The 5th International Forum on the Decommissioning of the Fukushima Daiichi Nuclear Power Station

Efforts to Ensure Safety in Decommissioning （No. 3)

Safety and Challenges in Decommissioning

November 1, 2021

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0. Table of Contents

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1. What is "Safety" in decommissioning?

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Decommissioning is a "Risk reduction activity" in itself

・Operating reactors: Insufficient safety state
→ Low-risk state can be achievable by shutdown

・1F: Stagnation in decommissioning work can lead to slowing down in risk reduction or lead to increased risk
→ Decommissioning work is "Effort to improve safety"
: However, individual tasks may be associated with significant risk
→ Work needs to be forwarded even in high-risk conditions and environments
→ Some short-term risk needs to be tolerated to reduce mid-to-long term risk

Looking at decommissioning from a safety perspective,

decommissioning is the work to reduce long-term risk of the plant continually while continuing to minimize the risk of individual tasks and plant at that time, sometimes tolerating short-term risk

2. Difficulties and challenges in decommissioning

The concept of "Safety" has the same meaning in decommissioning and operating, however, the approach to "Safety" differs significantly.
→Understanding this difference is critical in “Safe decommissioning”

2-1. Different concepts for ensuring safety

→ What to take care of

2-2. Unestablished safety assurance system

→ What is enough

2-3. Difficult environment for developing safety awareness

→ Environment where workers are less aware of nuclear safety

2-4. Projects requiring Trial & Error

→ Agile response ⇔ Doesn’t tolerate failure

2-1. Different concepts for ensuring safety

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Difficulty ①

There is no template of "What to take care of"

In normal reactors

- There are some basic concepts for ensuring safety.

- Examples of basic concepts for ensuring safety:
  - Defense in-depth
    Occurrence prevention-Escalation prevention-Mitigation
  - Five layers of walls
    Pellet - Cladding tube - RPV - PCV - Reactor building
  - Fail safe
    SCRAM mechanism, HE proof

2-1. Different concepts for ensuring safety

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Difficulty ①

There is no template of "What to take care of"

At 1F

・Defense in depth
Using custom-ordered and general-purpose products
(makes difficult to keep defense in depth)

・Five layers of walls
Pellet - Cladding tube - RPV - PCV - Reactor building
Only PCV is barely remaining

・Fail safe
⇔Human error directly leads facility shut-down

The design is not necessarily well-balanced, and "What to take care" have to be determined on a case-by-case basis.

2-1. Different concepts for ensuring safety

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Effort to address the Difficulty ①

・Most challenges are "Application problems"
→ "Thinking skills" is required, especially "Thinking skills as an organization"
→ Proven results from other industries shall be adopted without being persisting nuclear safety

・One failure could lead serious consequences
→ Understanding the importance of each equipment and device

・Defense in depth: Within the sequence of "Occurrence prevention-Escalation prevention-Mitigation", "occurrence prevention" is usually the most important.
→ Quality management to prevent failure is important
→ "Quality improvements" for facilities that have been constructed in a hurry after the accident are still in progress

2-1. Different concepts for ensuring safety

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(Reference)
Examples of experience facing challenges in quality management

- Malfunctions in equipment for fuel removal from Unit 3
- Operation error of the emergency shutdown button for the containment vessel gas management system
- Leaks from the waste storage container
- Damage to the exhaust filter in the HIC transfer device

2-2. Unestablished system for ensuring safety

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Difficulty ②

There is no standard for “What is enough”

In normal reactors

- There is a standard for ensuring safety.

- Examples of standards for securing safety:
    - Importance classification guideline
    - Safety design guideline/safety assessment guideline
    - Design basis accidents
    - Seismic standard (design basis ground motion, seismic class classification)
    - Exposure assessment methods

2-2. Unestablished system for ensuring safety

TEPCO

Difficulty ②

There is no standard for "What is enough"

At 1F

・There is no "Standard for securing safety."

・What is "Safety critical equipment"?
・Should there be redundancy in systems?
Is emergency power necessary?
・What are transients and accidents should be assumed?
・How much quality management requirement should be made?
・Which systems should have LCO?

