Safety Enhancement of Nuclear Power Plants
and
Nuclear Safety Reform in TEPCO

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Outlines

1. Safety enhancement of nuclear power station
    (1) Lessons learned from Fukushima accident
    (2) New guideline of safety design improvement
    (3) Hardware enhancement

2. Nuclear safety reform in TEPCO
    (1) Root cause analysis of Fukushima accident
    (2) Limitation of previous reform activities
    (3) Major action plans to reform TEPCO nuclear organization

Lessons Learned from Fukushima

1. Deficiency in defense in depth（DID） protection against external events

Deficiency in DID protection against external events

Facts:

- Underestimate tsunami height for design base.
- Site level was not high enough to prevent inundation of tsunami as the 1st layer of DID.
- Equipments as 3rd ,4th barriers of DID layer were disabled by tsunami. (common cause failure mode)

Lessons Learned:

- Necessary to enhance DID for external events

Basic policy of safety enhancement

- Define Design Extended Condition (DEC) for each DID functions – physical barriers (1), shutdown (2), cooling (3), confinement (4)

2. Inadequate high-pressure water injection functions in station blackout condition（SBO)

Inadequate high-pressure injection in SBO

Facts:

- Isolation condenser (high-pressure injection function) in 1F1 didn't work well after Tsunami hit .
  - Core melted down in 5 hours after scram
- High-pressure injection systems worked 3 days for 1F2 and one day for 1F3 .
  - Couldn't depressurize RPV and lined up alternative injection systems while RCIC & HPCI were operating.

Lessons Learned:

- Necessary to enhance high pressure injection function which is very important after SBO.

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Basic policy of safety enhancement

- Extend DB-SBO duration to 12hours and enhance high pressure injection functions

Lessons Learned from Fukushima

3. Lack of protection measures for primary containment vessel in severe accident conditions

Unit 1

Unit 3

Unit 4

Revision of design requirements for PCV

Facts:

- 1F Unit 1,2,3 containment were breached by high temperature and pressure resulted from core damage, and radioactive materials were released.
- Design requirements of PCV as the 4th barrier were not clearly defined.
  - Original design requirements for PCV as a 3rd layer were based on LOCA

Lessons Learned:

- PCV designed based LOCA cannot withstand core meltdown condition.

Basic policy of safety enhancement

- Enhance the design requirements for PCV and related equipments as a 4th barrier of DID in melt through condition.

DID enhancement policy

- External events do damage the 1st & 3rd barriers of DID
  → necessary to enhance each layers of DID
- Necessary to use Design Extended Condition (DEC) for each DID layer in order to consider safety enhancement measures.
- To cope with tangled & complex B-DBE situation, DEC design requirements should promote diversity and flexible measures.
- In order to enhance the reliability of high pressure injection and RPV depressurization function, SBO should be treated as design base, then single failure criteria should be applied.

