Ageing Management of Reactor Internals for TEPCO

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I. Impact to the Kashiwazaki-Kariwa NPS from the big earthquake on July 16th

Kashiwazaki-Kariwa Nuclear Power Station

Kashiwazaki Kariwa
7 plants

- 7 units, 8,212 MWe
- Reactor type
  - Units 1-5 : 1,100MWe BWR
  - Units 6, 7: 1,356MWe ABWR

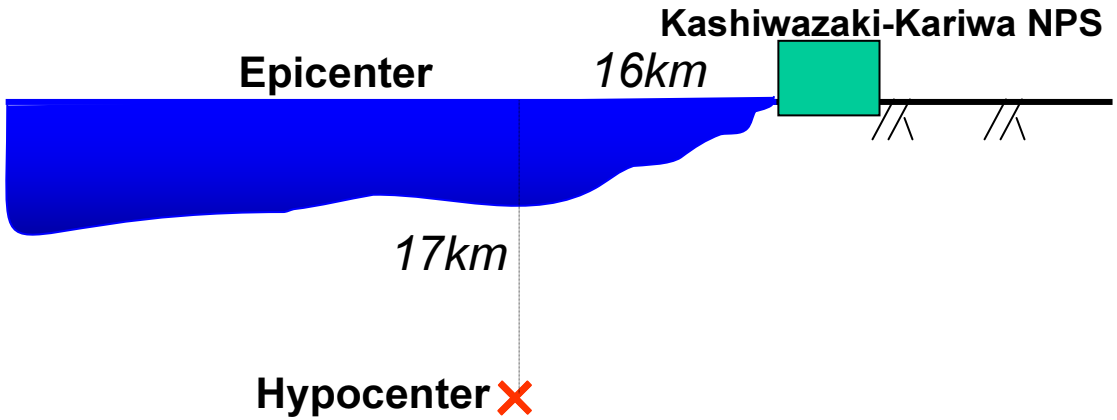
Higashidori
Preparing for construction : 2 plants

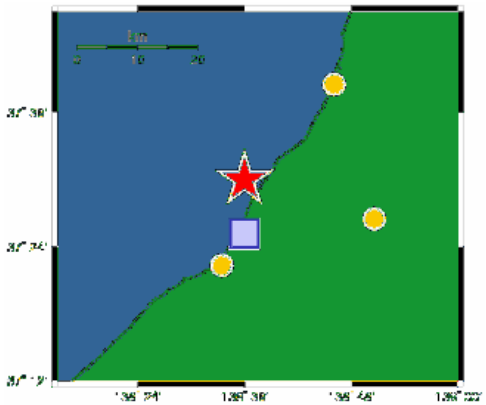
Fukushima Daiichi
Under operation 6 plants
Preparing for construction : 2 plants

Fukushima Daini
Under operation 4 plants

Plants hit by the quake but shut down safely

- An earthquake, rated at 6.8 on the Richter scale with its hypocenter 17 km underground, hit Chuetsu area on July 16, 2007.





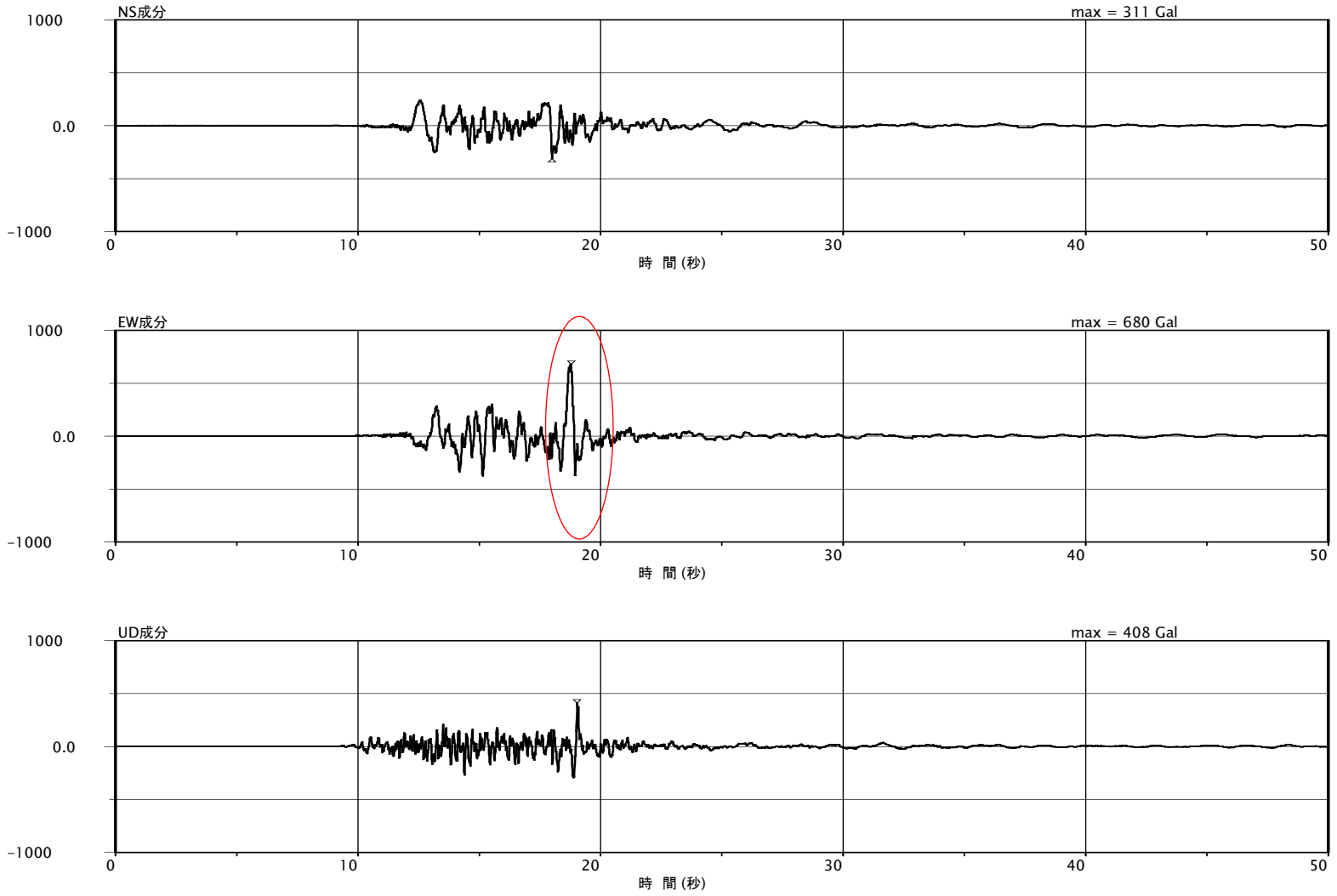
- The maximum acceleration at Unit 1 Rx/B mat: 680 gal against the design value of 273 gal.

