for evaluating internal exposure at the time of an accident and response procedure.
- Establishing the method for preventing inflow of radioactive materials into the emergency countermeasures office and implementing the training.
- Implementing education for personnel measuring radiation at all offices in order to enable them to perform radiation measurement in wide area.

Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [medium- to long-term]
Red Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (being implemented)
Black Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (completed)
Measures based on the Niigataken Chuetsu-oki Earthquake, etc.
Accident management countermeasures developed prior to the accident at the Fukushima Daiichi Nuclear Power Station
Conventional responses being continued

Specific response (Countermeasures classification):

Reinforcement of monitoring device
- Deployment of one unit of monitoring car
- Reinforcement of monitoring car (1 unit to 3 units)
- Duplication of the power supply and transmission system at the monitoring post
- Reinforcement of the power supply of the monitoring post (emergency power supply)
- Deployment of a movable monitoring post

Materials and equipment for radiation protection, method for evaluating internal exposure, prevention of inflow of radioactive materials, increase the number of personnel
- Deployment of radiation protection accessories and APD for restoration personnel
- Increasing the number of APD at the important seismic isolated building and the main control room
- Deployment of the simple area entry control device
- Deployment of simple WBC
- Reinforcement of deployment of radiation protection accessories for restoration personnel
- Measures for preventing inflow of radioactive materials into the emergency countermeasures office
- Sharp increase of radiation measurement personnel

(17) Announcement and transmission of information to society at the time of an accident

Problem (lessons learned)
Announcement and communication at the event of the accident were not sufficient.

Policy
- Reconstruction of the system for handling news report
- Preparation of documents that are used in case of a severe accident
- Active transmission of information by use of Internet

Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [medium- to long-term]
Red Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (being implemented)
Black Measures based on the accident at the Fukushima Daiichi Nuclear Power Station [short-term] (completed)
Measures based on the Niigataken Chuetsu-oki Earthquake, etc.
Accident management countermeasures developed prior to the accident at the Fukushima Daiichi Nuclear Power Station
Conventional responses being continued

Specific response (Countermeasures classification):

Reinforcement of announcement and transmission of information to society at the time of an accident
- Reconstruction of system for handling news report
- Preparation of documents that are used in the event of a severe accident
- Real-time release of monitoring post data, etc.
- Transmission of information by use of PR car
- Transmission of information by use of emergency radio-casting
- Active transmission of information by use of Internet

(12) Current Actions for Accident Preparedness

Issues (Lessons)

Protection against a tsunami of unexpected size was weak.

Policy
- Procedures for response activities against failure of all power sources and other unexpected events will be set up.
- Repeated trainings and educations will be done to the response procedures.
- Employees are encouraged to get a license of operating heavy machines, etc.

Legend:
- (Pink) **Measures (mid- to long activities) based on the Fukushima Daiichi Plant accident**
- Red: **Measures (short-term) based on the Fukushima Daiichi accident (ongoing)**
- Black: **Measures (short-term) based on the Fukushima Daiichi accident (done)**
- (Yellow) Measures against the Niigata Prefecture Chuetsu Off-shore Earthquake
- (Light blue) Accident management measures set up before the Fukushima Daiichi Plant accident
- (White) Actions continued from the past

Concrete Actions

Classification of measures	Setting up of Procedures		Education and Training		Acquisition of a license
	More improvement of guidance		**Operator training using simulators for earthquakes, tsunami, and SBO**		
	Action guides in the case of loss of power supply, etc.	Ad hoc action guides in case of an emergency	**Training for responding to loss of power sources**	**Reinforcing emergency drills**	
	Accident Management (AM) Guide	**Accident Management Guide for Tsunamis**	**Training operators using a tsunami accident management guide**	Training to assume severe accidents in a case of an emergency	
	Symptom-based operation procedure during an accident	Operation procedure during severe accident	Training operators using Accident Management Guide	Accident Management training	
	Operation procedure during an alert	Operation procedure during an accident	Operator's simulator training	Emergency drill	**Operation license of heavy machines**

(12) Reinforcing Procedures and Training in Preparation for Severe Accidents <Preparation for an Accident>

(1) Action procedures are being set up for an accident of significantly unexpected size, including tsunamis and total power loss.
(2) Repeated education and trainings are performed for the action procedures.
(3) Employees are encouraged to obtain a license required to operate heavy machinery, etc.

