
TEPCO's Activities on the Investigation into Unsolved Issues in the Fukushima Daiichi NPS Accident

IAEA IEM8

Vienna International Centre, Vienna, Austria
February 16-20, 2015

Daisuke YAMAUCHI
Tokyo Electric Power Company

Overview of TEPCO's activities on investigation into unsolved issues

(1) Purpose of investigations into unsolved issues

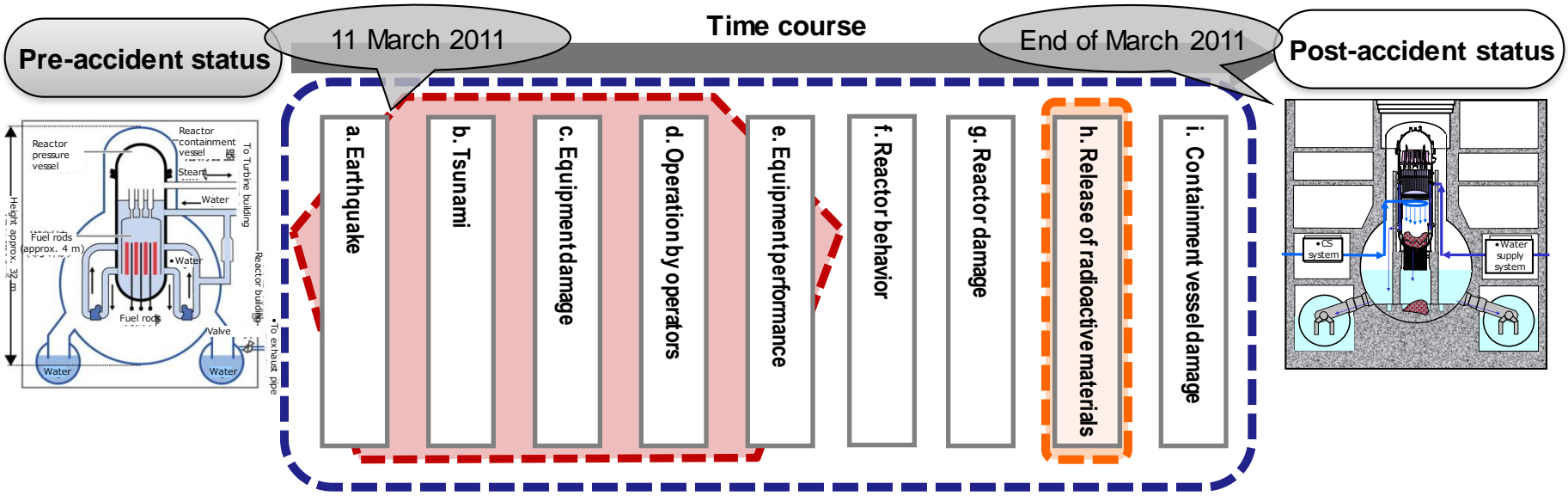
As the operator of the nuclear power station and the main party responsible for the accident, TEPCO is fully committed to clarifying all aspects of the accident

Solving reactor decommissioning issues and acquiring information

Improvement in safety measures and enhancement of safety at Kashiwazaki-Kariwa Nuclear Power Station

Overview of TEPCO's activities on investigation into unsolved issues

(2) Areas of investigation activities to identify issues



Area I

Investigation activities were conducted mainly focused on “What happened” and the results were established in June 2012.
 This report is available from: http://www.tepco.co.jp/en/press/corp-com/release/2012/1205638_1870.html

Area II

Total amount of released FP and the cause of the land contamination of the northwest direction were evaluated and the results were established in May 2012.
 This report is available from: http://www.tepco.co.jp/en/press/corp-com/release/2012/1204659_1870.html