- Units 1, 5 and 6 were not in operation for annual outage.

- Units 3, 4 and 7 were in operation, and Unit 2 was in the process of starting operation (soon after drywell inspection).

These four units shut down automatically as designed and remained in their cold shutdown conditions.

Time history (acc.) Base mat (B5F) R/B #1 1-R2



Incidents associated with the quake

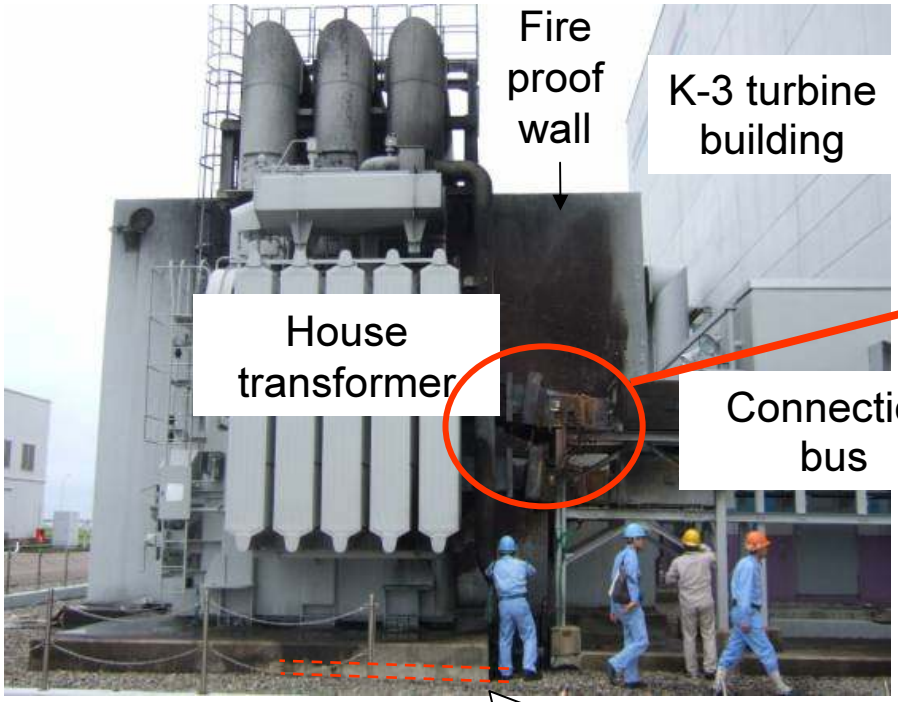
- No serious damage was confirmed so far to reactor or turbine building structures or to components of high safety significance.
- But some incidents caused social impact through mass media.
- 66 major incidents were confirmed, of which the followings were of highest concern to the public:
  - ***K-3 : Fire***
    - a fire broke out in the house transformer and lasted two hours.
  - ***K-6 : Small Amount of Radioactive Leakage into the Sea***
    - 1.2 cubic meters of water with small amount of radioactivity resulting from the spillover of fuel pool was discharged to the sea.
    - Radiation dose: 2×10^{-9} mSv << 2.4 mSv from natural sources annually
  - ***K-7 : Small Amount of Radioactive Release into the Air***
    - Radioactive iodine and other particulate materials were discharged through the main stack.
    - Radiation dose: 2×10^{-7} mSv << 2.4 mSv from natural sources annually

Damage to the roads inside the site

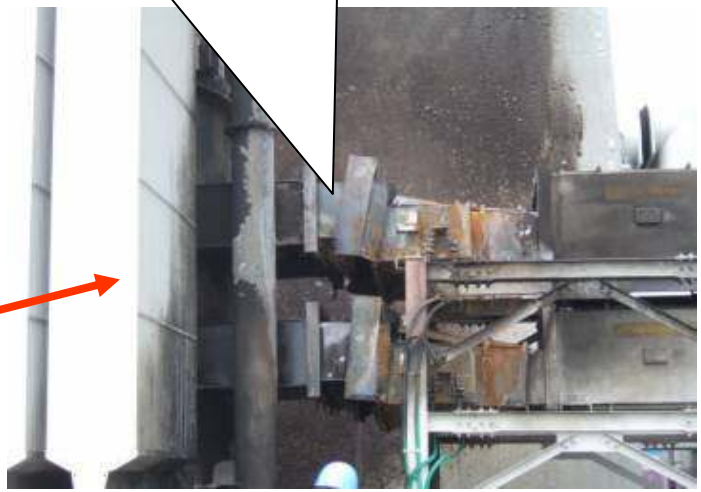
- Road damage near K-5.

- Road damage near Switch Yard.