Newly Established Procedures

- Accident Management Guide for Tsunamis
  ~ Contains a guide for power supply via power source car in the case of loss of power and for injection of water to SFP.
- Ad hoc action guides in the event of an emergency
  ~ Contains a guide for pressure reduction and water injection to RPV when power is lost.
- Guides for loss of power supply, etc.
  ~ Contain a guide for site workers to restore power supply using a power source car and a gas turbine generator (GTG).
- About a procedure book, the guide, we carry out a further review continuously


Newly established procedures

Completed Training

- Comprehensive training: 7 times, 1,420 total participants
- Individual training: Done 282 times in total (as of the end of October 2012), incl. training for operation of power supply cars and GTGs, water injection by fire engine, and monitoring in an emergency, etc.
- The comprehensive training also included blind training assuming the occurrence of a severe accident.


Power supply training from a GTG

Acquisition of licenses

As of the end of Nov. 2012
Holders of driving a heavy vehicle : 48
Holders of driving a special heavy vehicle : 21
Holder of a large trailer license : 18

(13) Measures against Complex Disasters and Simultaneous Damages to Multiple Plants

Issues (Lessons)

The organization of the plant was in turmoil due to the complex disasters and simultaneous damages to multiple plants.

Policy

- The number of emergency response workers in the plant is increased so that actions can be taken against damages to multiple plants and against prolonged accident conditions.
- The number of operators and night duty workers is increased for initial on-site response activities.
- The necessary number of night duty workers and emergency response workers at the head office for correct support of a disaster-affected plant
- An alternative TSC for the emergency response headquarters is added.
- Command lines from the emergency response headquarters are clarified.
- ICS (Incident Command System) is introduced.
- A support network from supportive companies and makers, etc. is reinforced.
- A nuclear rescue team equivalent to the size of the Federation of Electric Companies of Japan (which has a remote control robot) is formed.

Legend:
- (Pink) Measures (mid- to long activities) based on the Fukushima Daiichi Plant accident
- Red: Measures (short-term) based on the Fukushima Daiichi accident (ongoing)
- Black: Measures (short-term) based on the Fukushima Daiichi accident (done)
- (Yellow) Measures against the Niigata Prefecture Chuetsu Off-shore Earthquake
- (Light blue) Accident management measures set up before the Fukushima Daiichi Plant accident
- (White) Actions continued from the past

Concrete Actions

Classification of measures: **Increase of response workers**
- Night duty and holiday workers system
- Reinforcing the night duty and holiday workers system and the number of radiation controllers
- **Increasing night duty and holiday workers (for communication with outside entities and collecting information)**
- **Increasing night duty and holiday workers (site workers)**
- Emergency response workers
- **Significant increase of emergency response workers**
- **Increasing the number of operators**

Classification of measures: **Action organization improvement**
- **Clarification of command lines (Assignment of a manager for each reactor)**
- **Introduction of ICS**
- **Setting up of a nuclear rescue team**
- **Reinforcing a support system**
- **Setting an additional command center**

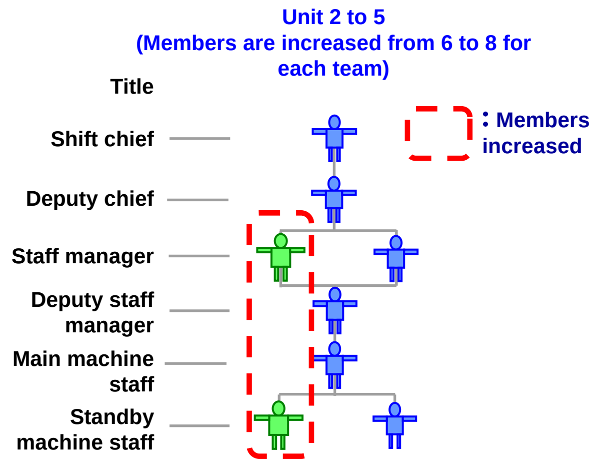
(1) The number of the plant's emergency response workers is significantly increased to cope with simultaneous damages to multiple plants and prolonged accidental conditions.

