Preparations and challenges for the restart of Kashiwazaki Kariwa Unit 7 after long term shutdown

February 28, 2024

Tokyo Electric Power Company Holdings, Inc.

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved.

無断複製・転載禁止 東京電力ホールディングス株式会社

TEPCO

Table of contents

I. State of TEPCO

- Plant overview
- Road to restart

II. Response to equipment issues during the long shutdown period

- Self-assessment using the Maintenance Guideline during long-term shutdown
- “System health assessment”—Assessment of maintenance records by system—

III. Future initiatives

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社

TEPCO

Table of contents

I. State of TEPCO

- Plant overview
- Road to restart

II. Response to equipment issues during the long shutdown period

- Self-assessment using the Maintenance Guideline during long-term shutdown
- “System health assessment”—Assessment of maintenance records by system—

III. Future initiatives

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社

TEPCO

Status of TEPCO's nuclear power plants

Kashiwazaki Kariwa Nuclear Power Station (KK)

- All units in shutdown
- Currently preparing to restart Unit 7

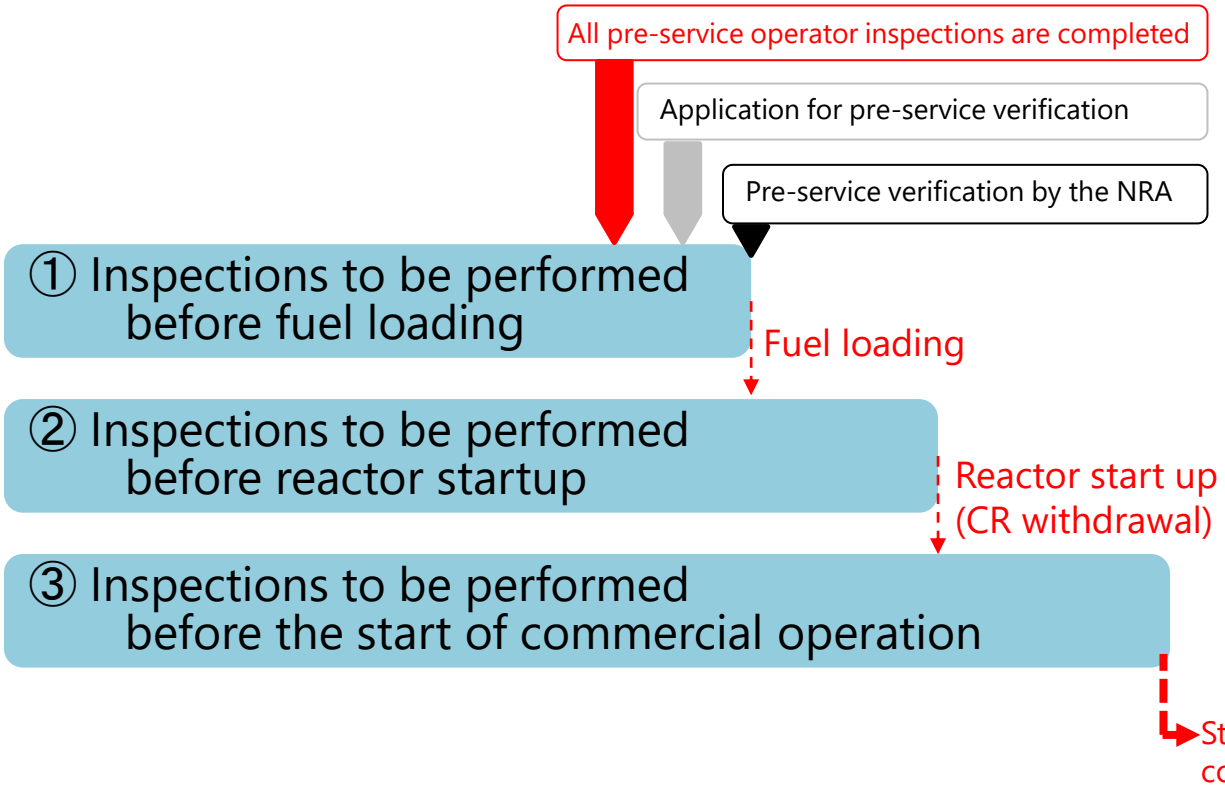
Aerial view of Unit 5-7

	Unit 1 – 5	Unit 6	Unit 7
Reactor type	BWR	ABWR	ABWR
Plant state	In outage	In outage	In outage
Status of NRA procedures	—	• Permission to change the reactor installation license →Permission granted • Approval of the design and construction plan → Application being prepared	• Permission to change the reactor installation license → Permission granted • Approval of the design and construction plan → Approval granted • Pre-service operator inspection → Being performed

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社

The road to the restart of Unit 7

- Safety measures to comply with the new regulatory requirements are generally completed.
- All pre-service operator inspections to be performed before fuel loading has been completed.
- Final checks are being performed to make sure that there are no omissions in the pre-service operator inspections, in order to submit the pre-service verification application to the NRA Secretariat.



Reference: Completed / Total (# of inspections* at Unit 7)
460/460 inspections
12/19 inspections
0/3 inspections

*Factors including the replacement of expendables could lead to re-inspections, and change the number of inspections completed

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社

Table of contents

I. State of TEPCO

- Plant overview
- Road to restart

II. Response to equipment issues during the long shutdown period

- Self-assessment using the Maintenance Guideline during long-term shutdown
- “System health assessment”—Assessment of maintenance records by system—

III. Future initiatives

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社