Incidents associated with quake (Fired transformer K-3)

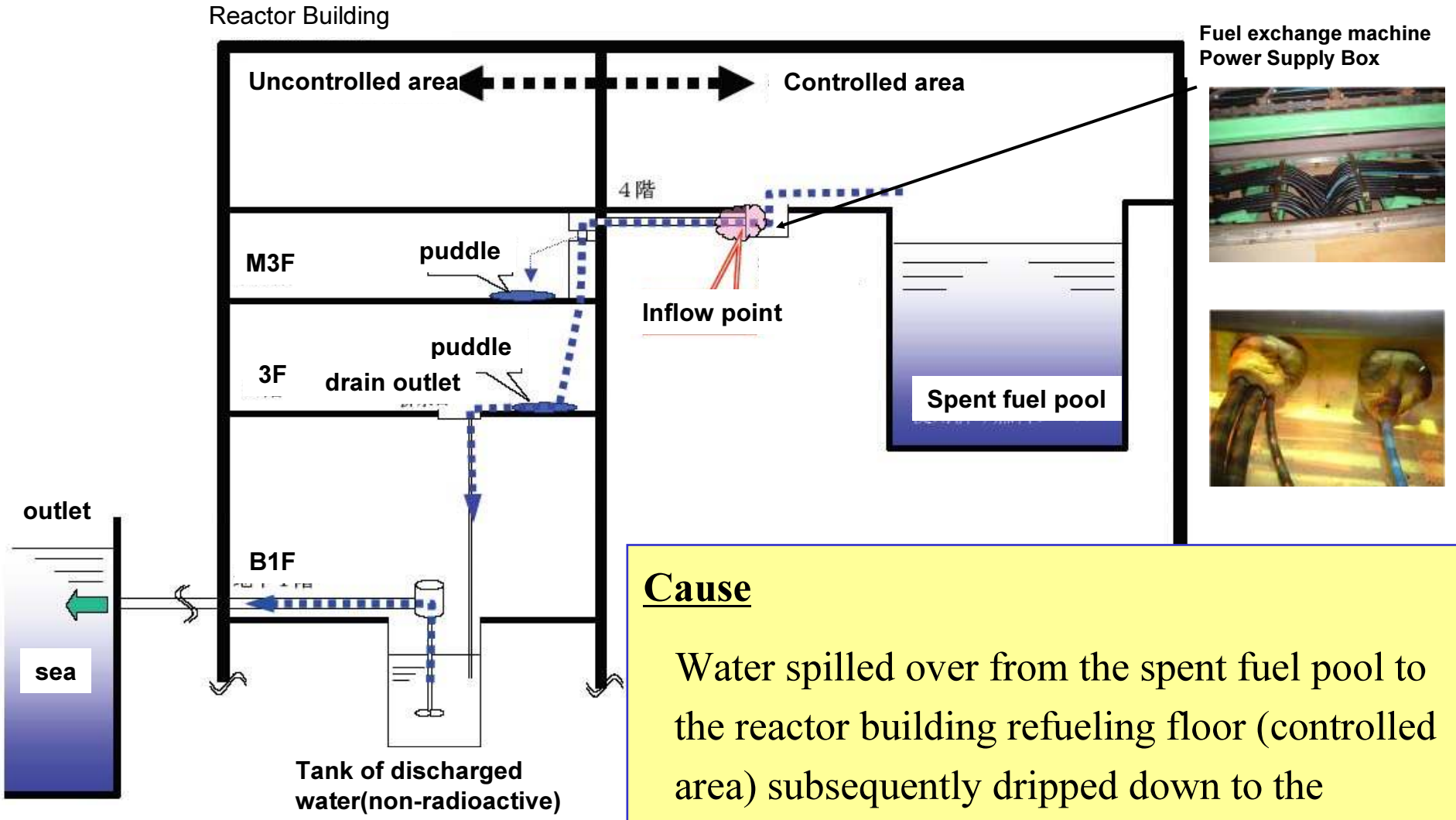


Connecting bus bar of the secondary side shifts vertically.



Connecting bus bar of secondary side subsides deeply compared to the base of the transformers.

Incidents associated with quake(Water leakage K-6)



Fuel exchange machine
Power Supply Box

Cause

Water spilled over from the spent fuel pool to the reactor building refueling floor (controlled area) subsequently dripped down to the uncontrolled area via cable and conduit of the refueling machine.

Incidents associated with quake (Radioactive materials release at K-7)

- Iodine and particulate radioactive materials at the monitor of main stack detected

  Iodine radioactive materials: 4×10^{8} Bq

  Particulate radioactive ingredient : 2×10^{6} Bq

(Equivalent to an exposure of about 2×10^{-7} mSv)