(2) The number of operators and night duty workers is increased for initial on-site actions.

(3) The number of operators and night duty workers is increased at the head office for supporting affected plants.

Plant Operators, Night Duty Workers, and Emergency Response Workers

- After learning actions required after the tsunami, operators will be increased by 60 (30 operators already added) (205 → 265 operators) (full members).
- The number of emergency response workers will be increased after considering the shift working system (324 → 649 workers).
- The night duty system is reinforced for communication with outside entities and collecting plant information immediately after a disaster (6 → 8 workers).
- Workers are stationed at the plant round-the-clock so that power can be restored as soon as possible, water can be injected swiftly, and debris can be removed promptly and for other early site response activities (about 20 workers).



Head Office Emergency Response Workers

- Emergency response workers are increased as required at the head office as well after considering the shift working system.
- Night duty staff are also increased at the head office to extend support as required by the affected nuclear plant.

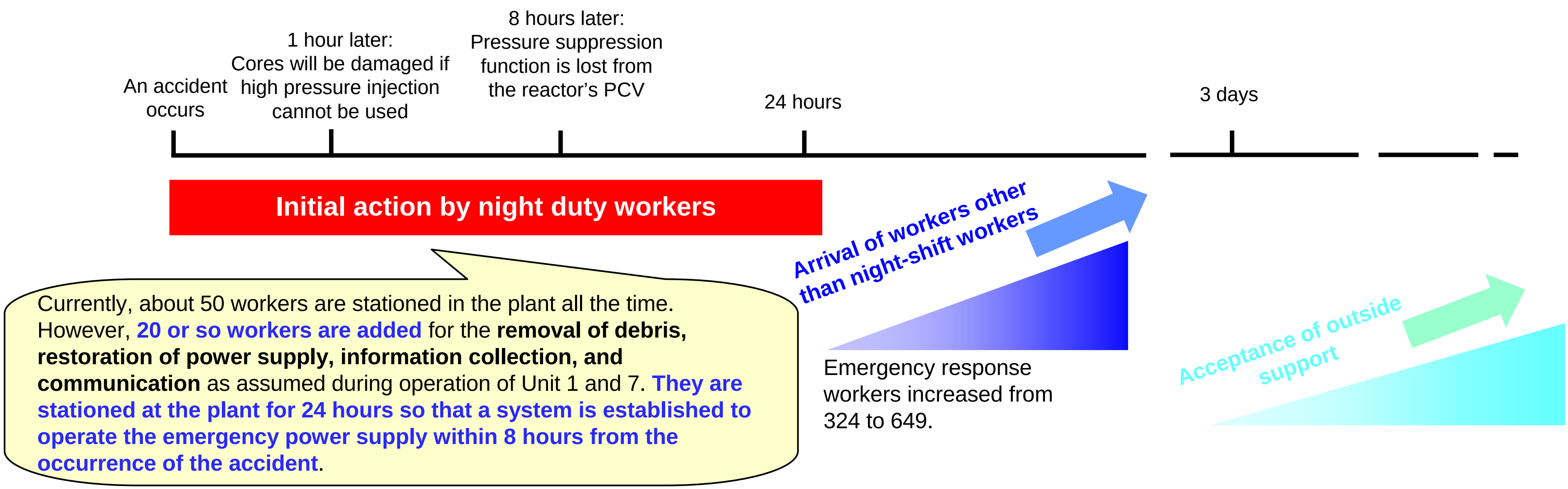
What should the Site do for Initial Response Activities?

