Safety Measures taken at Kashiwazaki Kariwa NPS based on the Fukushima Daiichi Accident

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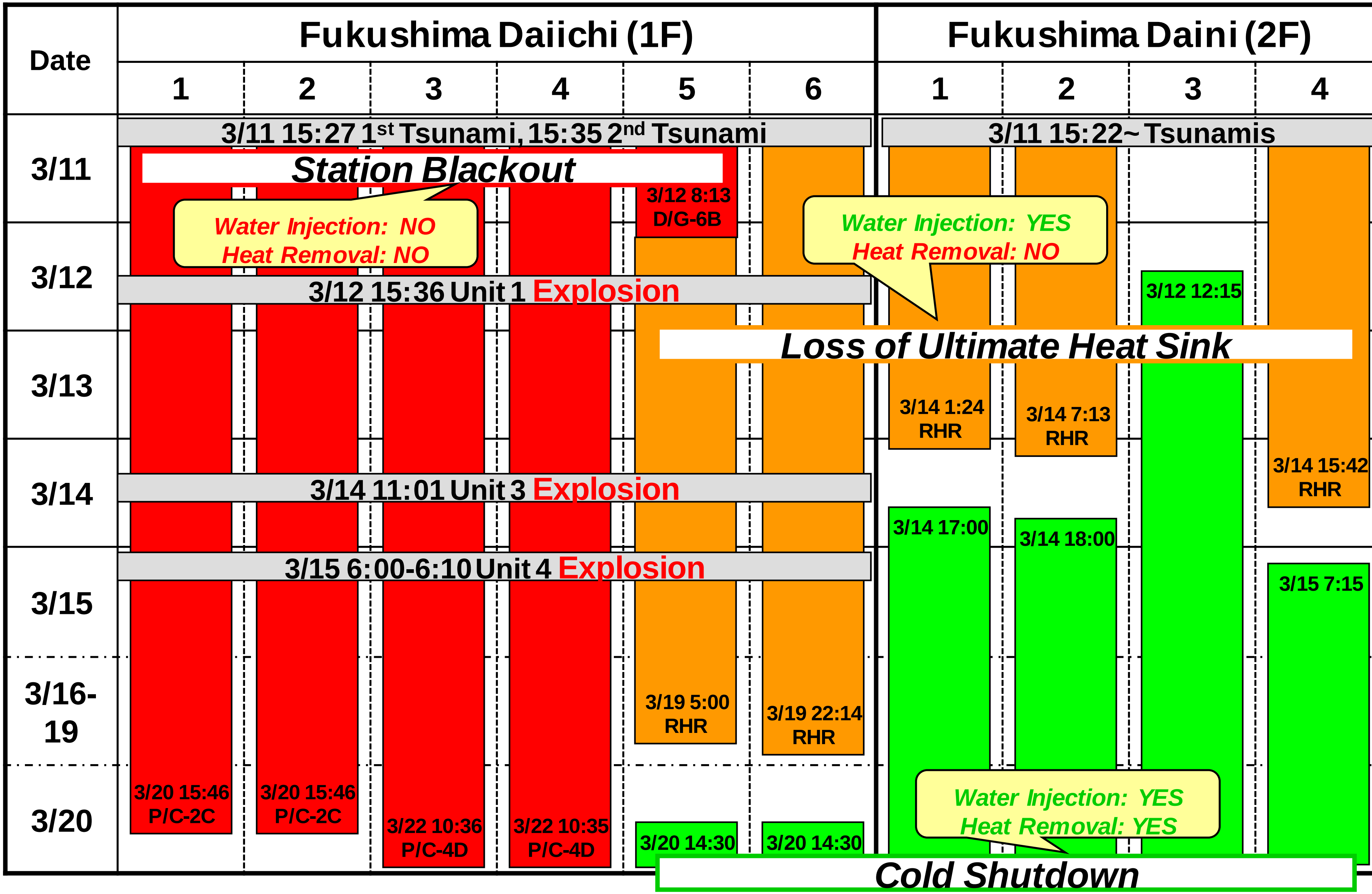
Overview of the 10-Unit Simultaneous Accidents



Lessons Learned from the 1F Accident Response

- Protection against a tsunami exceeding assumptions was weak

- Sufficient preparations were not made for
  - preventing station blackout (SBO)
  - ensuring high-pressure cooling water injection, depressurization, low pressure water injection, heat removal as subsequent measures after SBO

- Means were not well prepared to mitigate the impact after reactor core damage (prevention of containment failure, hydrogen control, countermeasures for core melt-through, prevention of a large release of radioactive material into the environment, etc.)