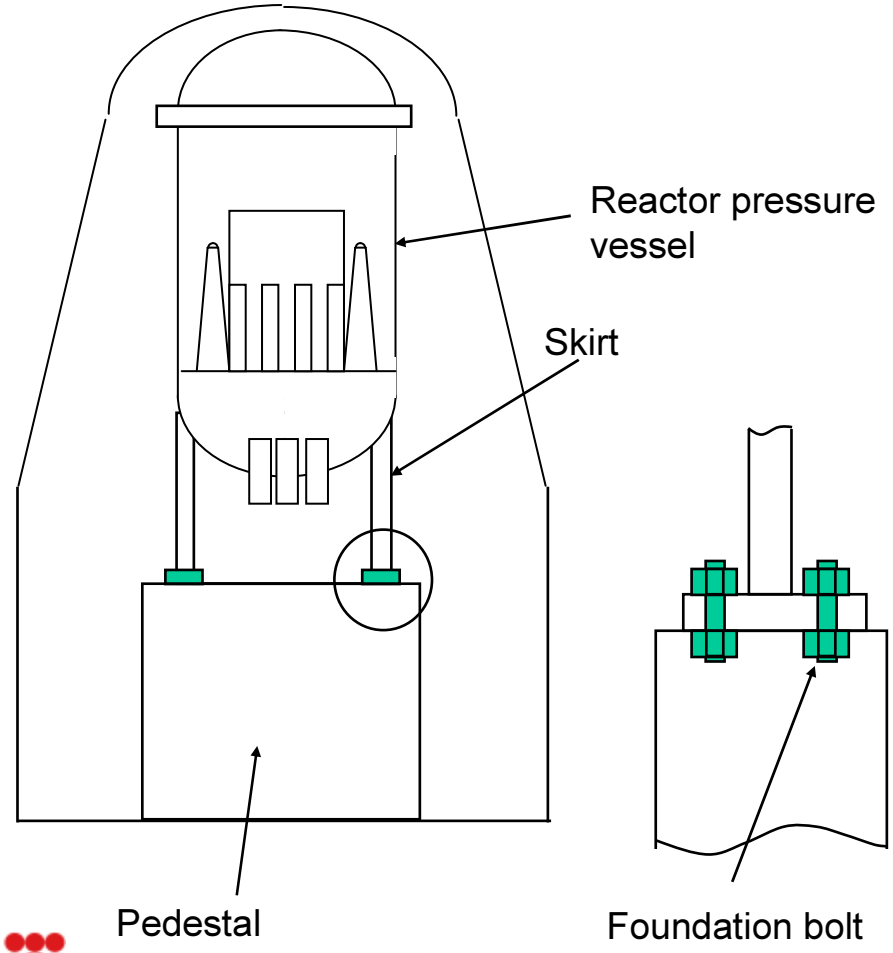
(Regulatory limit of annual exposure for an ordinary person is 1 mSv.)

- Cause

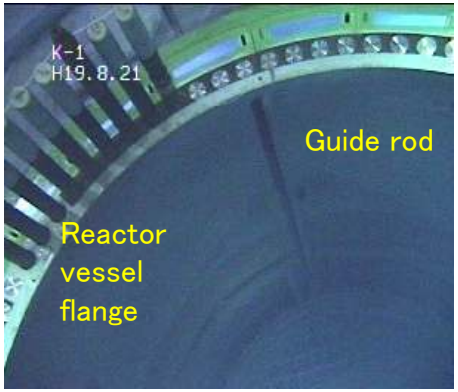
  Iodine and particulate radioactive materials which was accumulated in condenser was vacuumed up and released by turbine grand steam exhauster, because the termination of operation of turbine grand steam exhauster was delayed.

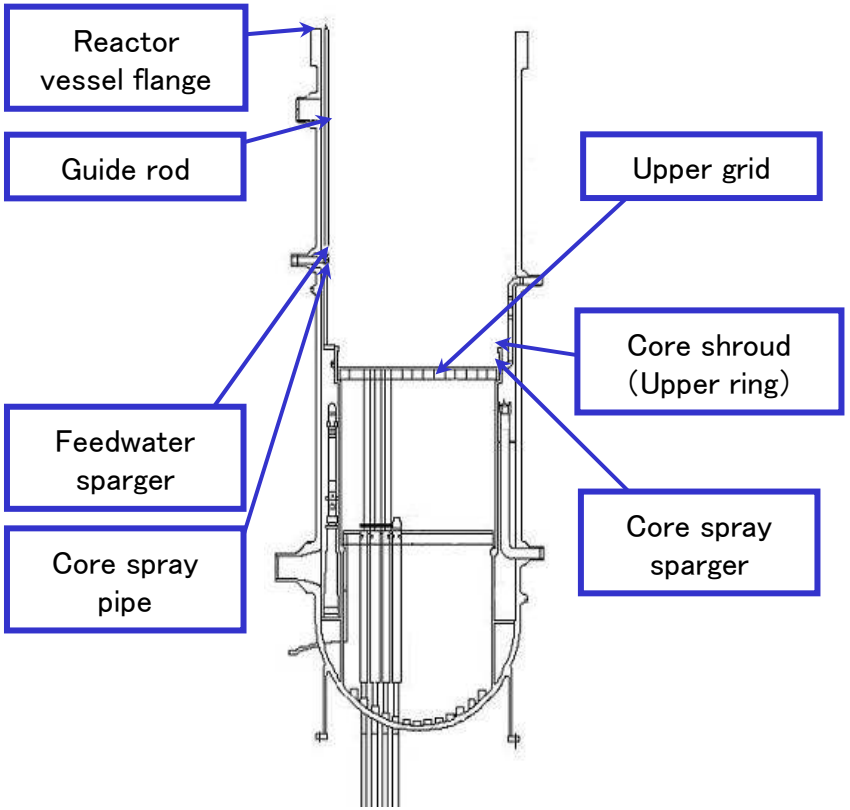
Foundation bolts for the reactor pressure vessel at K-1

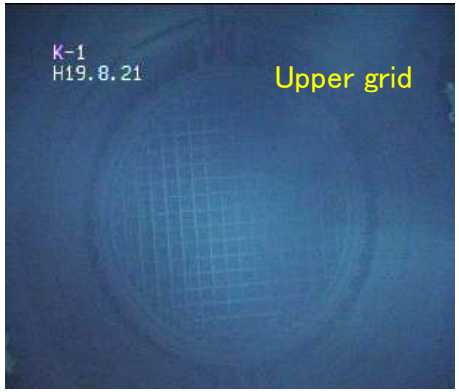
- Visual inspection of the foundation bolts for the RPV at K-1