The accidents in Fukushima taught us that effective actions should be initiated immediately after the occurrence of an accident. Hence, it is necessary to ensure an initial site action response system that can respond to the development of an accident.

In examining the initial site action response system for severe accidents, the following items are taken into consideration for strengthening the system.

- No help by workers other than night-shift workers will be expected for 24 hours from the start of an accident.
- No help by external entities will be expected for 3 days from the start of an accident.

[Development of Events upon Total Loss of Power and Heat Sink]



(13) Measures against Complex Disasters and Simultaneous Damages to Multiple Plants <Emergency Preparedness>

(5) An alternative TSC for the emergency response headquarters is added.

(6) Command lines from the emergency response headquarters are clarified.

Addition of an Alternative TSC

- Addition of emergency response workers activity sites is under examination now, and within this fiscal year, an alternative TSC of the emergency response headquarters will be added to Unit 5 as an additional measure in preparation for occurrence of further unexpected phenomenon.
- The ventilation and air-conditioning system has a function to remove radioactive substances, and workers can stay in the plant for a long time even if radioactive substances are released into the atmosphere.
- It is very sturdy against various disasters and the TCS can be used as an activity site on the Ominato side.

Clarification of Command Lines in the Emergency Response Headquarters

- Who is the next authority in command in the absence of the top management will be clarified, and officials sent from OFC have been revised.
- A reactor manager is appointed in the power generation team and the restoration team in the nuclear power plant emergency response headquarters to strengthen the system of reporting and issuing instructions.
- An incident command system is introduced so that restoration activities are performed with swift decision-making when an accident and/or disaster occurs at multiple plants simultaneously.

(13) Measures against Complex Disasters and Simultaneous Damages to Multiple Plants <Emergency Preparedness>

(7) The support network of supportive companies and makers, etc. is reinforced.

(8) A nuclear rescue team equivalent to the size of the Federation of Electric Companies of Japan (which has a remote control robot) is formed.

Strengthening the Support System

- In order to get and strengthen support from outside entities at the initial stage of an accident, agreements are signed with supporting companies and makers.
- The Federation of Electric Companies of Japan reviewed an agreement among electric companies and a new agreement has been signed. (The addition of radiation protection equipment, etc., is revised in consideration of the Fukushima accident).

Nuclear Rescue Team

- The Federation of Electric Companies of Japan, which has a robot which can be remotely controlled from Fukui Prefecture (The Japan Atomic Power Company), decided to have a rescue team.
- In November, training began for a total of 6 employees stationed at the Fukushima Daini and Kashiwazaki-Kariwa nuclear power plants.

Packbot ®

Warrior

(14) Reinforcing Plant Monitoring Means of Communication, and Information Sharing <Disseminating and Sharing Information>

Issues (Lessons)

The status of the plant was unable to be understood and shared smoothly as the blackout robbed the plant of its means of communication.

Policy

- Means of monitoring and information dissemination are reinforced including strengthening the power supply and ensuring redundancy of means of communication.
- A guidebook is created which formalizes important information to be disseminated/collected in the event of an accident to share it between operators, the nuclear power plant emergency response room, and the head office.
- The government of Japan dispatches members of the regulation committee and an emergency response supervisor to the head office. The head office is connected with a video conference system that connects the government of Japan and relevant authorities.

Legend:

- (Pink) Measures (mid- to long activities) based on the Fukushima Daiichi Plant accident
- Red: Measures (short-term) based on the Fukushima Daiichi accident (ongoing)
- Black: Measures (short-term) based on the Fukushima Daiichi accident (done)
- (Yellow) Measures against the Niigata Prefecture Chuetsu Off-shore Earthquake
- (Light blue) Accident management measures set up before the Fukushima Daiichi Plant accident
- (White) Actions continued from the past