Basic Approach to Safety Design

- Reinforcement of defense in depth against external events

- Reinforcement of the following functions using phased approach
  - Power supply function
  - high pressure water injection, depressurization, low pressure water injection, and heat removal functions on the assumption of SBO

- Clarification of PCV design requirements for mitigating impact after reactor core damage

Basic Approach to Safety Design

(1) Reinforcement of defense in depth against external events

Reinforce defense in depth based on the assumption that multiple function failures could happen by external events

① Establish safety measures along with defense in depth concept focusing on diversity and positional dispersion

② Consider not only earthquake and tsunami but also 40 natural events and 20 human induced external events shown in US NUREG* and the IAEA Safety Guide**

③ Select the external events based on their cliff edge effect and their probability and then establish safety measures against them

④ Strengthen measures also against internal flooding and internal fire

⑤ Use of probabilistic risk assessment (PRA) to:

- select accident sequences to be evaluated
- evaluate effectiveness of the established safety measures

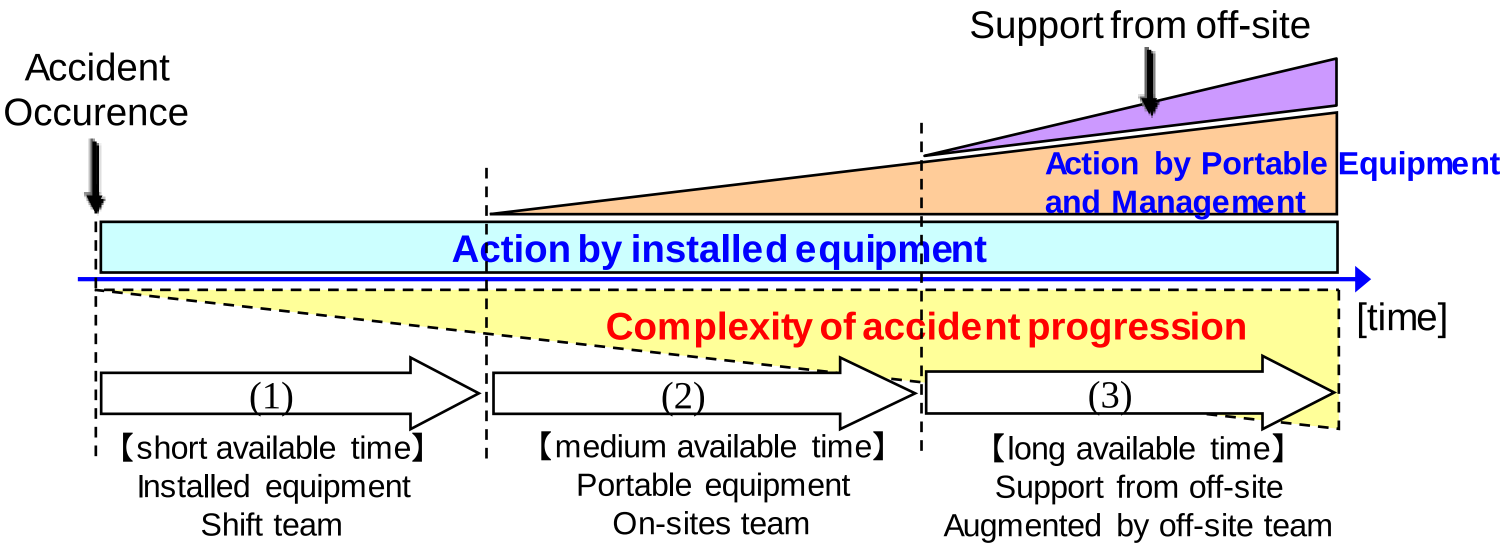
* NUREG/CR-2300 Vol.2, "PRA Procedures Guide"

** IAEA Specific Safety Guide SSG-3, "Development and Application of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants"

Basic Approach to Safety Design

(2) Adoption of phased approach

Select safety measures based on the assumption that possible measures and their required reliabilities are different depending on time to spare



Phased Approach for DID enhancement

(3) Design requirements for PCV to mitigate impact after reactor core damage and to suppress release of radioactive materials

Clarify the requirement for the containment vessel and its auxiliary equipments after core damage and then implement safety measures

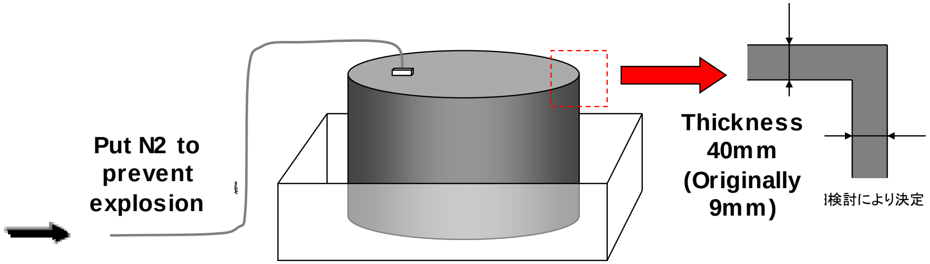
Measures to prevent abnormalities

Measures against tsunami (15m)

Tidal Embankments, Walls, Boards, Water Tight Doors, etc.