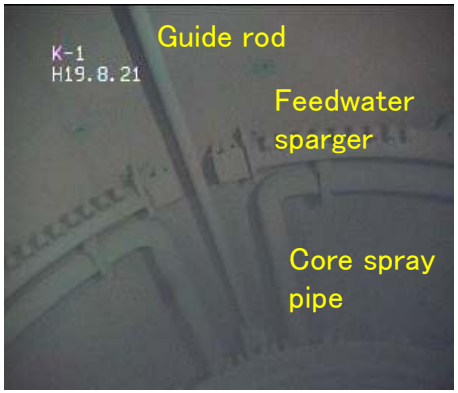


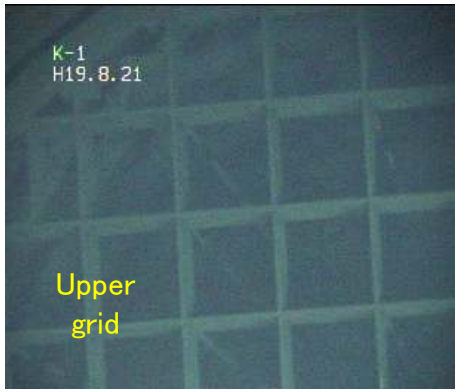
In-Reactor-Vessel Inspection at K-1

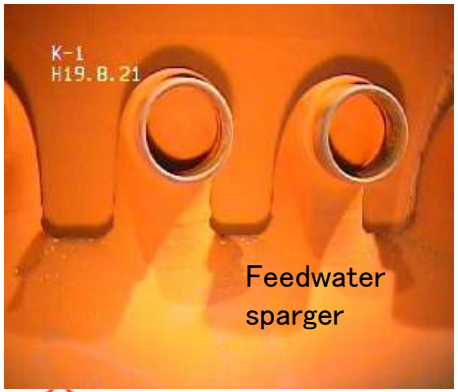


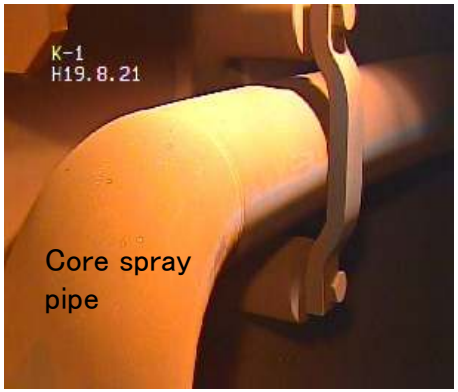


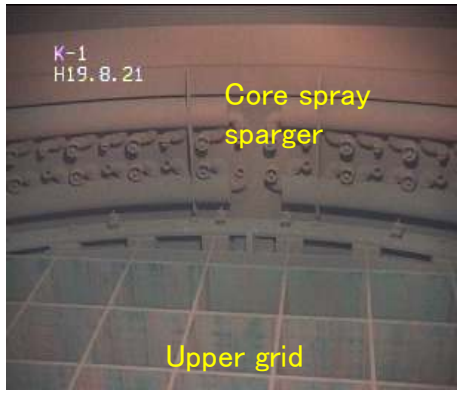


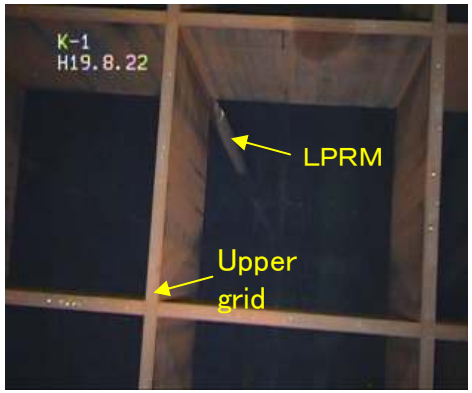




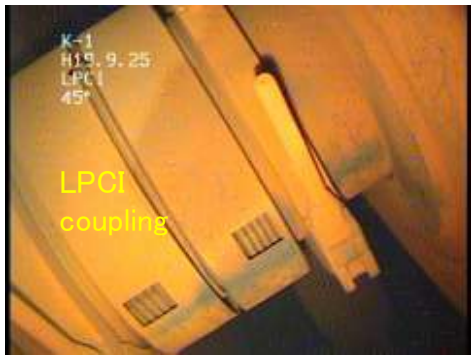


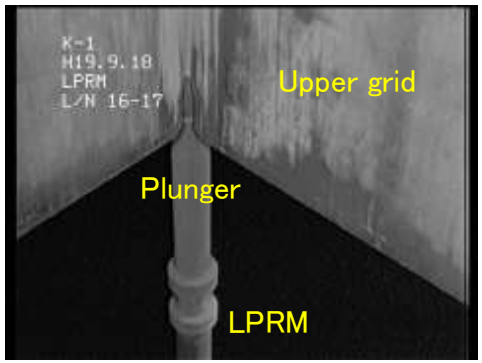


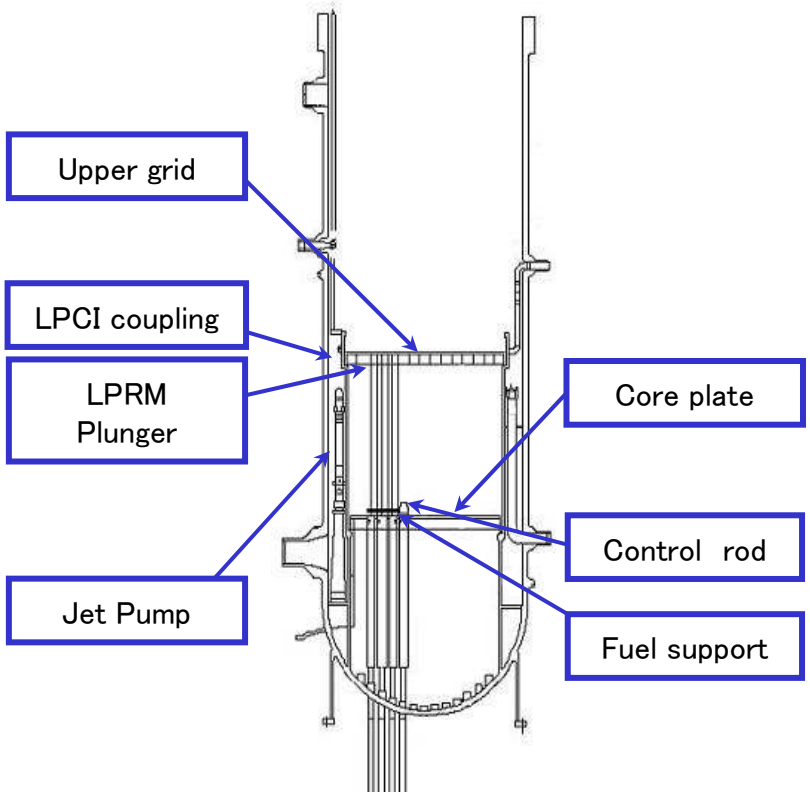