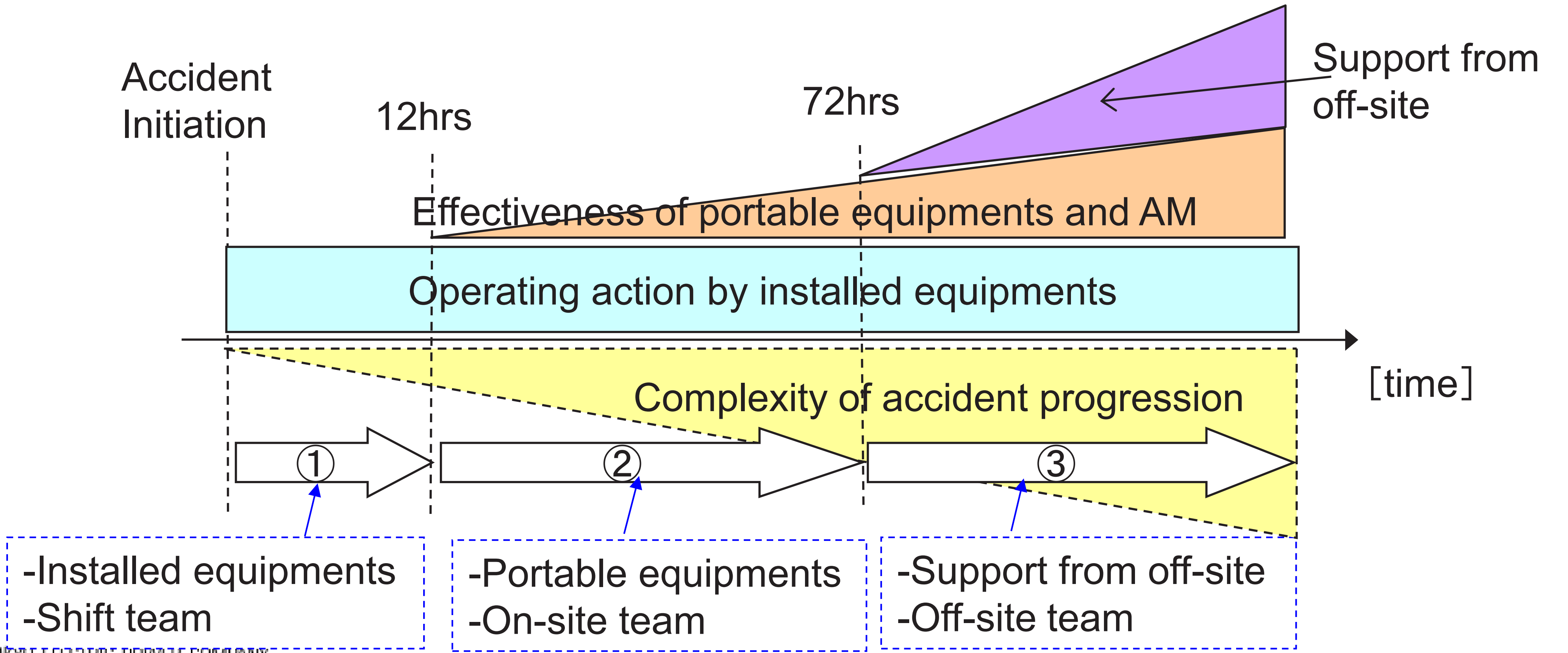
Measures in each DID layer for Tsunami

DID layer	Purpose (Important Function)	Design Requirement	
		Design Base	DEC (promote diversity & flexibility) Newly added as DEC
1st	Prevention of anomaly (Physical barrier)	Site elevation, Embankment, Tidal wall, Tidal board	- Water tight doors to limit water inundation to significant areas - Water discharge pump at safety significant areas
2nd	Prevention of accident excursion (Shutdown)	No additional system	No additional system
3rd	Prevention of core damage (Cooling)	[Cooling] - additional high pressure water injection system besides RCIC - increase DC battery capacity for RCIC	[Cooling] - portable DC battery for RCIC -CUW and MUWC enable by power supply vehicle -fire engine, Diesel Driven pump, Movable heat exchanger, hardened w/w vent, filter vent (before core damage)
		[Depressurization] No additional system	[Depressurization] - dedicated DC battery for SRVs - increase N2 capacity and pressure - compressor - additional diverse depressurization method
4th	Mitigation of accident (Confinement)	- substitute spray, pedestal water injection, top head flange cooling - filter vent (after core damage) - passive hydrogen recombine system in reactor building Originally defined as DEC	

Phased approach for DID enhancement

Design requirements for countermeasures should be determined according to the required time or available alternatives.

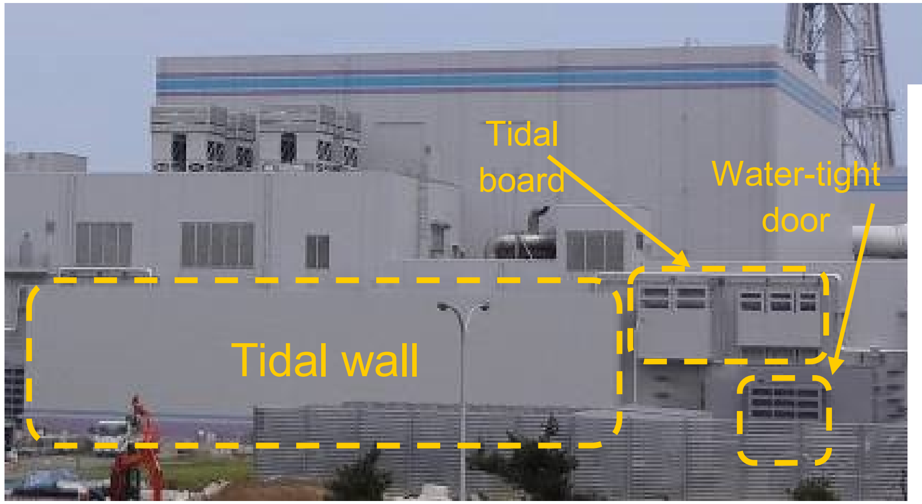
- Early phase: limited human resource, difficult to access the field
  Installed equipments are appropriate.
- Later phase： complex situation make difficult to cope with installed equipments
  Diverse and flexible mobile equipments are effective.