Area III

Investigation activities have been conducting focused on the detailed behavior of the equipment in steps e. and f., RPV and PCV damage processes in steps g. to i., and their post-accident statuses.
 Progress reports are available from;
http://www.tepco.co.jp/en/press/corp-com/release/2013/1233101_5130.html
http://www.tepco.co.jp/en/press/corp-com/release/2014/1240140_5892.html

Overview of TEPCO's activities on investigation into unsolved issues

(3) Investigations which TEPCO has done until now

- Tsunami arrival evaluation and the fact that the tsunami was a main cause of the loss of cooling function

- Relationship between the earthquake and flooding in reactor building at Unit 1

- RCIC flow rate after loss of control power at Unit 2

- State of the RHR system after the tsunami arrival at Unit 2

- Identification of causes of PCV pressure decrease after RCIC shutdown at Unit 2

- Investigation on the accident progression based on reactor water level behavior after HPCI shutdown at Unit 3

- Possibility of rapid reactor depressurization due to ADS triggered at Unit 3

- Steep increase in reactor pressure after rapid depressurization at Unit 3, and its relationship to the reactor core damage progression

Overview of TEPCO's activities on investigation into unsolved issues

(4) Progression of the study of ten high-priority issues

- Cause of the shutdown of the reactor core isolation cooling system at Unit 3

- Evaluation into the amounts of water injected to the reactor vessels by fire engines

- Evaluation of HPCI system operational state at Unit 3 and its impact on the accident progression

- Rise in RPV pressure after the forced depressurization at Unit 2

- Status of safety relief valve operation after reactor core damage

- Vent operation and rupture disk status at Unit 2

- Behavior of melted core relocation to the lower plenum

- Thermal stratification in the suppression pool at Unit 3

- Increase of dose rate at 1F site since March 20

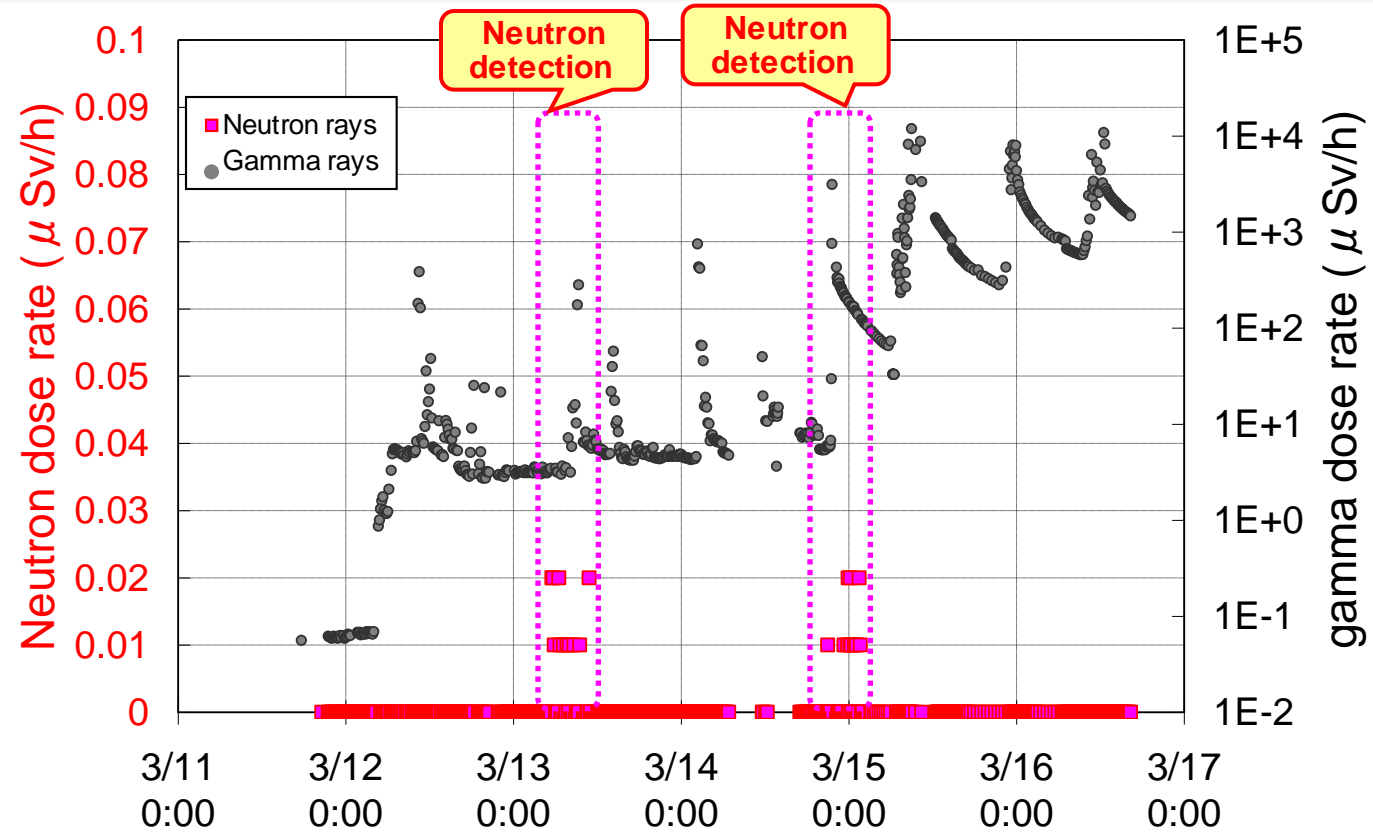
- Causes of the high-contamination of pipes in the reactor building closed cooling water system at Unit 1