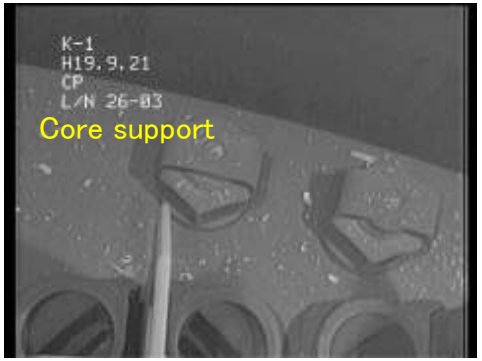


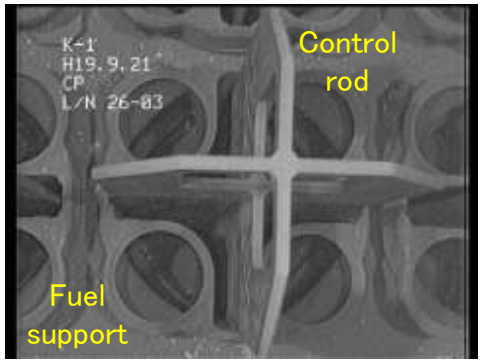
In-Reactor-Vessel Inspection at K-1

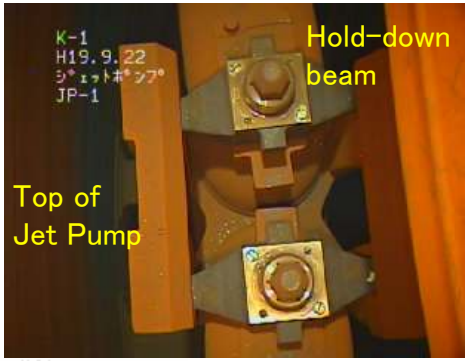


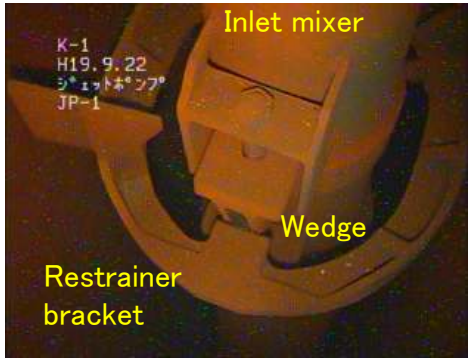


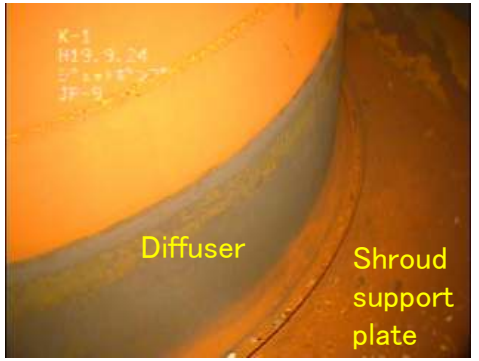






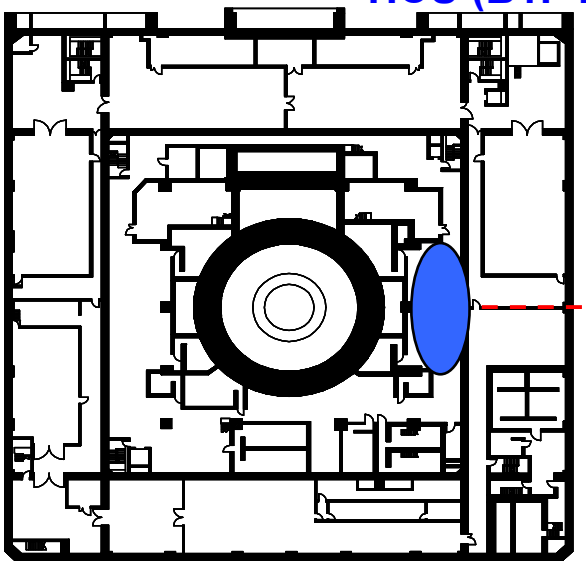




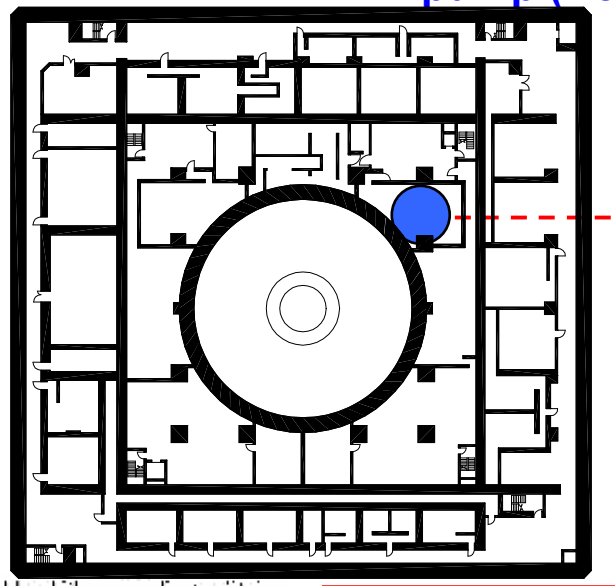


HCU and RHR pump at K-3

HCU (B1F in the reactor building).