TEPCO

Self-assessment using the Maintenance Guideline for long-term shutdown (1)

① Development of a maintenance guideline during long-term shutdown

- ✓ In response to the shutdown period getting longer, a maintenance guideline was developed (led by ATENA) to ensure that each utility performs appropriate aging degradation management during long-term shutdown.
- ✓ Operating experiences from maintenance activities during long-term shutdown and knowledge of aging degradation events were analyzed and organized to be able to reflect onto the utilities' maintenance program.

Table 1 * List of inputs used to develop the technical basis for this guideline

Item	Input	
Operating experience (non-conformance information)	Domestic information	Overseas information
	1) NUCIA*1 information 2) CAP information	3) EPRI Reports (Browns Ferry Unit 1) 4) Analysis of overseas OE during long-term shutdown
Knowledge of aging degradation events	5) Existing knowledge of aging degradation events	

*1 NUClear Information Archives

* Source: ATENA(Atomic Energy Association)
https://www.atena-j.jp/report/docs/ATENA20-ME02%20%EF%BC%88Rev.0%EF%BC%89.pdf

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社

TEPCO

Self-assessment using the Maintenance Guideline for long-term shutdown (2)

- Equipment issues related to maintenance program that utilities have experienced during long-term shutdown were compiled based on the inputs.

Table 2* List of issues related to maintenance program during long-term shutdown

Aging degradation events	In components and structures in storage*1	In components and structures in use
Sticking	1 case	
Corrosion (general corrosion)	1 case	
Fatigue cracking		1 case
Total	2 cases	1 case

*1 Issues that have occurred in equipment and components in long-term standby have also been counted under the "in storage" column (the same hereinafter)

(Examples)*

Sticking	Tohoku EPCO	Onagawa Unit 1	Partial sticking of the boric acid injection system accumulator supply and discharge valve
Corrosion	Kyushu EPCO	Genkai Unit 3	Steam leaks from the deaerator air drainage valve
Fatigue cracking	Shikoku EPCO	Ikata Unit 2	Cracking of the residual heat removal system vent pipe

* Source: ATENA(Atomic Energy Association)
https://www.atena-j.jp/report/docs/ATENA20-ME02%20%EF%BC%88Rev.0%EF%BC%89.pdf

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社

TEPCO

Self-assessment using the Maintenance Guideline for long-term shutdown (3)

- Items that need to be considered in maintenance were also extracted from problems that have occurred in plants abroad that have been shutdown for a long time, similarly to the process for domestic plants, and reflected onto the Guideline.

(Example)*

- EPRI reports

Information extraction method:

- Extracted examples of defects that occurred in Browns Ferry Unit 1 listed in the EPRI review.