Measures against Tornado (Fujita Scale 3

Replacement of the gasoil tanks



New Gasoil Tank

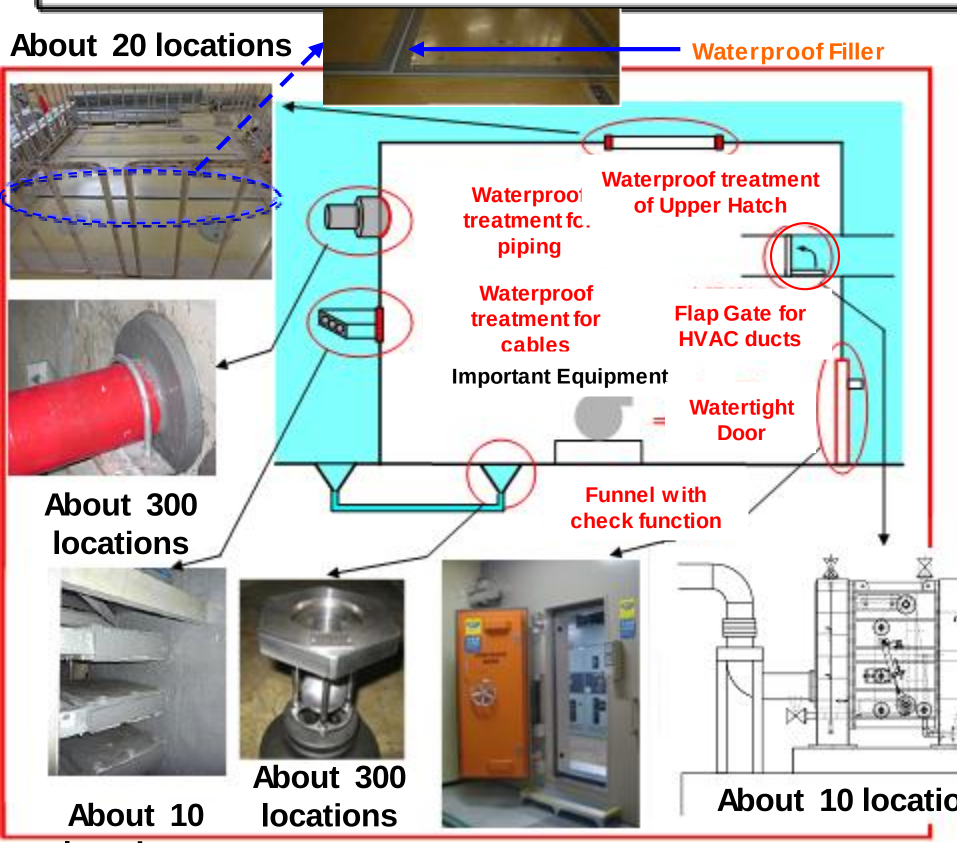
Measures against External (Forest) Fire

Creation of the fire protection zones

Measures to control abnormalities 1

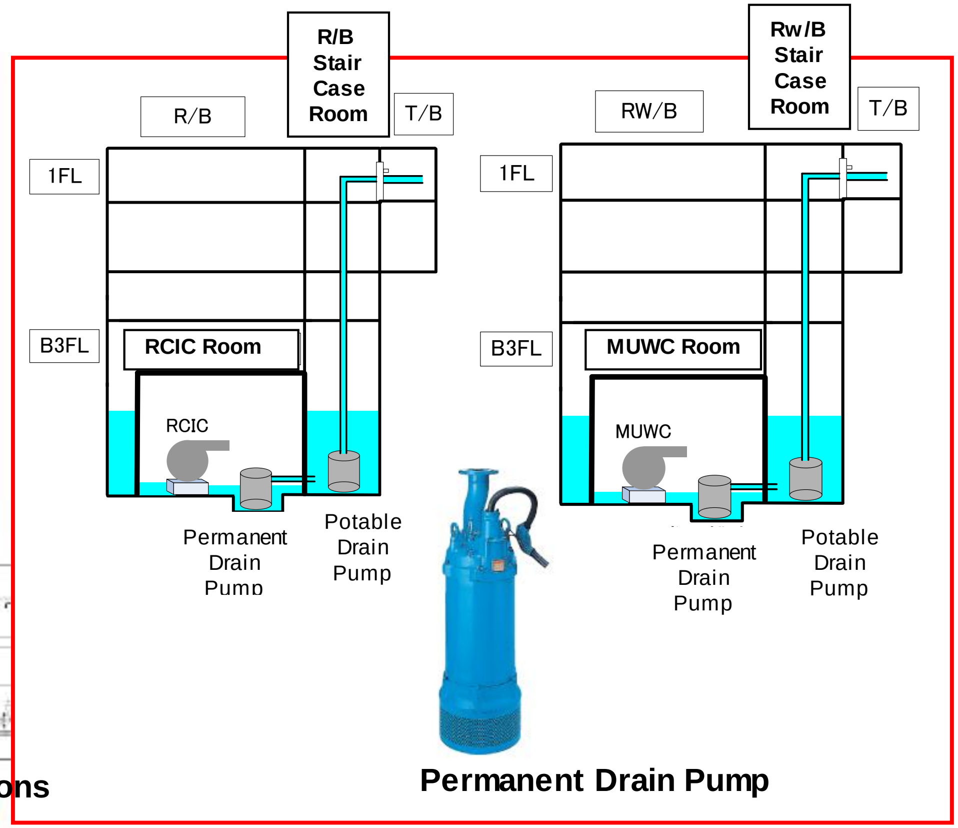
Measures against Tsunami Flooding and Internal Flooding

- Reduce flooding sources (seismic enhancement of class B/C equipment)
- Waterproof treatments/ flap gates to protect important equipment
- Install drain pumps for inundation beyond postulated damage



About 50 locations

Measures against internal flooding (Numbers of Locations are for KK7)