Concrete Actions

Classification of measures	Concrete Actions
Reinforcing plant monitoring and means of communication	Installing a hotline between the central control room and the important anti-seismic building; Installing outdoor antennas for satellite mobile phones; **Deploying batteries to central control room**; **Reinforcing means of communication in central control room**
Reinforcing plant monitoring and means of communication	Satellite mobile phones; **Increasing the number of satellite mobile phones**
Plant parameters	Plant parameter transmission system (SPDS); **Guide for sharing plant information when SPDS stops**
Connecting with GOJ	Video conference system; **Connection to a video conference system with the government of Japan**; **Diversification of the report means to the local government**

(14) Reinforcing Plant Monitoring, Means of Communication and Information Sharing <Disseminating and Sharing Information>

Lessons Learned and Measures (Done)
Lessons Learned and Measures (Ongoing)
Lessons Learned and Measures (Mid- to Long-Term)

(1) Means of monitoring and information dissemination are reinforced, including strengthening the power supply and ensuring the redundancy of means of communication.

(2) A guide book is created that formalizes the important information to be disseminated/collected at an accident to share it between operators, the nuclear power plant emergency response room, and the head office.

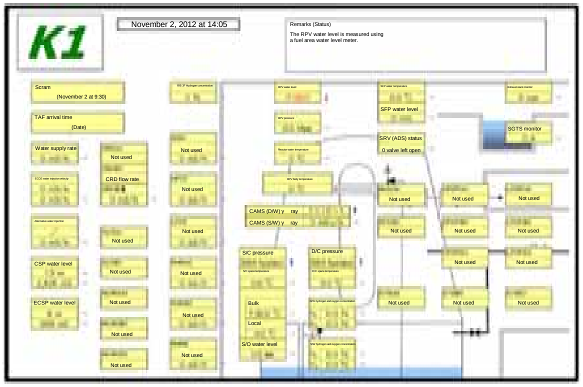
(3) The government of Japan dispatches members of the regulation committee and an emergency response supervisor to the head office. The head office is connected with a video conference system that connects the government of Japan and relevant authorities.

Reinforcing Plant Monitoring and Means of Communication

- In addition to the emergency lighting system, the central control room is equipped with temporary lighting system, batteries, and other materials and equipment.
- Communication equipment (wireless system and Antenna for satellite mobile phones) is added in the central control room.
- Satellite mobile phones is added

Sharing of Critical Information

- Two workers are added to night duty for collecting plant information.
- A form and a guidebook are established to ensure that important plant parameters and other information can be shared even when the plant's parameter system (SPDS) is unable to function.



Example of a form that allow sharing of plant status

Connecting with GOJ, Diversification of the report means to the local government

- The government of Japan establishes a nuclear facility accident quick response center in the head office and sends members of regulation committee and an emergency response supervisor to the center.
- The head office is connected with a video conference system in which the GOJ and relevant authorities participate (using a dedicated line as well as a satellite line).
- We examine introduction of the all at once report FAX using a satellite line because of diversification of the report means to the local government

(15) Strengthening Procurement of Materials/Equipment and Transportation Systems

Issues (Lessons)

Materials and equipment were not enough to solve the accident.

Policy
- Foods and fuels, etc., that would be required in the case of a disaster are stored in the plant, considering possible transportation shutdown due to a natural disaster.
- Agreements are signed with transportation companies so that required items can be transported even when the plant area is designated as a cautionary zone, and radiation protection training is performed with regard to their drivers.
- Logistics support areas (logistics areas and egress/ingress control areas) are set up reflecting the lessons learned from the Fukushima accident.

Legend:
- (Pink) Measures (mid- to long activities) based on the Fukushima Daiichi Plant accident
- (Green, Red text) Measures (short-term) based on the Fukushima Daiichi accident (ongoing)
- (Green, Black text) Measures (short-term) based on the Fukushima Daiichi accident (done)
- (Yellow) Measures against the Niigata Prefecture Chuetsu Off-shore Earthquake
- (Light blue) Accident management measures set up before the Fukushima Daiichi Plant accident
- (White) Actions continued from the past

Concrete Actions

Classification of measures	Storage	Reinforcing transportation system	Logistics support sites
Concrete Actions	**Emergency fuel procurement agreement**	**Radiation protection education to drivers of the transportation companies**	
	Storage of fuel	**Transportation agreement with transportation companies (incl. caution zone)**	
	Storage of 7 days consumption volume of food and beverages for emergency response workers	**Transportation agreement with transportation companies**	**Logistics support sites**

(15) Storing Necessary Items within the Plant and Reinforcing Transportation System <Strengthening Materials/Equipment Procurement and Transportation System>

(1) Food and fuels, etc., that would be required in the case of a disaster are stored in the plant, considering a possible transportation shutdown due to a natural disaster.