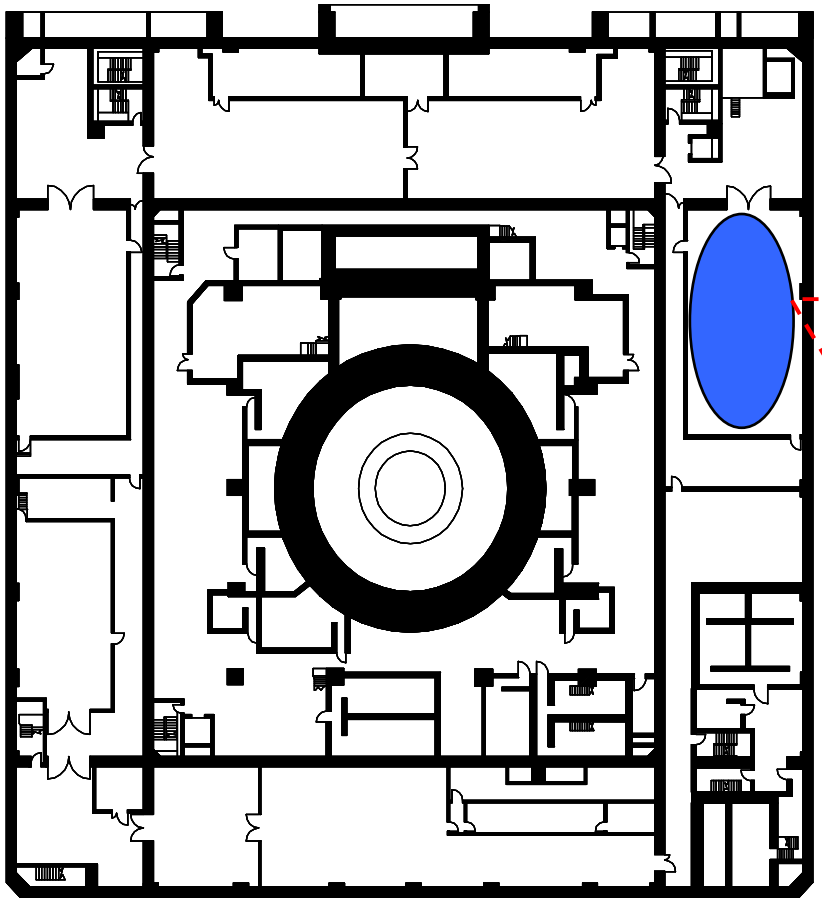


RHR pump (B5F in the reactor building).



Emergency diesel generator at K-3

B1F in the annex of the reactor building.



Upper side of the emergency diesel generator.

Lower side of the emergency diesel generator.

The 20 emergency diesel generators at units 1 to 7 underwent a manual startup test from July 25 to 27 to confirm their availability.

II. Aging management of reactor internals considering seismic load

Aging Management of Reactor Internals

(1) Low-cycle fatigue of the shroud, etc.

- The shroud and the shroud support,etc. are likely to suffer fatigue due to thermal transients.
- Calculated fatigue should be less than the allowable level considering 60 years plant operation.

(2) IGSCC at the shroud

- At the shroud support, IGSCC with the assumed size should be considered based on the inspection result for cracks.
- Considering the future growth of the crack (typically five years), the structural soundness should be evaluated by comparing necessary cross sectional area and the calculated residual area.
- Detected cracks should be monitored periodically.

(3) IASCC at the upper grid plate, etc.

- Potentially, IASCC can occur at the upper grid plate and the shroud (middle range) with high irradiation associated with operation
- The structural integrity should be monitored through visual inspection.

(4) Neutron irradiation embrittlement in Upper grid plate, etc.

- At the upper grid plate and the shroud (middle range), the toughness may be declined by high level neutron irradiation.
- However, if no significant defect exists, it is unlikely that unstable fracture will occur under the actual irradiation level.

Seismic evaluation for aging management

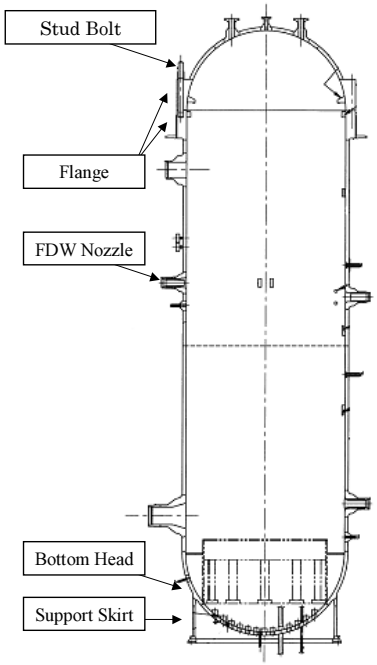
■Low-cycle fatigue

✓The historical operational data are collected, and fatigue is calculated by extrapolating those data to 60 years operation.

✓Fatigue from design earthquake is also calculated.

✓The total fatigue (Uf: Usage Factor) should be less than the criterion (1).