1st layer of defense in depth

The flood by tsunami is prevented and the measure which protects power sources and other important apparatus is implemented.

Embankment : Preventing inundation of site

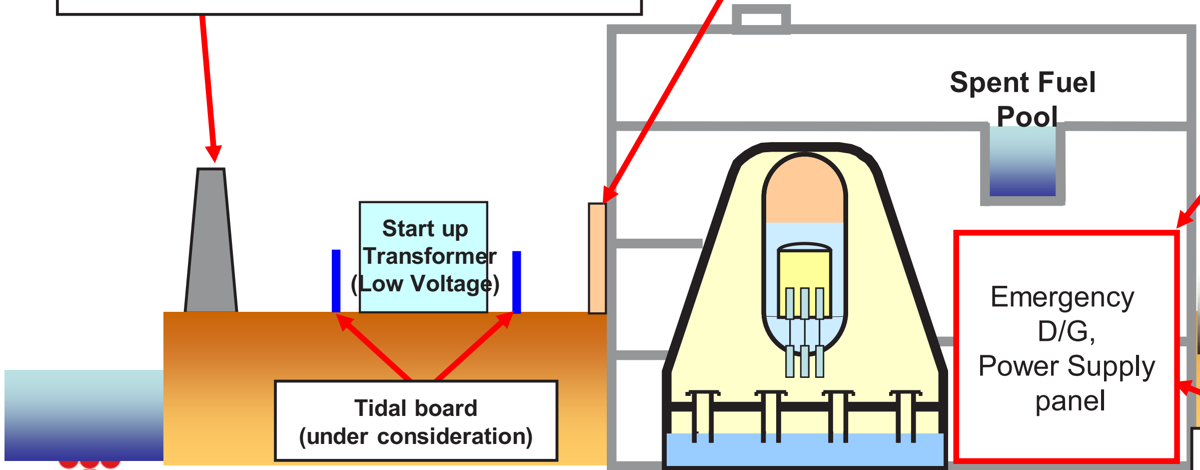


Tidal wall : Preventing inundation of building

Water-tight door : Preventing flooding of critical areas (~60 places)