Installation of Drain Pumps

Measures to control abnormalities 2

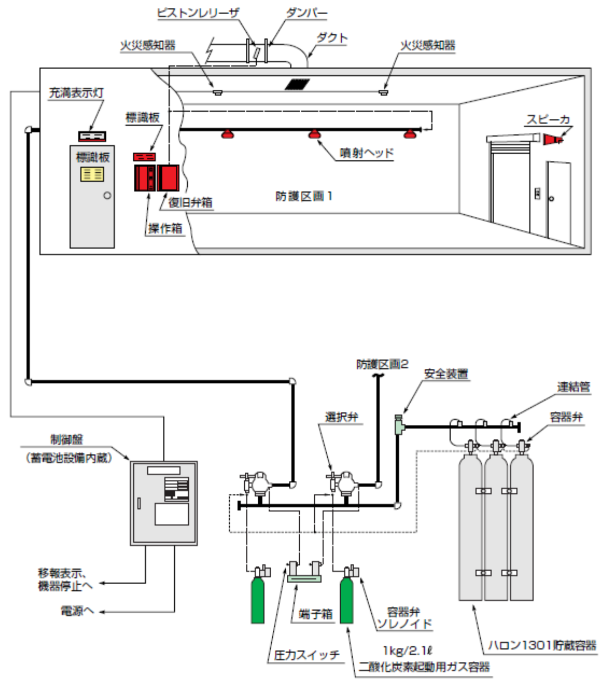
Measures for Fire Protection

➢Prevention

- Fireproof or fire-retardant materials (incombustible cable has been used at KK since construction)
- Rigid management of combustible materials like lubricant oil.

➢Early detection and extinction

- Fire detection devices (for about 230 locations)
- Fixed fire suppression system (for about 100 areas)



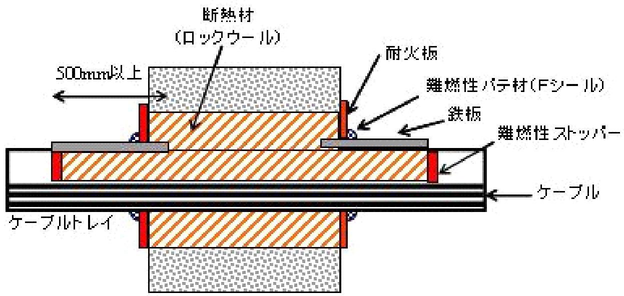
Fixed Fire Suppression System

➢Mitigation

Fire Barriers with 3-h fire resistance capability

- Fire proof dumpers (about 200)
- Fireproof treatment on piping and cable penetrations (for about 2300 cable penetrations and 300 pipe penetrations)
- Cable wrapping (about 100m for cable trays and 300m for cable conduits)

Cable Wrapping (7 layers)