There are no standards or precedents for "What is enough", and everything has to be determined on each system

2-2. Unestablished system for ensuring safety

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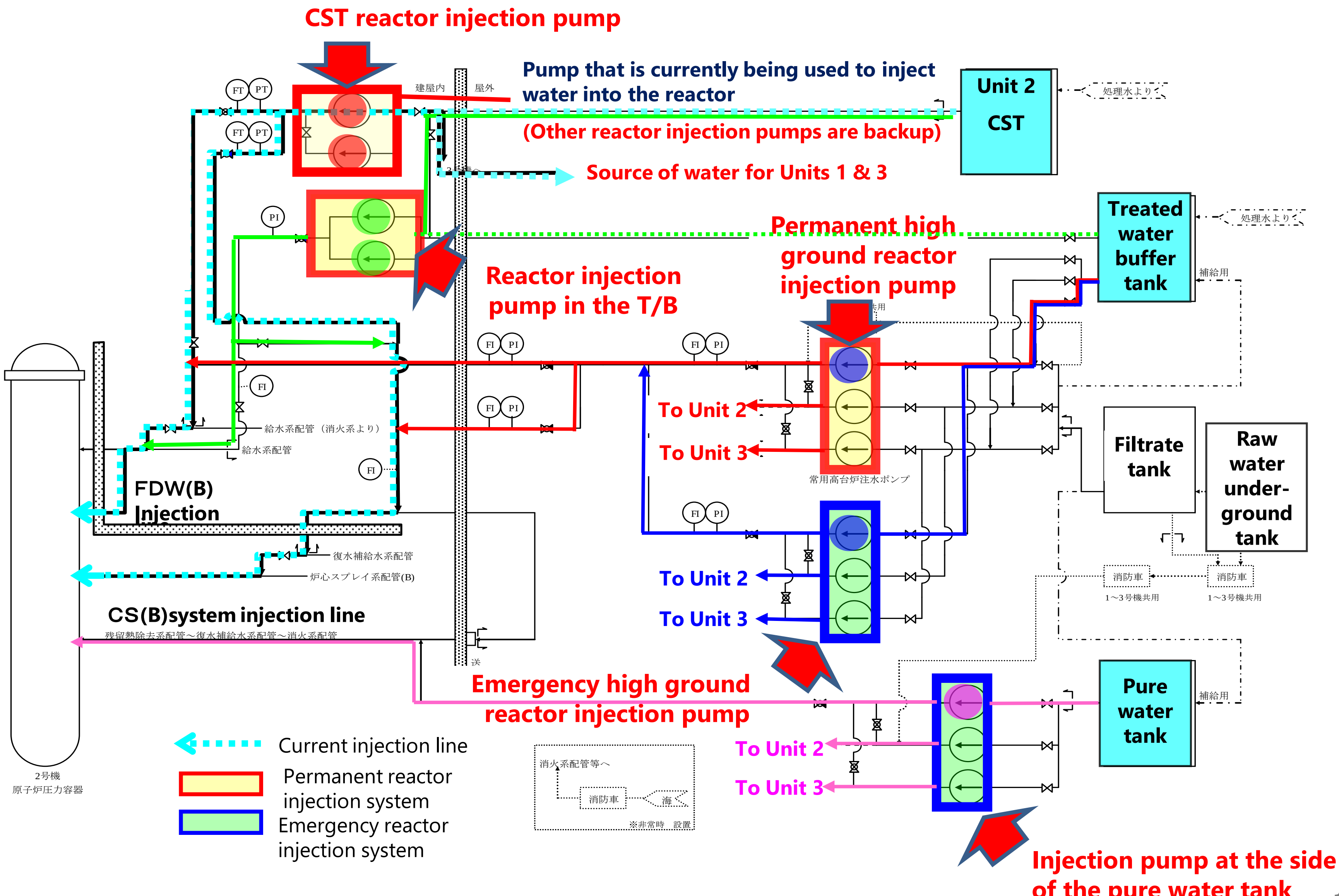
Example: Redundancy in the reactor injection pump



2-2. Unestablished system for ensuring safety

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Effort to address the Difficulty ②

Establishing standards suitable for the actual situation at 1F

- Importance classification of decommissioning facilities
- Approach to seismic design (Fukushima Earthquake, 2/13/2021)
- Quality management for important procurement items (based on experience of fuel removal from Unit 3)

Flexibly review standards in accordance with progress in decommissioning

- LCO related to injection (see next slide)

The followings need to be clarified in accordance with progress in fuel debris retrieval

- Scope of events that should be assumed (definition of accident events)
- Criteria for assessing impact (1 mSv/y at surrounding site, 5 mSv/accident)