TEPCO will continue investigations of the unsolved issues and will report the investigation results semi-annually.

Topic: Investigation on neutron detection in accident progression

(1) Overview

In the morning of March 13 and in the night of March 14, small amounts of neutrons were detected near the main gate.
The cause of neutron detection was unclear.



The timing of neutron detection and the increase in the gamma dose rate are not correlated.

Topic: Investigation on neutron detection in accident progression

(2)Monitoring point and Detectors



Monitoring car was located near the main gate.

Detectors

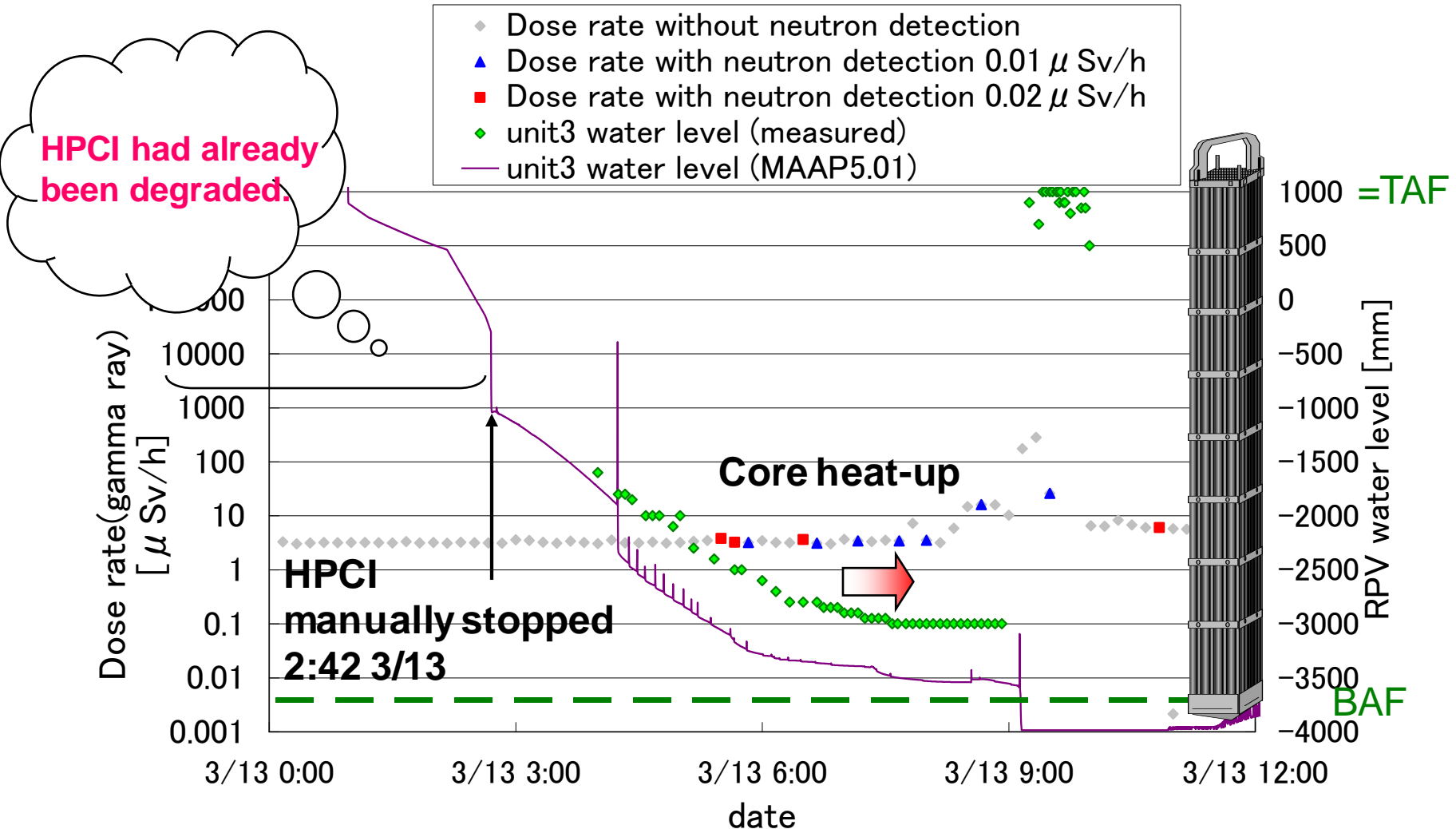
- Dose rate:
Ion chamber installed in the monitoring car
- Neutron dose rate:
Portable neutron survey meter (^3He)