✓TEPCO's experiences for fatigue damage: Mechanical vibration
(Steam dryer's drain channel, Jet pump sensing line)



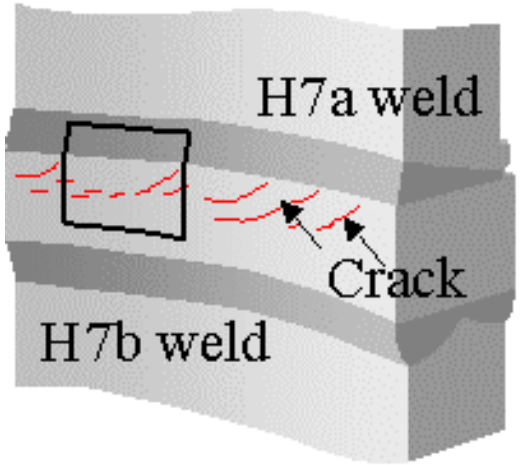
Region to be evaluated	Uf in the no. of predicted transient frequencies	Uf due to earthquake motion (S2)	Total
Flange	0.045	0.000	0.045
Stud Bolt	0.264	0.000	0.264
FDW Nozzle	0.336	0.001	0.337
Bottom Head	0.243	0.000	0.243
Support Skirt	0.027	0.000	0.027

Seismic evaluation for aging management

■SCC of reactor Internals

✓TEPCO has experienced SCC and damage to Reactor Internals.

✓Typical examples: Shroud, Core Spray, Sparger T-BOX and ICM Housing

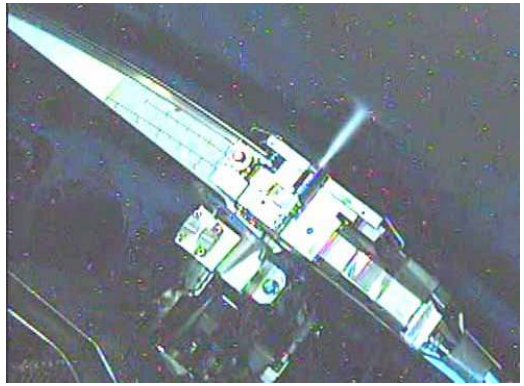


<Countermeasures>

✓Adoption of SUS 316 L

✓Replacement of shrouds (1F-1,2,3 and 5)

✓Peening

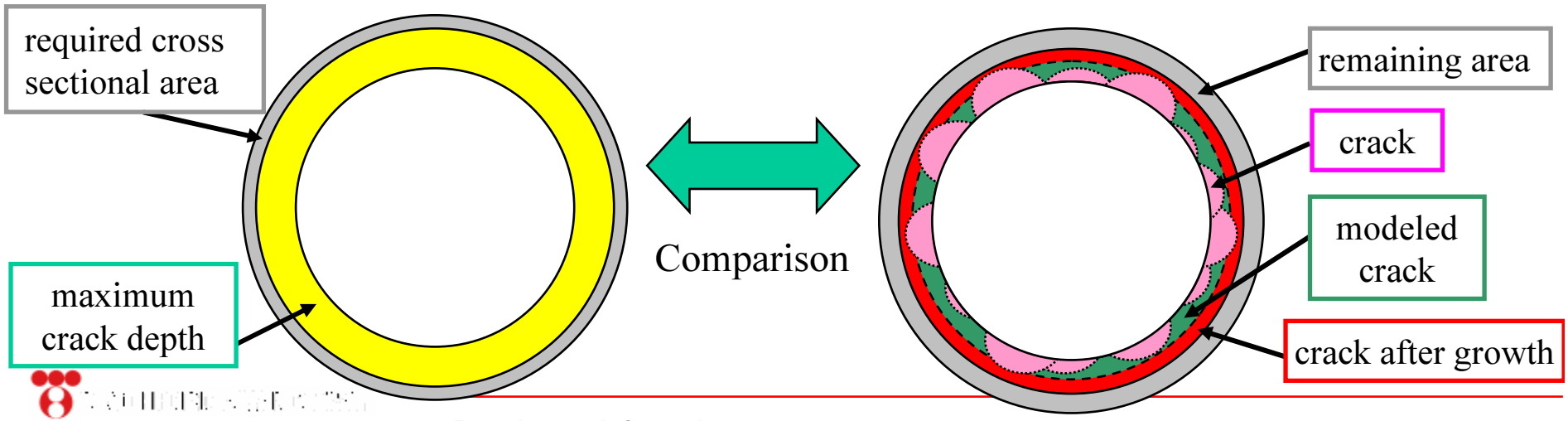


Water jet peening

Seismic evaluation for aging management

<Evaluation of cracks>

- At the shroud support, IGSCC with the assumed size should be considered based on the inspection result for cracks.
- Considering the future growth of the crack under the service condition plus 1/3 seismic load for elastic design . (Evaluation period: 5 years)
- The structural soundness should be evaluated by comparing
  - Required area: Service condition + seismic load for ultimate safety design
  - Calculated remaining area
- Detected cracks should be monitored periodically.



Future actions considering the earthquake at KK site

Seismic load from the Niigata Chuetsu Earthquake exceeded the design seismic force used for the original evaluations.

Evaluations for low-cycle fatigue

Re-assessment of fatigue due to earthquakes based on the new seismic load

Evaluations for SCC

Re-measurement of cracks and re-evaluation of the structural strength based on the new seismic load

Summary

- When the Niigata Chuetsu Earthquake occurred on July 16, four units under operation or start-up were shut down automatically as designed, and all seven units remained in the cold shutdown conditions at Kashiwazaki-Kariwa NPS.
- However, the seismic load from the Niigata Chuetsu Earthquake exceeded the design seismic load.
- TEPCO has been performing aging management (especially for reactor internals), and will continue our effort with considering the new seismic load.
- TEPCO will do its best to share the experiences for the plant operation and the big earthquake with the public and the world nuclear society.