2-2. Unestablished system for ensuring safety

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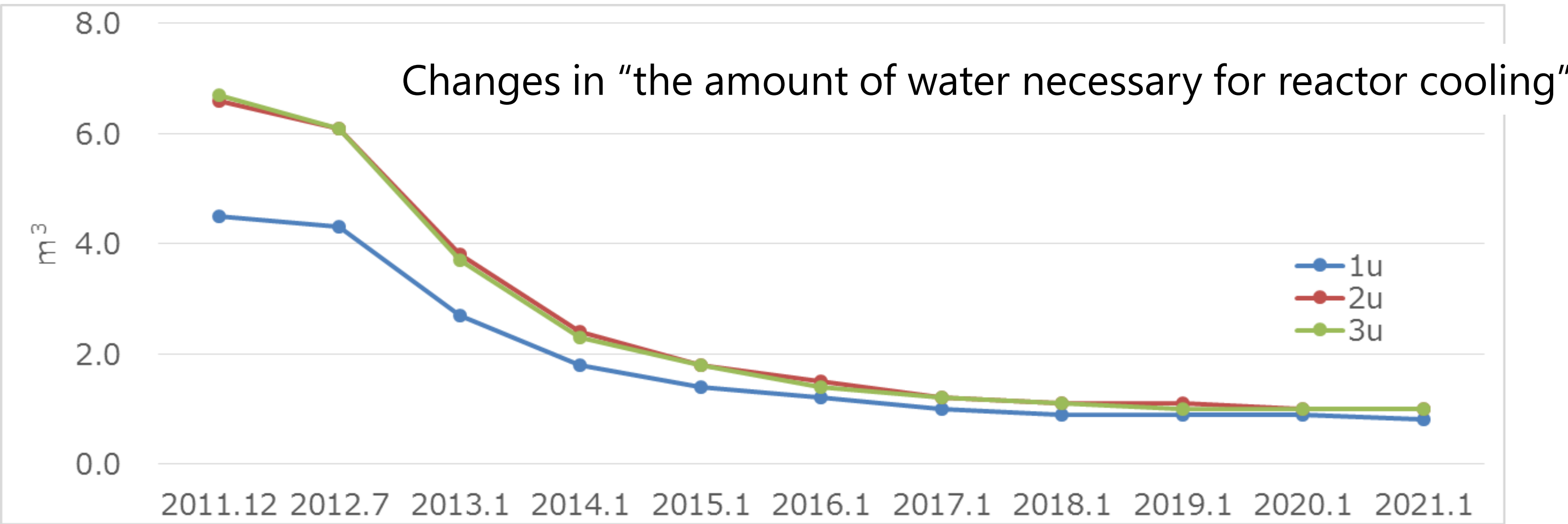
Example of reviewing standards in accordance with progress in decommissioning

- LCO related to reactor injection -

- Continuous water injection: Require constant injection → Allow temporary suspension
- Injection water amount: 4.5 m^3/h→0.9 m^3/h (Unit 1)



•Increase in injection water amount: 1.0 m^3/h→1.5 m^3/h→3.0 m^3/h

•Power source: A dedicated DG for the pump is required. →No DG requirement

2-3. Difficult environment for developing safety awareness

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Difficulty ③

Environment where workers do not develop an awareness of nuclear safety

In normal reactors

・Through routine tasks and learning about the nuclear power plant system, workers can “naturally” obtain knowledge of “nuclear safety”.

- ・Clear concept of not exposing the surrounding public to radiation risk
- ・Existence of a clear source of risk: "core“ (especially in a critical state)
- ・Straight-forward accident scenarios where risk is faced
- ・Existence and awareness of the basic concepts of and standards for ensuring safety

2-3. Difficult environment for developing safety awareness

TEPCO

Difficulty ③

Environment where workers do not develop an awareness of nuclear safety

At 1F

- **Environment where workers do not naturally develop an awareness of nuclear safety**
- **Nuclear safety ≒ Do not expose the surrounding public to radiation risk**
  - There were no people in the surrounding area (for a while after the Accident).
  - Risk sources are distributed across the station.
    (fuel debris, spent fuel, waste from water treatment, contaminated rubble, etc.)
  - Plant potential energy that could cause an accident is significantly lower.
    (Operating reactor: Low frequency, high impact→1F: High frequency, low impact)
  - Workers have got "used" to abnormal situations
    (seeing a damaged reactor building every day, exposed to high dose on daily basis, working in highly exposed areas, experience in the environment 'speed is the priority' just after the Accident)

Awareness of nuclear safety needs to be deliberately established.