(2) Agreements are signed with transportation companies so that required items can be transported even when the plant area is designated as a cautionary zone, and radiation protection training is performed with regard to their drivers.

(3) Logistics support areas (logistics areas and egress/ingress control areas) are set up reflecting the lessons learned from the Fukushima accident.

Storage of Foods, Beverages and Fuels

- Food and beverages: 7 day-equivalent volume for emergency response workers
- Fuel (Light oil): 150 day-equivalent volume for power source cars and fire engines
- Signed procurement agreements with local fuel suppliers as an emergency measure

Food and beverages are stored.

Reinforcing Transportation System

- In order to ensure prompt transportation of necessary materials and equipment to the plant from outside of the disaster area, an agreement was signed with transportation companies.
- Radiation protection education was provided to drivers of contracted transportation companies beforehand. (58 drivers have completed the course.)

Logistics Support

- A guide for selecting and setting up the logistics support sites (logistics site and egress/ingress control sites) is in place.

Logistics site (J-Village)

(16) Strengthening Radiation Control System in Case of an Accident

Issues (Lessons)

<u>The spread of contamination and the inappropriate radiation control system</u> made it difficult to perform accident response activities.

Policy

- The monitoring post power supply is strengthened and more monitoring cars are added.
- More radiation meters and radiation prevention materials/equipment are added to the emergency response room and the central control room.
- Procedures are set up for how to evaluate internal exposure and countermeasures therefor in the event of an accident.
- How to prevent the inflow of radioactive substances to the emergency response room is established and training thereof is performed.
- Radiation dose measurement training is performed for the entire office in preparation for the need to measure radiation levels over a broad area.

Legend	Meaning
(pink)	Measures (mid- to long activities) based on the Fukushima Daiichi Plant accident
Red	Measures (short-term) based on the Fukushima Daiichi accident (ongoing)
Black	Measures (short-term) based on the Fukushima Daiichi accident (done)
(yellow)	Measures against the Niigata Prefecture Chuetsu Off-shore Earthquake
(light blue)	Accident management measures set up before the Fukushima Daiichi Plant accident
(white)	Actions continued from the past

Concrete Actions

Classification of measures	Reinforcing Monitoring Equipment		Radiation protection materials/equipment, procedure for evaluating internal exposure, preventing radioactive substances from flowing-in, and adding more staff	
			Deploying simple WBC	
		Deploying portable monitoring posts	**Deploying a simple access control system**	**Significant increase in the number of radiation measuring staff**
	Adding monitoring cars (1 unit → 3 units)	**Reinforcing power supply to monitoring posts (Emergency power supply)**	**Adding APDs to the important anti-seismic building and the central control room**	**Actions for preventing radioactive substances entering the emergency response room**
	Deploying a monitoring car	Enhancing power supply and transmission system to and from monitoring posts	Deploying radiation protection equipment APD to restoration workers	**Adding deployment of radiation protection equipment for restoration workers**

(16) Adding Radiation Meters and Educating Staff <Reinforcing Radiation Control System in Case of an Accident>

(1) Reinforcing the monitoring post power supply and adding monitoring cars
(2) Adding radiation meters and radiation protection materials/equipment to the emergency response room and the central control room.