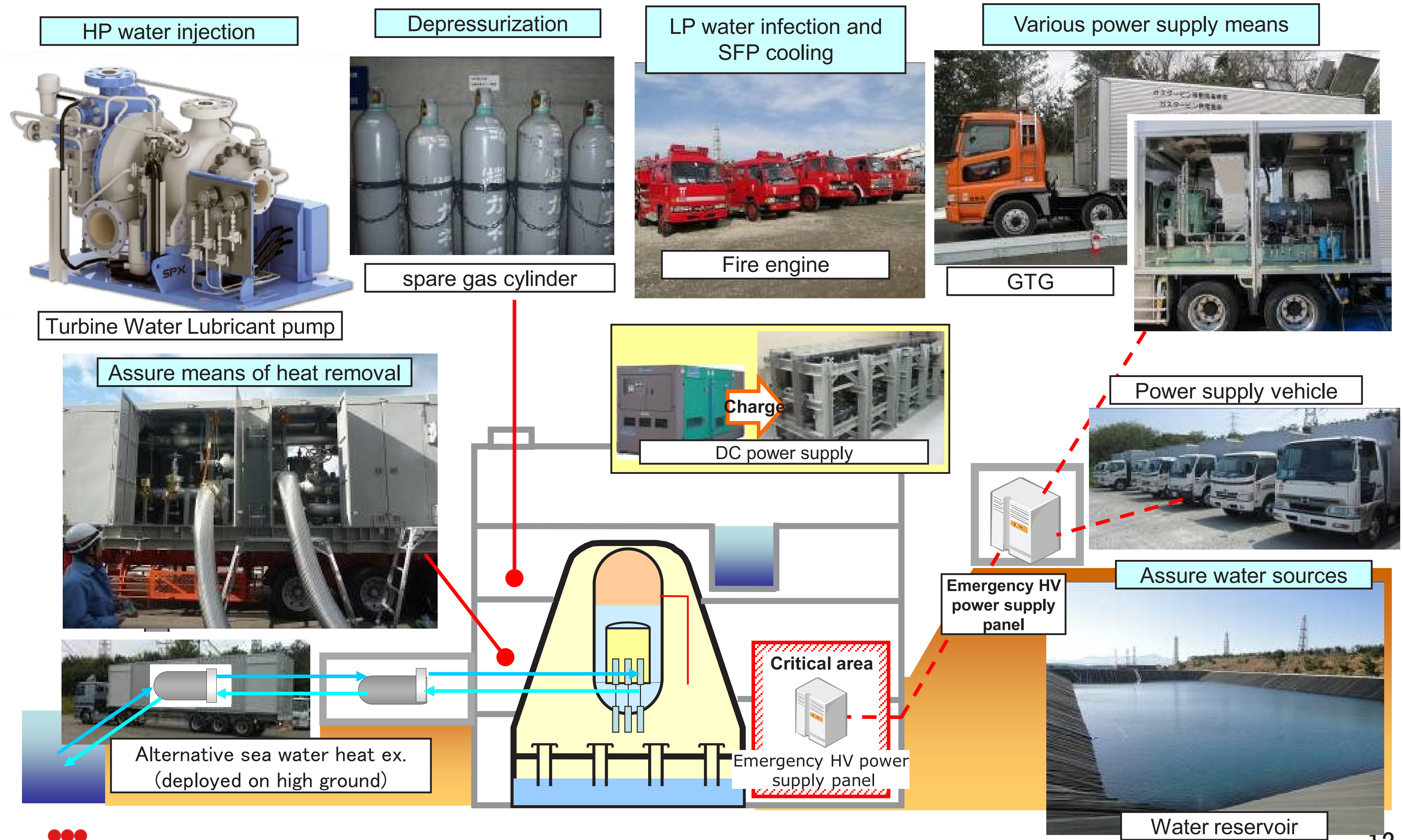
Waterproof treatment at Cable trays

Waterproof treatment at Pipes

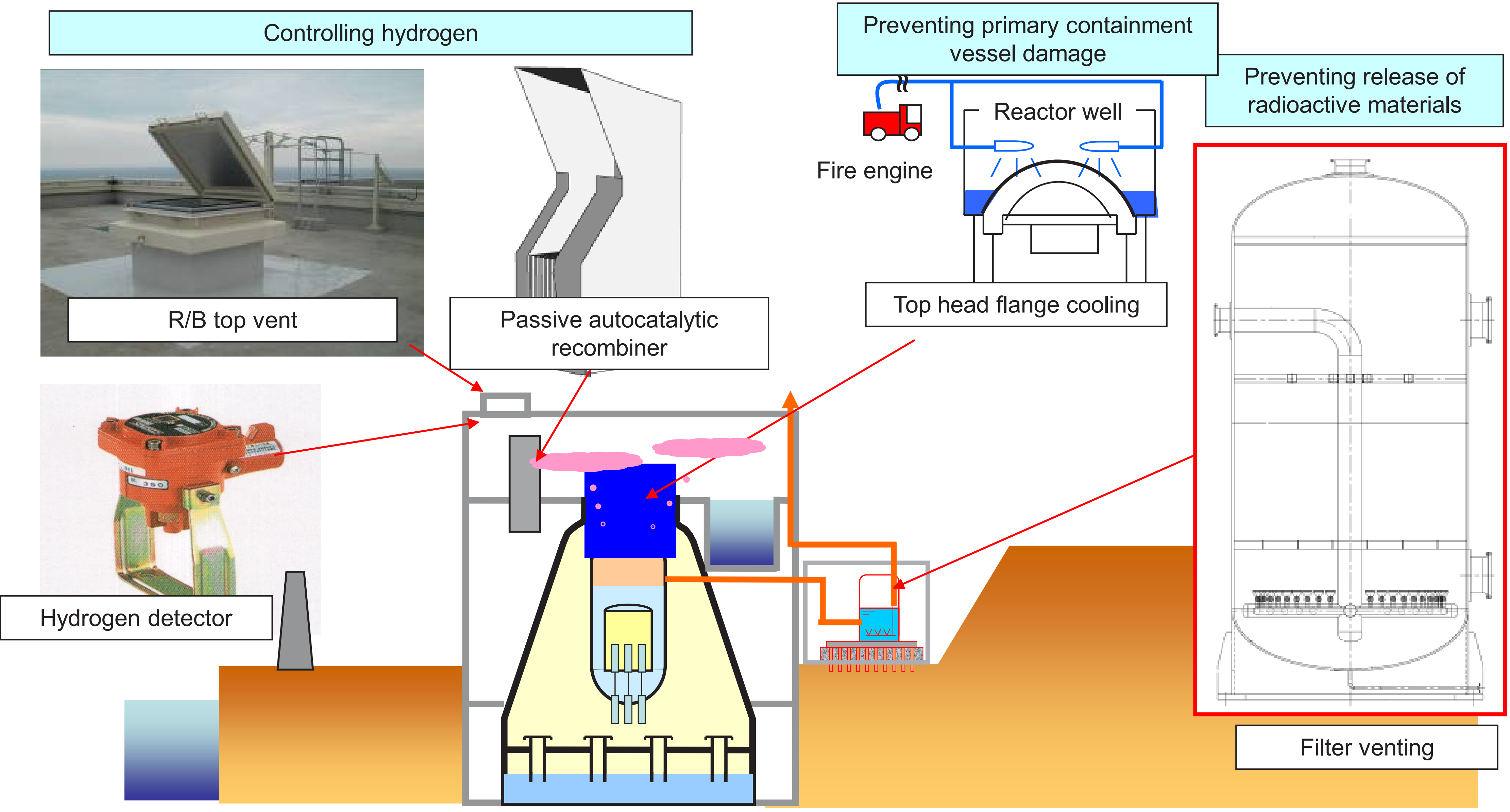


Waterproof treatment : Preventing flooding of critical areas (~ 300 places)

3rd layer of defense in depth



4th layer of defense in depth



Nuclear Safety Reform in TEPCO

Objective: Strengthen safety culture in TEPCO.

Root cause analyses : Reviewed safety activities in the 2000s and identified deficiency in safety awareness, engineering and communication ability.

Action plans:

1. Enhance safety awareness of top managements
2. Implement Independent Internal Safety Assurance Organization
3. Reorganize emergency response team based on Incident Command System
4. Improve engineering ability to propose defense in depth safety measures