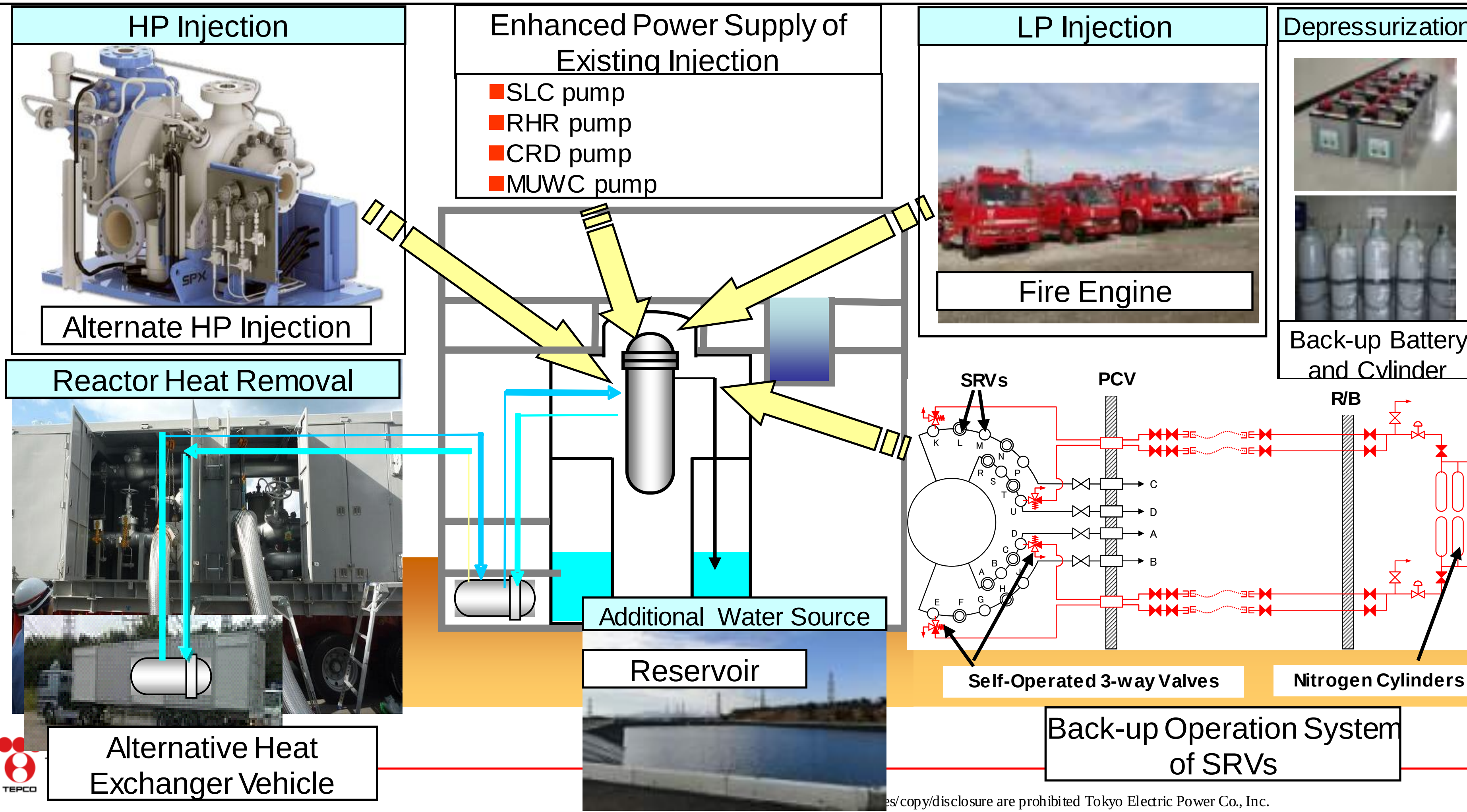


Fireproof Treatment of cable tray

Measures to control accident 1

Water Injection and Heat Removal Functions

- Enhance High Pressure Injection Function: High Pressure Alternate Cooling System
- Enhance Depressurization: Back-up Operation System of SRVs
- Additional Water Source: Reservoir
- Enhance Heat Removal Function: Alternative Heat Exchanger Vehicle

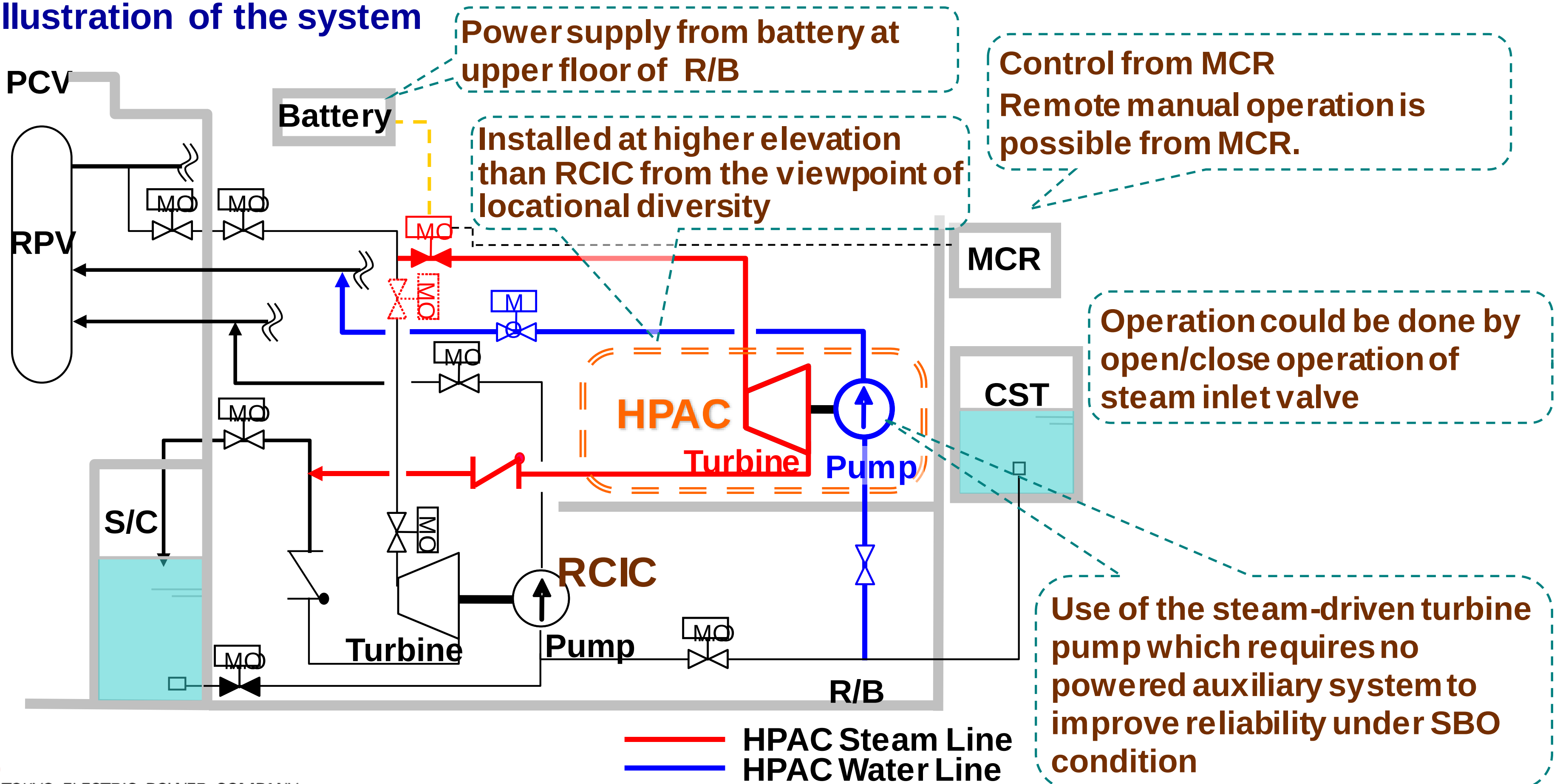


Measures to control accident 2

High Pressure Alternate Cooling System (HPAC)