Data is uploaded to

<http://www.tepco.co.jp/en/press/corp-com/release/11052811-e.html>

Topic: Investigation on neutron detection in accident progression

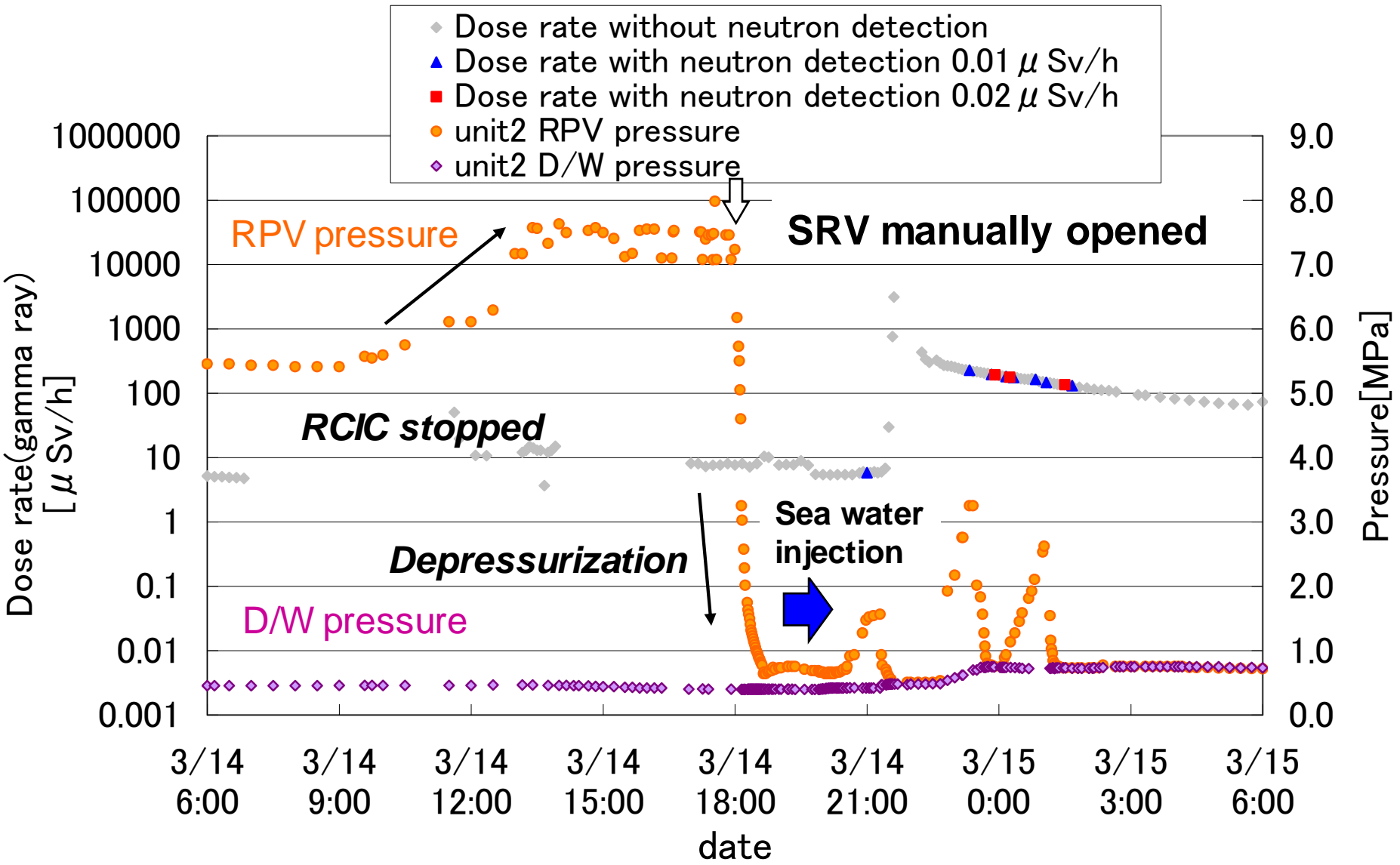
(3) Unit 3 accident progression reflecting early HPCI degradation



Neutron was detected when unit 3 core reached to high temperature due to W-Zr reaction.