5. Enhance on-site staff technical capabilities
6. Adopt risk communicators to build trust with local community and public.

Defects in Measures for Severe Accidents

Root Cause: We believed that sever accident was unlikely then it was not necessary to improve safety measures more.

Safety Awareness

- Lack of awareness that it was important to improve safety continuously
- Reluctant to improve safety measures beyond regulatory requirements
- Overestimate current safety features reliability

Engineering Ability

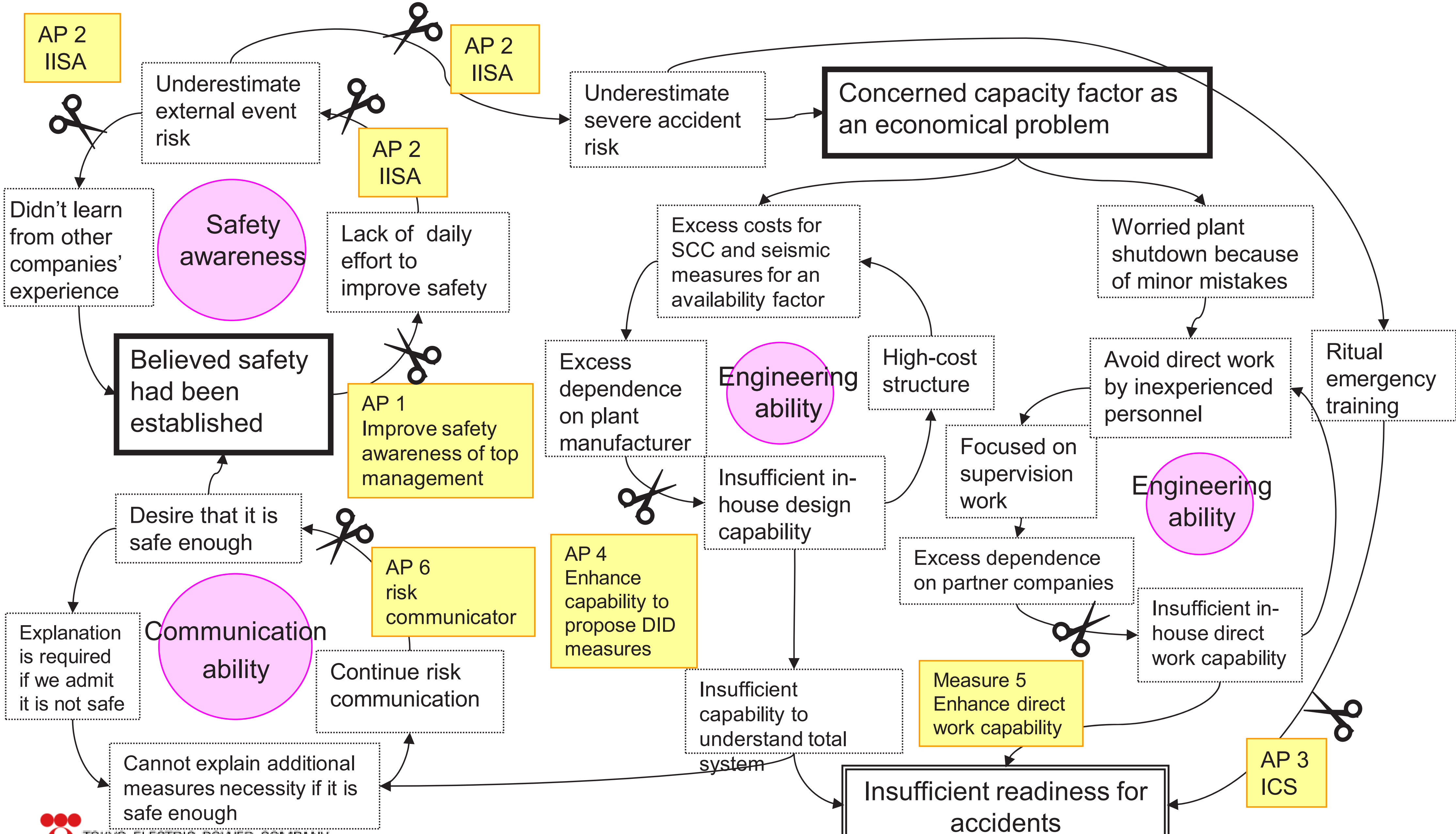
- Lack of awareness that external events cause SBO, which is highly likely to lead to severe accidents
- Lack of ability to develop effective safety measures with limited resources in short period
- Cannot use information effectively from overseas or other power stations