Back-up system of RCIC to enhance reliability of the high pressure core injection: activated in case of malfunction of the RCIC system to prevent the core damage

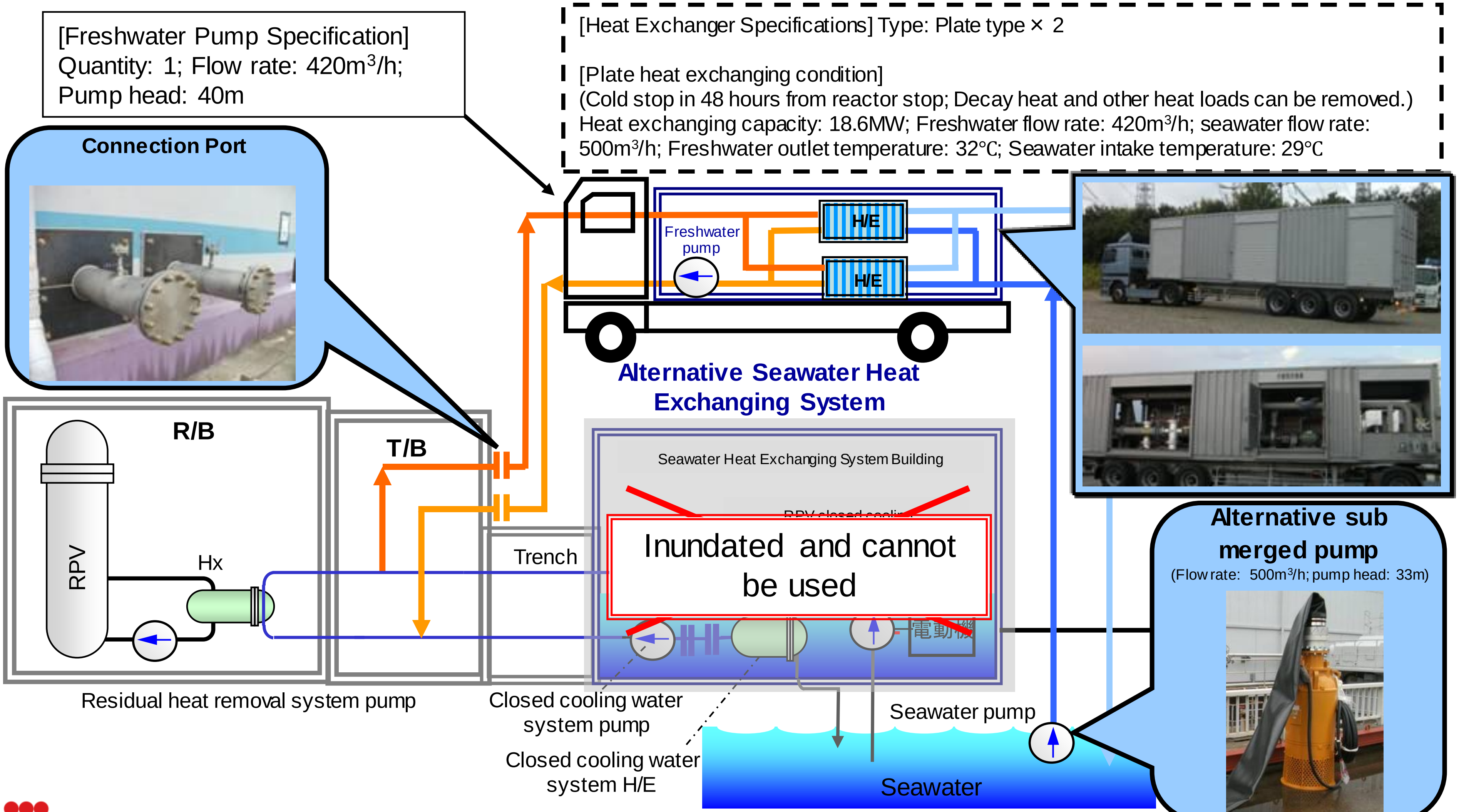
○ Illustration of the system



Measures to control accident 3

Alternative Heat Exchanger Vehicle

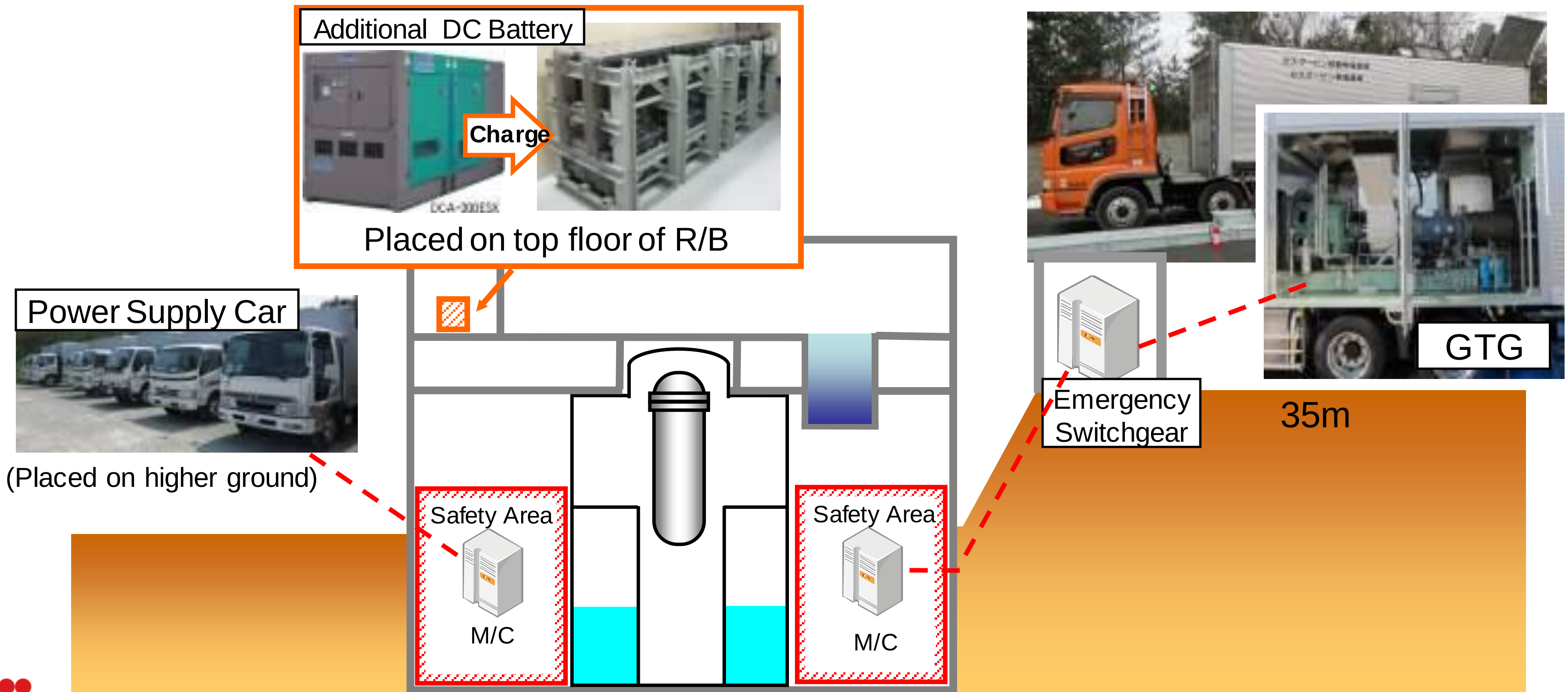
Back-up ultimate heat sink enhancing system in case of LUHS events