Extraction result:

- Corrosion event in residual heat removal service water (RHRSW) system and reactor building cooling water (RCW) system piping.

- Analysis of overseas OE during long-term shutdown

Information extraction method:

- Analysis OE data (INPO and WANO data).

Extraction result:

Aging degradation events	In components and structures in storage	In components and structures in use
Foreign matter adhesion	1 case	
Conduction failure	1 case	
Corrosion (erosion)		2 cases

* Source: ATENA(Atomic Energy Association)
https://www.atena-j.jp/report/docs/ATENA20-ME02%20%EF%BC%88Rev.0%EF%BC%89.pdf

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社

TEPCO

Self-assessment using the Maintenance Guideline for long-term shutdown (4)

② Applying the maintenance guideline during long-term plant shutdown

ATENA
Atomic Energy Association
ATENA 20-ME02 Rev.0

非公開版

添付書類－１

Maintenance Guideline during Long-term Shutdown *

原子力エネルギー協議会

2020 年 9 月

The Guideline was created in 2020 to include items that should be considered in maintenance during long-term shutdown in addition to the summary of the equipment problems that have occurred during long-term shutdown (approximately 200 pages including the portions that are not disclosed to the public.)

In response to this guideline, TEPCO has

- Conducted a self-assessment based on the ATENA guideline
- Updated the maintenance program based on the results of the self-assessment and also verified that the “our maintenance plan does not need to be amended taking into consideration the problems observed at other plants.”

* Source: ATENA(Atomic Energy Association)
https://www.atena-j.jp/report/docs/ATENA20-ME02%20%EF%BC%88Rev.0%EF%BC%89.pdf

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社

TEPCO

Table of contents

I. State of TEPCO

- Plant overview
- Road to restart

II. Response to equipment issues during the long shutdown period

- Self-assessment using the Maintenance Guideline during long-term shutdown
- "System health assessment"—Assessment of maintenance records by system—

III. Future initiatives

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社

TEPCO

“System health assessment”—Assessment of maintenance records by system— (1)

A “system health assessment” is …

- A summary of the system integrity checks for each system created referencing the system test checklist used in plant construction
- Also covers the risks extracted in reviewing all the storage measures implemented, pre-startup inspections, equipment non-conformances, non-conformances that have occurred at other plants during startup

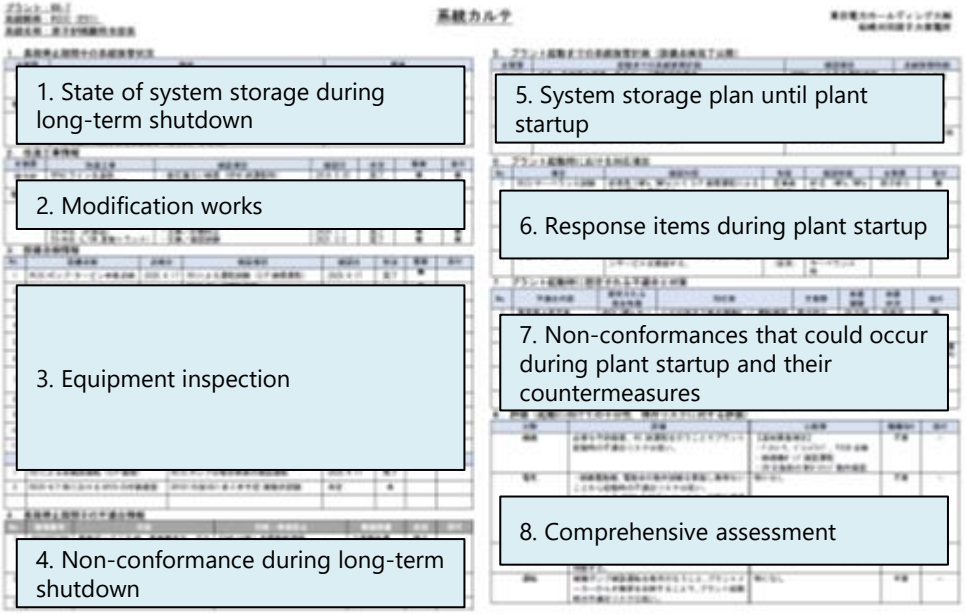
Objective of the assessment

- To check on the storage and maintenance status of each facility and prevent unexpected non-conformances before plant startup.