Topic: Investigation on neutron detection in accident progression

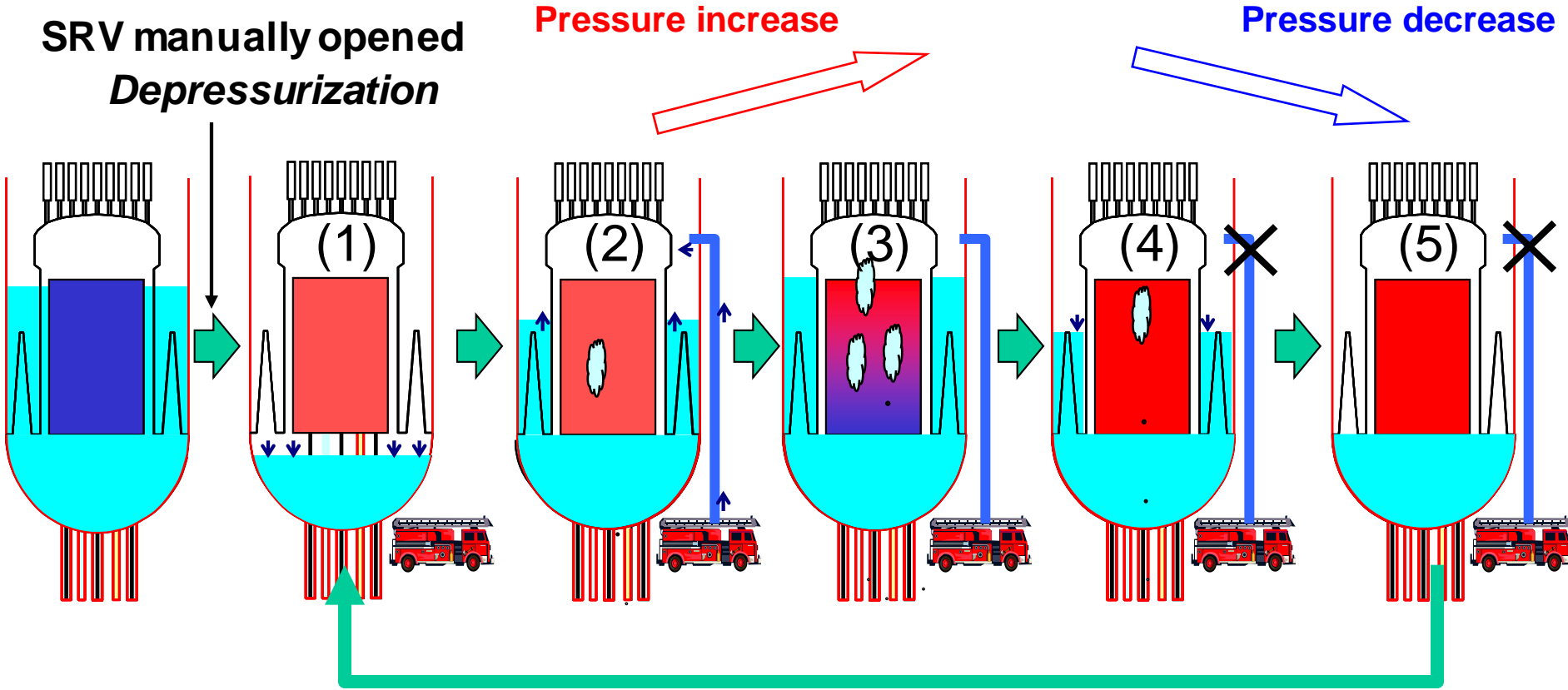
(4) Unit 2 accident progression with pressurization events