2-3. Difficult environment for developing safety awareness

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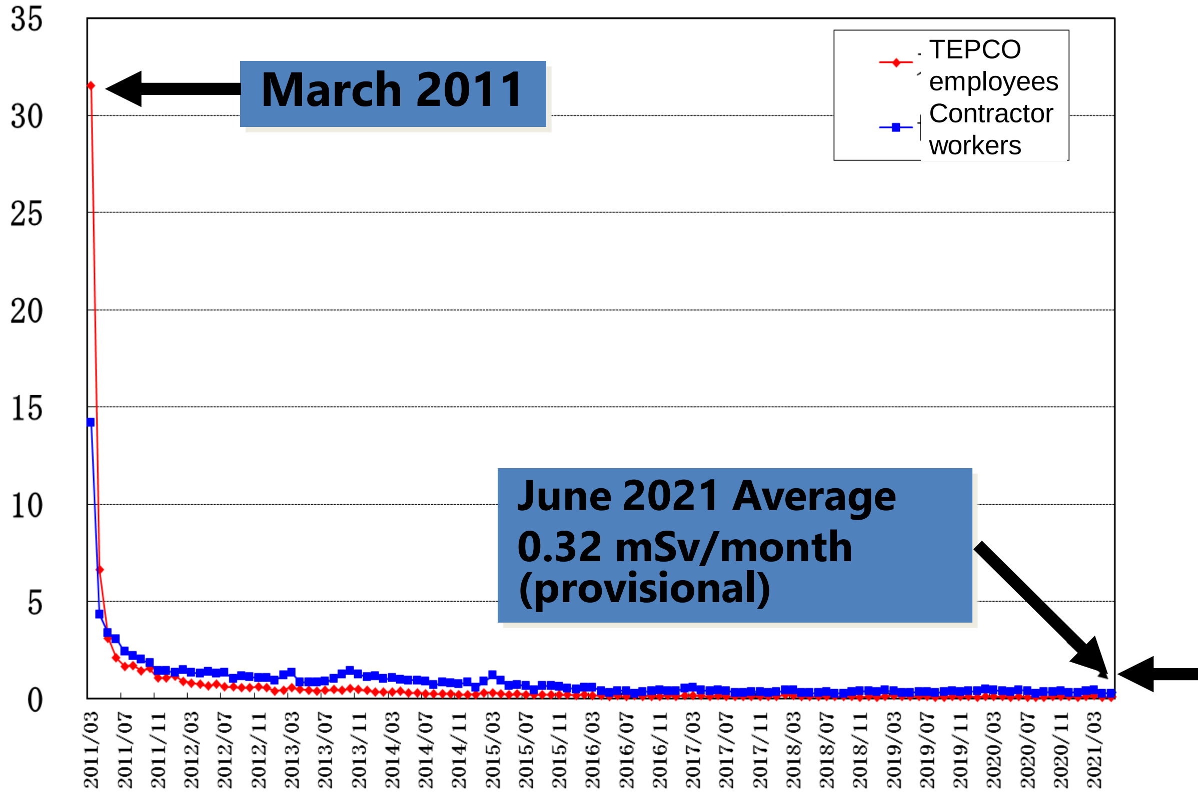
- The work environment has improved significantly since just after the accident.
- Worker exposure dose has fallen significantly.

Changes in worker personal exposure dose (month)



(reference)
Dose limit
1.67 mSv/month
(Monthly average of the dose limit of 100 mSv/five years)