Measures to control accident 4

Power Supply Functions

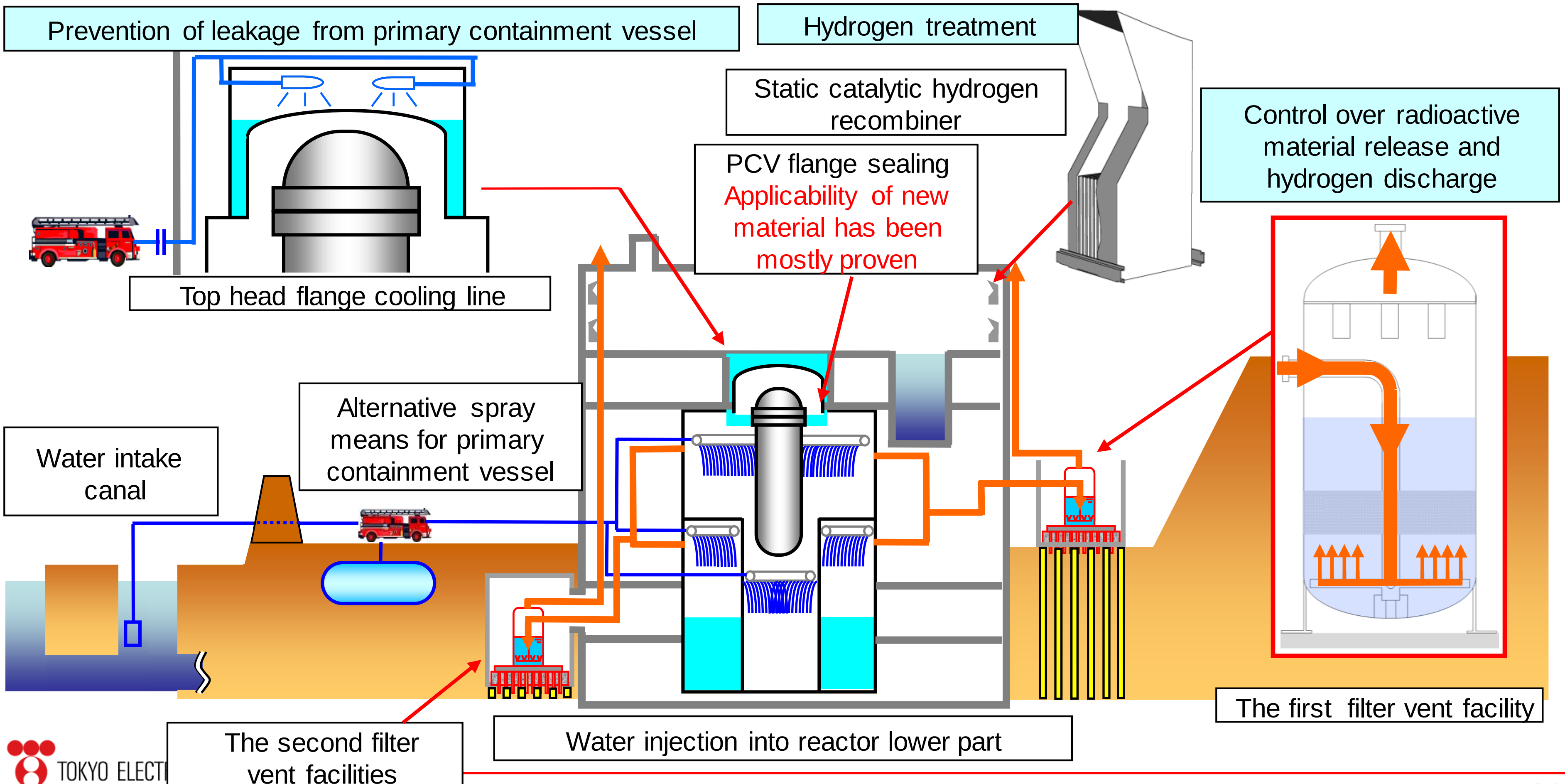
- Measures for quick power supply
  - ➢Gas-turbine generators, and power supply cars on higher ground.
  - ➢Emergency switchgear and installed electrical cable.
- Enhancement of DC Power
  - ➢Rechargeable additional DC power on top floor of the Reactor Building.