Topic: Investigation on neutron detection in accident progression

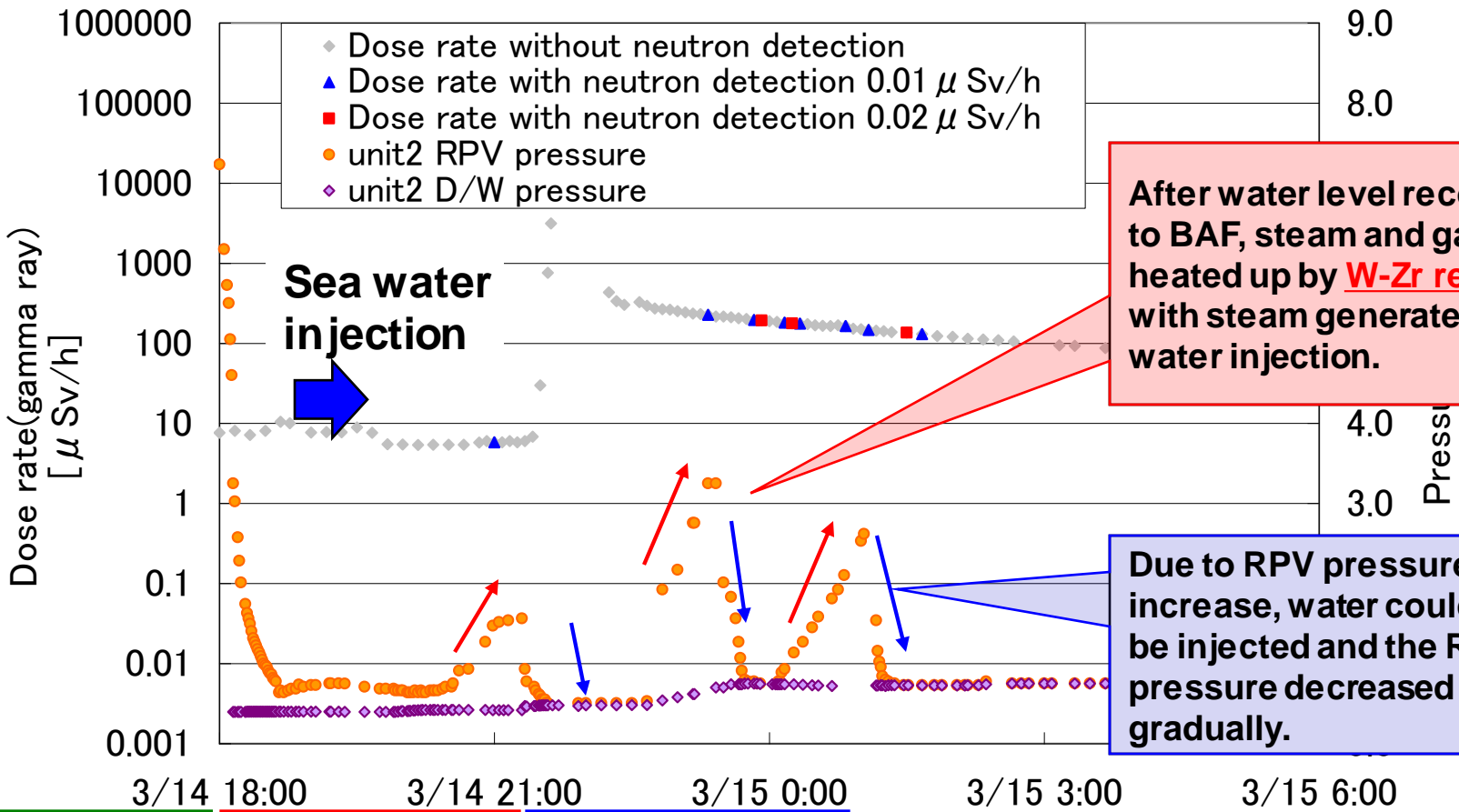
(5) Process leading up to fuel melting in Unit 2

We estimate a scenario where, after reactor depressurization, the steam generated by cooling water injection from fire engines caused a zirconium-water reaction, in turn causing reactor pressure to rise and lead to fuel melting.



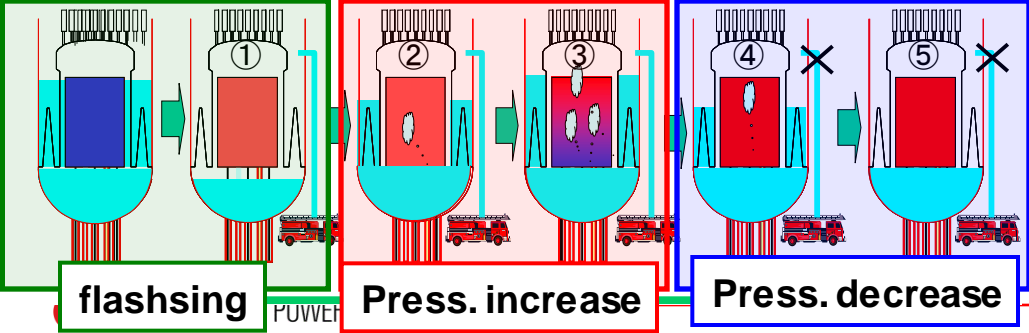
Topic: Investigation on neutron detection in accident progression

(6) Unit 2 accident progression with pressurization events



After water level recovered to BAF, steam and gas were heated up by **W-Zr reaction** with steam generated by water injection.