2-3. Difficult environment for developing safety awareness

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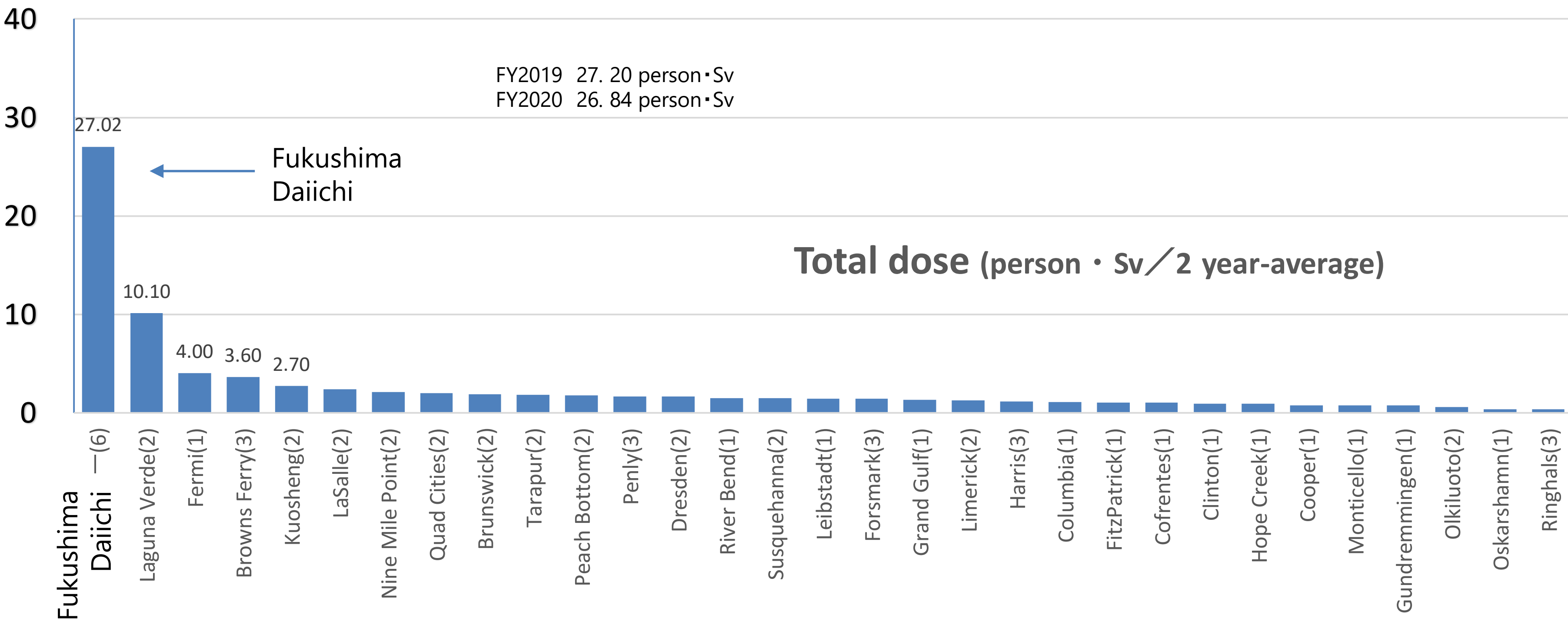
In the world, the annual dose is around 10.1 person・Sv even at the highest plant. 1F workers are still exposed to three times the exposure dose of a BWR plant with the highest dose rate in the world.



Comparison with other operating BWR reactors in the world (total dose for the site, FY2019 to FY2020)

2-3. Difficult environment for developing safety awareness

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Efforts to address the Difficulty ③

- Mechanisms to increase awareness of nuclear safety

  Established the Safety and Quality Office (in April 2020), Design Review Meetings, Risk Management, Nonconformance Management, Safety Culture Monitoring Meetings
- Introducing built-in gate processes to work
- Use of reviews by external organizations

  WANO, IAEA, JANSI,
  TEPCO Nuclear Reform Monitoring Committee,
  Nuclear Safety Oversight Office
- Others