Communication Ability

- Reluctant to acknowledge required improvements for fear of losing public confidence in nuclear safety

Cutting Negative Chain of Insufficient Readiness for Accidents

We believed safety had been established and concerned capacity factor mainly then reluctant to improve safety measures.



Enhance safety awareness of top managements

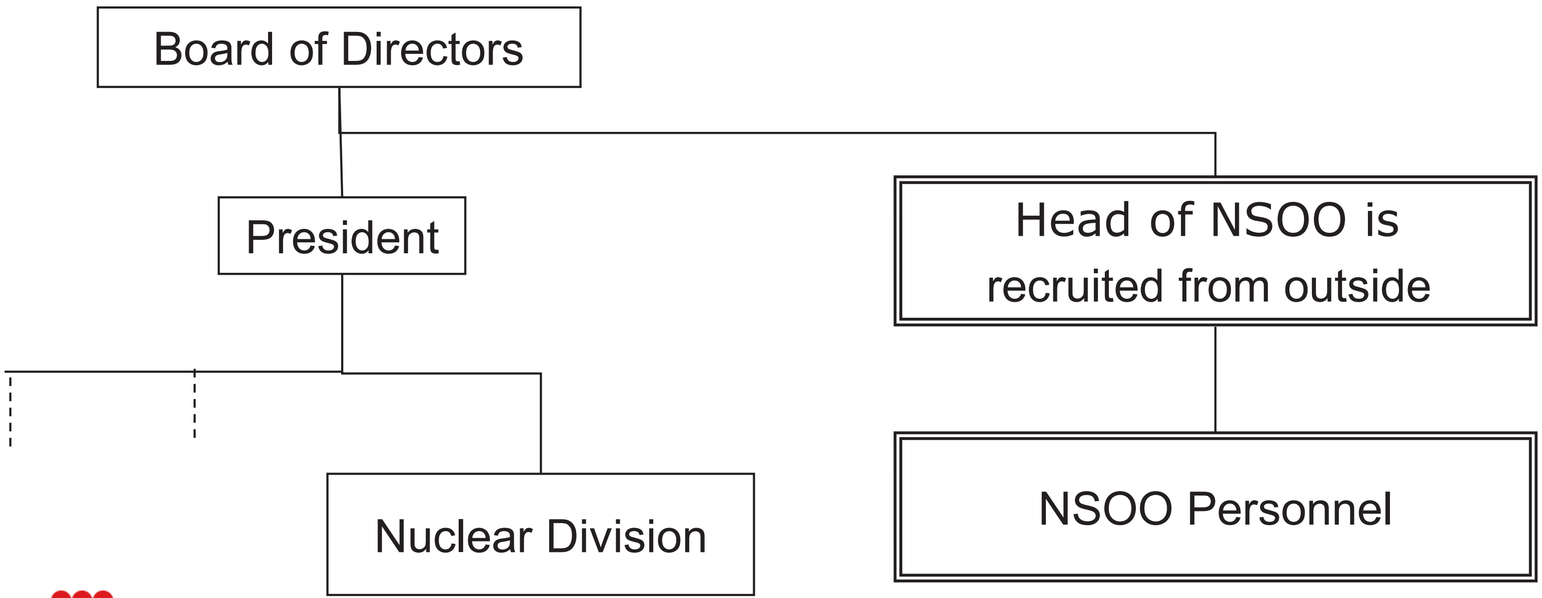
- Top managements should have a high level of awareness about the significant risks of nuclear power.
- Top managements should take full responsibilities of nuclear power operation .
- Training programs was conducted for corporate officers on basic principles of nuclear safety designs, safety culture and root causes of and measures taken after the Fukushima accidents.