Reinforcing monitoring systems

- Reinforcing the power supply of monitoring posts (emergency generator)
- Adding monitoring cars (1 unit → 3 units)

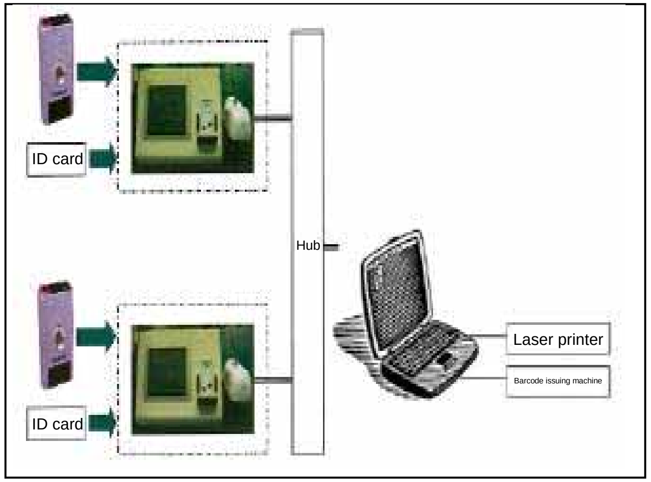
Deployment of radiation protection materials/equipment

- APDs are added to the important anti-seismic building (120 units→500 units).
  (March 2012) 7 units of APDs are installed in each MCR.
- A simple access control system is deployed.
- Radiation protection equipment for 8 days are stored for restoration staff.

Generator to backup power supply to monitoring posts

Monitoring cars
1→3 units

APD **120→500 units**



Simple Access Control Device (Image)

Radiation control materials/equipment

(16) Adding Radiation Meters and Educating Staff <Reinforcing Radiation Control System in Case of an Accident>

(3) Procedures are set up for how to evaluate internal exposure and countermeasures in case of an accident.
(4) How to prevent inflow of radioactive substances to the emergency response room is established and training therefor is performed.
(5) Radiation dose measurement training is performed for the entire office in preparation for the need to measure radiation levels over a broad area.

Internal Exposure Evaluation Procedure

- Two simple WBCs that can be disassembled for transportation are deployed and procedures for evaluating internal exposure are set up.

2 units of simple WBCs

Preventing inflow of Radioactive Substances

- Materials used to prevent radioactive substances from flowing into the emergency response room are secured. Staff training has already been made conducted (3 times).

Training to suppressing contamination

Training of Radiation Measurement Staff

- Approx. 9,400 employees have undergone radiation measurement training for the entire company (as of the end of November 2012).

Training of radiation measurement (**approx. 9,400 employees**)

(17) Announcing and Disseminating Information to Society in an Accident

Issues (Lessons)

Announcement and information dissemination was insufficient when the accident occurred.

Policy
- The media response system is re-established.
- Documents to be used at the time of a severe accident are created.
- The Internet is used for proactive dissemination of information.

Legend	
(pink)	Measures (mid- to long activities) based on the Fukushima Daiichi Plant accident
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Black	Measures (short-term) based on the Fukushima Daiichi accident (done)
(yellow)	Measures against the Niigata Prefecture Chuetsu Off-shore Earthquake
(light blue)	Accident management measures set up before the Fukushima Daiichi Plant accident
(white)	Actions continued from the past

Concrete Actions

		Proactive dissemination of information using the Internet
		Information emitted through emergency radio broadcasting
		Information disseminated using cars
Re-establishment of media response system	**Making documents to be used at the time of a severe accident**	Real time disclosure of monitoring post data, etc.

Classification of measures: Reinforcing announcement and disseminating information to society when an accident occurs.