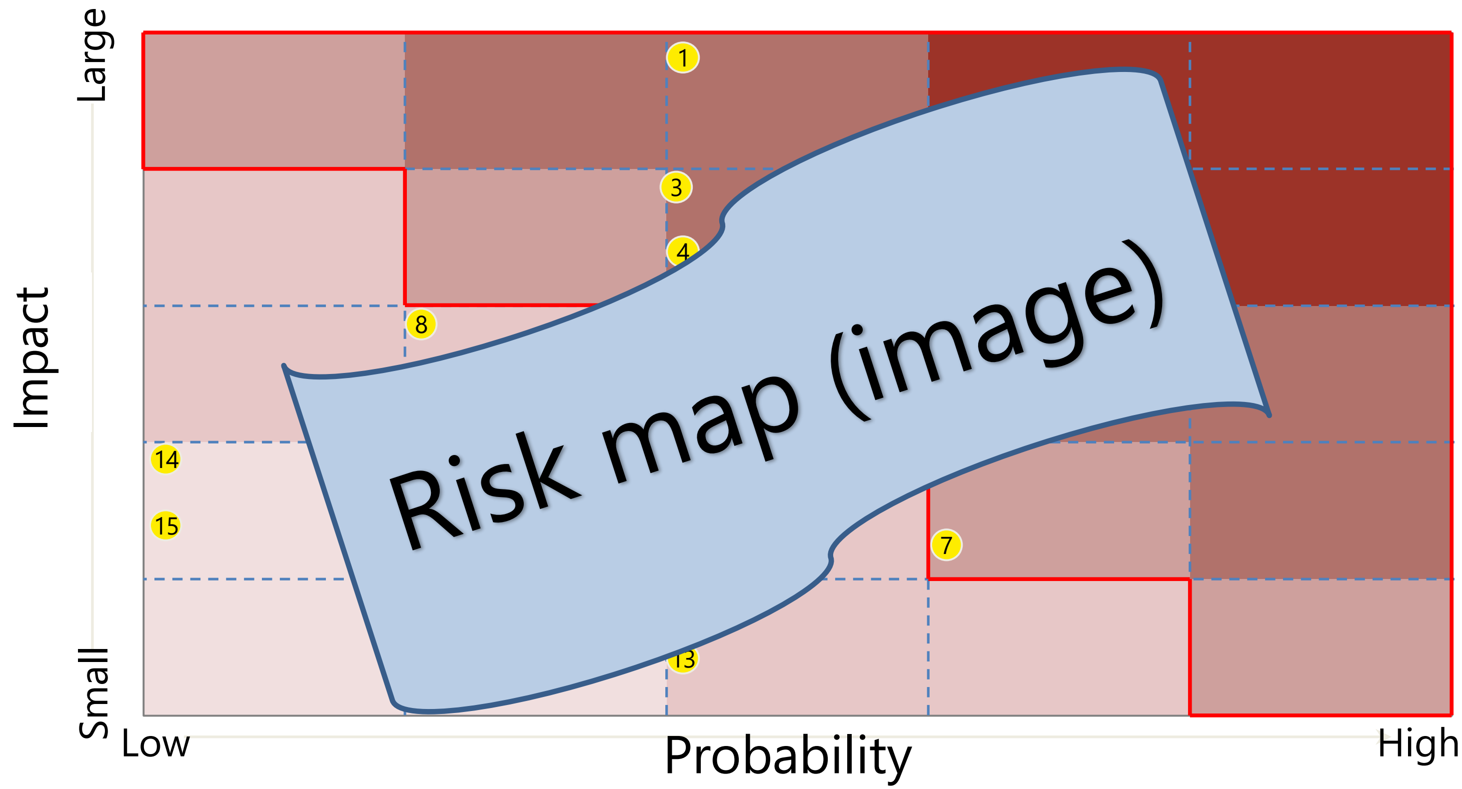
  10 Traits, Safety Improvement Proposal Competitions.

2-3. Difficult environment for developing safety awareness

Example: Use of risk maps

- ・Nuclear safety risk map
- ・PJ implementation risk map
- ・Operation maintenance risk map

→ ・Decommissioning CP risk map



2-4. Projects requiring Trial & Error

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Other characteristics of 1F related to nuclear safety

- ”Stop & Cool & Contain” and “Stop→Cool→Contain”
- Nuclear fuel materials that are not sealed (exposed)
- Work and timeline that make setting goals difficult
  (Decades without “operation → outages→ startup”. Ambiguous goals)
- Accumulation of immature technologies
  (Unproven technology, prototype, general-purpose items, and custom-ordered items)
- Areas that need trial and error ⇔ Culture that does not tolerate failure
- Difficulties in understanding the entire risk under the PJ system
  (Optimizing for each project rather than the entire)
- Equipment/facility documents are not fully developed.

3. Moving forward with safer decommissioning

Different ways of thinking and approach are necessary

- No standards
  → A lot of room to think and decide for oneself

- Habits built from old ways of thinking
  → Necessary for a shift in mindset, high expectations for the post-3.11 generations

- Different challenge than in nuclear power plants
  → Importance of learning widely from the experience of others, including overseas

- Agile approach (Trial & Error, Lead and Learn, PDCA, social receptiveness to DLTG)
  →Perspective of the local community/society and information provision in advance, Decommissioning Information and Planning Office

- Maintaining motivation
  → SDGs, adopting cutting edge technologies in the field despite the “backward facing” image of 1F work (robots and remote operation technology)