Training for corporate officers

(The speaking man is Mr. Naomi Hirose, president of TEPCO)

Independent Internal Safety Assurance Organization

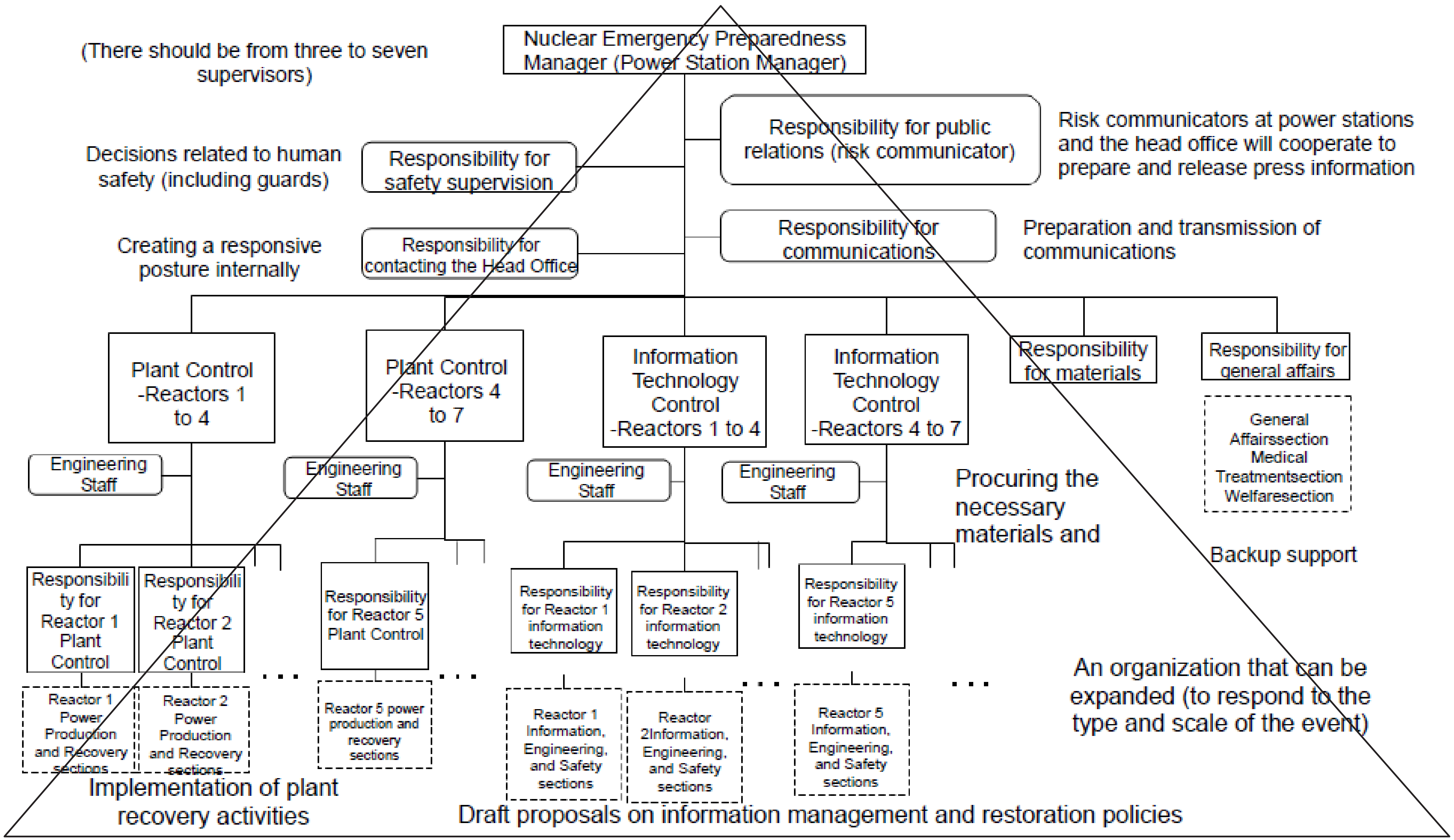
- As an internal Safety Assurance Organization, the Nuclear Safety Oversight Office (NSOO) was established on May 15, 2013.
- NSOO reports directly to the board of directors and is independent from the nuclear division.
- Head of NSOO is a person familiar with nuclear safety and is recruited from outside TEPCO.
- NSOO has oversight responsibilities of nuclear safety.