Measures to mitigate consequences of accident 1

Protection of the PCV and prevention of hydrogen explosion

- Protection of PCV by preventing over-pressure/temperature: PCV Top Head Flange Cooling, PCV Flange Sealing
- Mitigation of Radioactive material release: Filtered Vent
- Prevention of hydrogen explosion: Static catalytic hydrogen recombiner



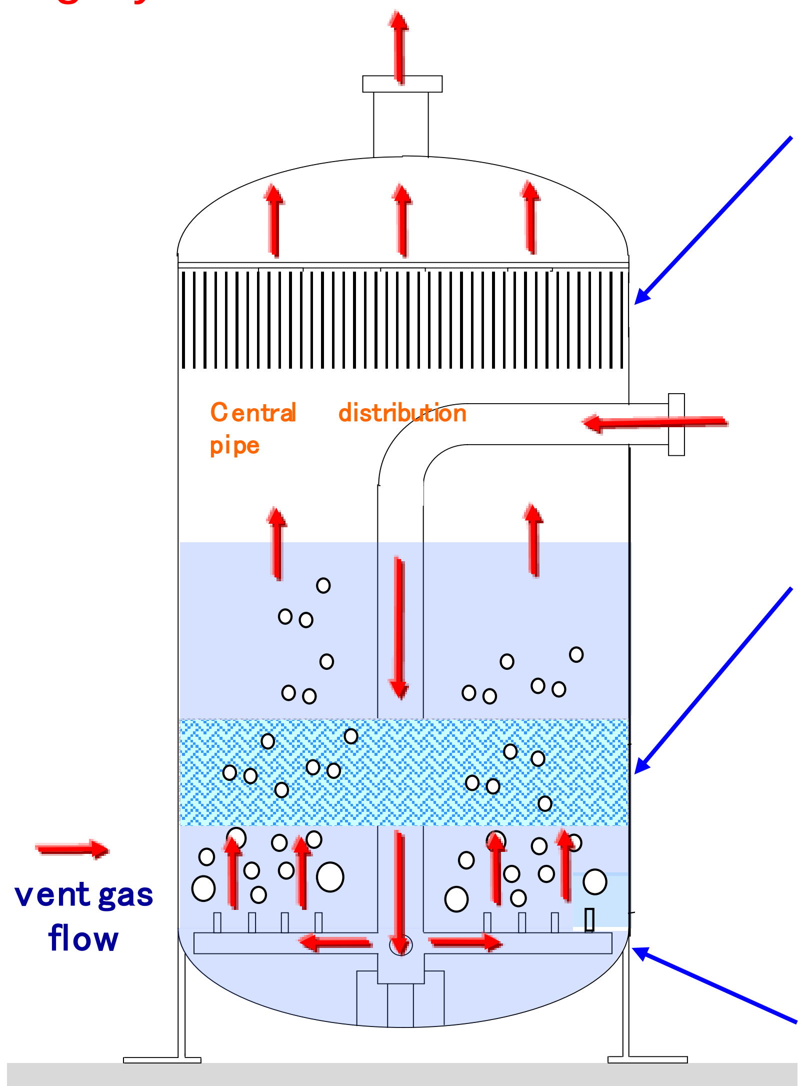
Measures to mitigate consequences of accident 2

Filtered Containment Venting System

**(1F accident)
Massive FP release,
Long term & contamination of soil**

→Prevent PCV failure by PCV spray and filtered venting system

→DF for particle FP is > 1000



FV unit image

③ Metal filter
Capture aerosol in vent gas. Separate droplet from vent gas

② Mixing elements
Mix Vent gas and scrubber water and atomize bubbles to enhance scrubing ratio

① Scrubber Nozzles
Vent gas is jetted to scrubber water uniformly over whole cross section.

Conclusion

- Safety level of Kashiwazaki Kariwa NPPs has been drastically improved by the safety measures based on the concept of
  - Reinforcement of defense in depth
  - Adoption of phased approach
  - Design requirements for PCV

- TEPCO is going to perform continuous safety improvement in accordance with the above basic policies, which is not only from hardware aspect but also from software aspect through the activities such as periodic safety analysis