Due to RPV pressure increase, water could not be injected and the RPV pressure decreased gradually.

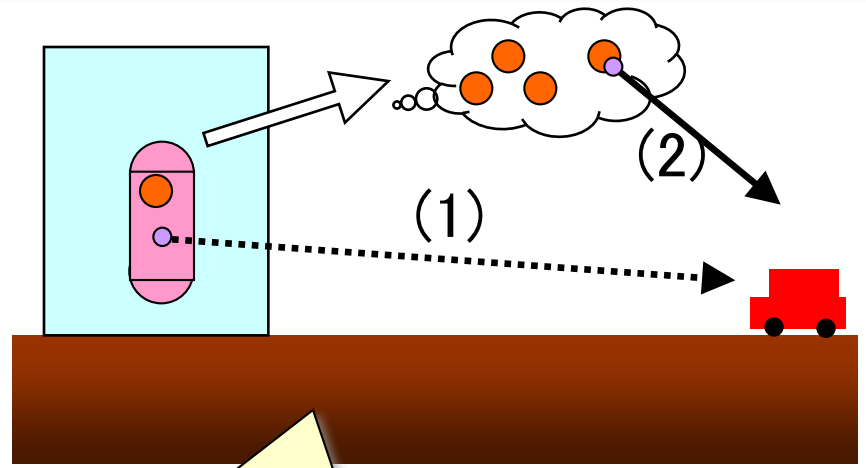


Neutron was detected when unit 2 core reached to high temperature due to W-Zr reaction.

Topic: Investigation on neutron detection in accident progression

(7) Origin of measured neutrons

The neutrons detected near the main gate may have been generated by the spontaneous fission of actinides released from RPV with core melt progression at Units 3 and 2.



As the result of soil sampling, short half-life actinides, such as Cm-242 and Cm-244, were detected. These may have been originated in the Fukushima Daiichi accident.

Path (1); Neutrons generated in RPV were detected directly.

X Unlikely due to shielding by reactor vessel and reactor building

Path (2)-1; Delayed neutrons deriving from the decay of fission products (Br-87, etc.) were detected.

X The delayed neutrons had become sufficiently attenuated due to short half-life of the delayed neutron precursors.

Path (2)-2; Neutrons deriving from the spontaneous fission of discharged actinides (Cm-242, etc.) were detected.

O - The timing coincided with that of fuel melting.
- Possible given the detection of actinides thought to arise from the Fukushima Daiichi accident in sampled soil.

(TEPCO also estimate Xe gas detected in PCV gas to have derived from spontaneous fission by Cm etc.)

(8)Summary

Why neutron was detected ?

- There is a possibility that detected neutron was derived from spontaneous fission of released actinides
- The timing of neutron detection might be related to the core melt with high temperature enough to release actinides.

For future R&D

It is important to understand the migration behavior of the radioactive nuclide from the point of view of radiation exposure and radioactive contamination.

- *How does the core melt progress?*
- *How are the radioactive nuclides released from the core?*
- *How do the plume and FP travel to environment from the reactor buildings?*

Summary

- Much information was obtained until now, however there are unclear issues on core damage progression and current situation of reactors and containment vessels.
- TEPCO continues the effort for revealing its complete picture by integrating obtained information including...
 - ✓ plant data, operator's action, considerations on equipment performance under the severe accident
 - ✓ Analysis through SA code simulations and various researches
 - ✓ Field investigations and activities towards the decommissioning
- TEPCO would like to share the insights obtained from investigation and discussion with researchers in the world
- TEPCO appreciates your proposal, advice and discussion

First progress report:

http://www.tepco.co.jp/en/press/corp-com/release/2013/1233101_5130.html

Second progress report

http://www.tepco.co.jp/en/press/corp-com/release/2014/1240140_5892.html