Nuclear Safety Oversight Office
General Manager, Dr. John Crofts

Reorganization of emergency response team based on ICS

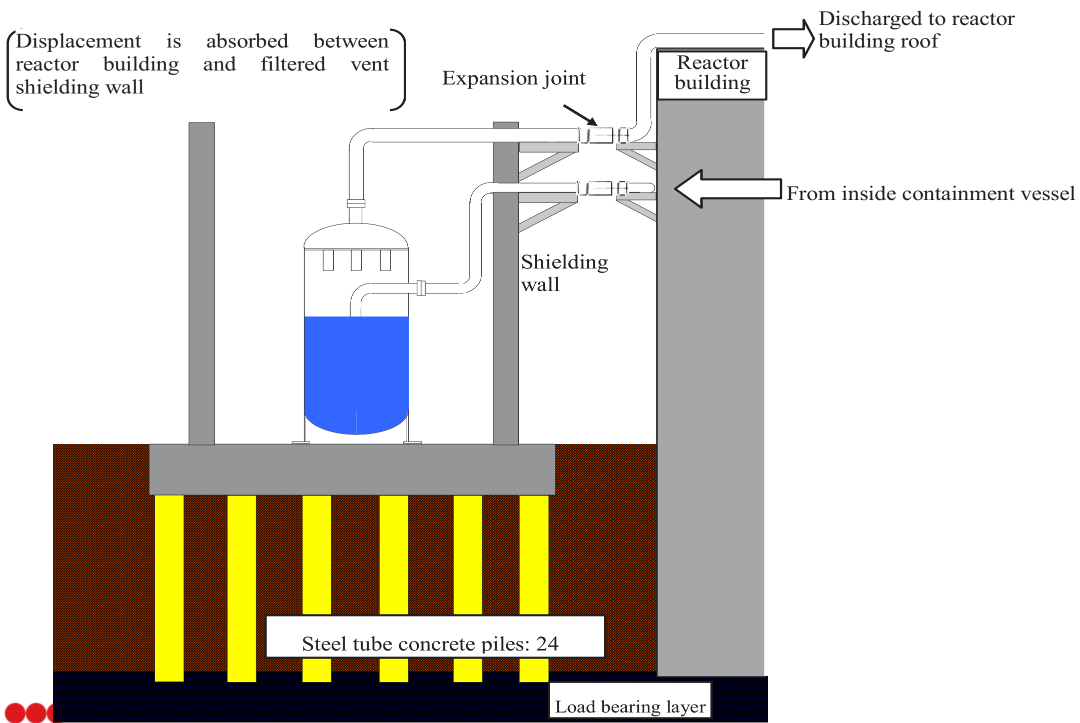
- ➢Clear and transparent command and control system
- ➢Effective information sharing
- ➢Maximum number of staff under one supervisor is 7



Improve engineering ability to propose DID safety measures

➢All nuclear division staff need to propose safety enhancement measures every year. The best proposal will be implemented at the plants after detailed design reviews.

➢Middle management's safety improvement practices will be evaluated via 360-degree evaluations by superior, subordinates and colleagues.



The filtered venting system was planed by TEPCO's direct management.

Enhancement of on-site technical ability

- Expanding the area we work directly in order to improve ability to respond emergency condition by site staff.

- Development rotation between operators and maintenance department.

Demonstration at ERC

Alternative heat ex connection drill

GTG connection drill

Adopt Risk communicators to build trust

- After March 11, 2011, the level of explanation requested by the society has increased.
- Required more technical and advanced explanation.
- Advanced dialogue and technological capabilities are required to promote risk communication.
- The Social Communication Office was established on April 10,2013 and since April 10, risk communicators have been appointed and stationed at posts.

Dialogue with local residents

Reviewing risk communication assignments roles during an emergency

Thank you very much
for your attention