Lessons Learned and Measures (Done)

Lessons Learned and Measures (Ongoing)

(17) Announcing and Disseminating Information to Society in an Accident

(1) Re-establishment of the media response system

(2) Making documents to be used at the time of a severe accident

(3) Proactive information dissemination through the Internet

Re-establishment of media response system

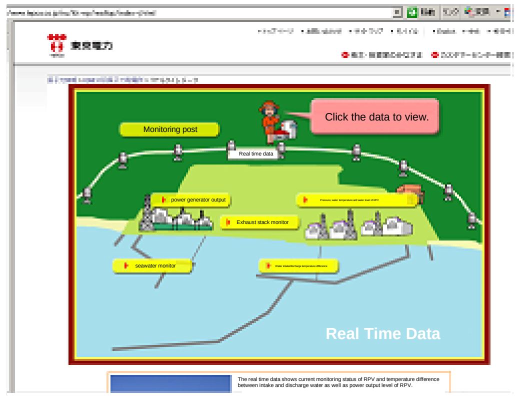
- Regular press conferences by top management
- Explanation by spokespersons in press conferences and HR development

Making documents to be used at the time of a severe accident

- Forming a set of drawings and glossaries to be used or required at the time of a severe accident

Proactive information dissemination through the Internet

- Real time disclosure of monitoring post and plant parameter data
- Distribution of live press conference scenes and dissemination of all press conference documents



Release of real Time Data

Distribution of TEPCO's Live Press Conference

Progress of Facility Development and Future Schedules

Attachment - 1

Item	Grand Schedule		
	FY2011	FY2012	FY2013
(1) Tsunami countermeasures	🟩 Waterproofing of critical areas, tide embankments, and tide barriers, etc.		🟥 Tsunami warning system, etc.
(2) Measures to secure power supply	🟩 Deployment of air-cooling GTG at high ground, etc.		🟥 Additional deployment of power sources at high ground, etc.
(3) Measures to secure water source	🟩 Water reservoirs, wells and various procedures, etc.		
(4) Measures to secure high pressure water injection	🟩 Procedure for emergency use of boric acid water injection system, procedure for control rod drive system, and procedure for RCIC manual startup		🟥 Alternative high pressure water injection facility, etc.
(5) Measures against pressure reduction	🟩 Deploying standby batteries, standby cylinders, and air compressors, etc.		
(6) Measures for low pressure water injection	🟩 Deploying fire engines and outdoor connection ports, etc.		🟥 Adding D/D pumps, etc.
(7) Measures to cool down (removing heat from) RPV and PCV	🟩 Deploying an alternative seawater heat exchanging system, etc.		
(8) Measures to alleviate aftermath of core melt down	🟩 Filter vent and hydrogen discharging system, etc.		
(9) Measures against SFP	🟩 Deploying fire engines and installing SFP water level meters, etc.		🟥 Adding D/D pumps, etc.
(10) Measures against earthquake	🟩 Assessment of stability of transmission line tower foundation and strengthening switching stations and transformers, etc.		🟥 Further anti-seismic treatment of switching stations and transformers, etc.
(11) Measures for other viewpoints	🟩 Deploying heavy machines for removing debris, etc.		🟥 Reinforcing activity sites, etc.

🟩 Measures (short-term) based on the Fukushima Daiichi Plant accident

🟥 Measures (mid- to long activities) based on the Fukushima Daiichi Plant accident

Progress of Facility Development and Future Schedules

Item	Grand Schedule		
	FY2011	FY2012	FY2013
(12) Preparedness for accidents of unexpected size	Revising procedures and doing emergency response drills		Continuous improvement
(13) Actions for combined disasters and simultaneous damage to multiple plants		Reinforcing operators, emergency response staff and night duty system	
(14) Reinforcing dissemination and sharing of information	Deploying batteries, etc. to the central control room, reinforcing means of communication and connecting the company to GOJ's video conference system (dedicated lines)		Connecting with GOJ's video conference system (Satellite lines)
(15) Reinforcing procurement and transportation of materials and equipment	Fuel procurement agreements, radiation control training to drivers and logistics support system		
(16) Reinforcing radiation control system at the time of an accident	Adding APDs to the important anti-seismic building and the central control room, reinforcing MP power sources and radiation measurement training		
(17) Reinforcing announcement and information dissemination to society at the time of an accident	Re-establishment of media response system and proactive information dissemination through the Internet, etc.		

Continuous improvement through trainings, etc.

Measures (short-term) based on the Fukushima Daiichi accident