System health report

Example of a system health report

Plant: Unit 7
System: Reactor core isolation cooling system (RCIC)



©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社

"System health assessment"—Assessment of maintenance records by system— (2)

Assessment method

- Each department within the plant (e.g., MA, OP, CY) and plant manufacturers meet and assess the system based on various evidence.
- The first version of the System health is created and the review meeting is conducted by stakeholders.
- A punch list is created from the concerns extracted during this review meeting and necessary measures are implemented.

[Assessed systems and assessment items]

Priority grouping	#	Target systems
Priority 1 （Major facilities that have yet to be functionally verified)	12	RCIC,CW,CC,MS,GEN,SWC,GSO,HGC C,FDW,CF,CD
Priority 2 （Facilities that have yet to be functionally verified or facilities in standby until startup)	24	RRS,RIP,HD,HV,RCCV,AC,DWC,SRNM,TIP, MS,AS,ES,TGS,MSH,MTb, Major turbine valves, LO, EHC, AO, condenser, OG, process calculator, TNK
Priority 3 (In-service facilities that are safety critical)	22	RCIS,FDWC,RFC,RHR,HPCF,SLC,EE, FCS,RSS,RPS,ATWS,APR,LDS,CRD,OI, HPIN,HS,HSCR,VGL,PRM,LPRM,

Assessment items
State of system storage during long-term shutdown
Modification works
Equipment inspection
Non-conformance during long-term shutdown
System storage plan until plant startup
Response items during plant startup
Non-conformances that could occur during plant startup and their countermeasures
Comprehensive assessment

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社

TEPCO

"System health assessment"—Assessment of maintenance records by system— (3)

(Example) Assessment results for condensate system equipment

Assessment item	Assessment result
1. State of system storage during long-term shutdown	**Rusting inside the system** **At risk**
2. Modification works	**Control panel updating test complete** **No risk**
3. Equipment inspection	**Low-pressure condensate pump/condenser inspection** **No risk**
4. Non-conformance during long-term shutdown	**N/A** **No risk**
5. System storage plan until plant startup	**Consider draining and storing**
6. Response items during plant startup	**Checked for leaks, support inspections**
7. Non-conformances that could occur during plant startup and their countermeasures	**Gland leaks, instrument indication failure**
8. Comprehensive assessment	**Seat leaks from rust in systems** **At risk**

Countermeasure

Flushing when filling systems that are not normally filled with water

Flushing sampling

Countermeasure

Performed system purification operation analyzing water quality for longer than normal

The risk of there being rust in pipes and valves still persist!

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社

TEPCO

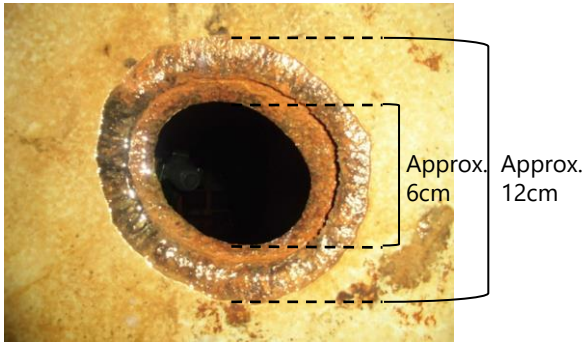
KK Unit 7 Holes in the circulating water pipes

- **Background**
  - A trial run of the turbine system, which is an integrity confirmation item identified in the system record, was performed.
  - In October 2022, the Unit 7 circulating water pump, which had not been used in a long time, was started.
  - A round hole (diameter of approx. 60 mm) was found in the lower part of the circulating water system pipe on the discharge channel side that connects to the circulating water pump, and a small amount of seawater was found to be leaking.
  - Presumed to be "a hole due to corrosion" from the investigation.

Date of event occurrence: October 20, 2022

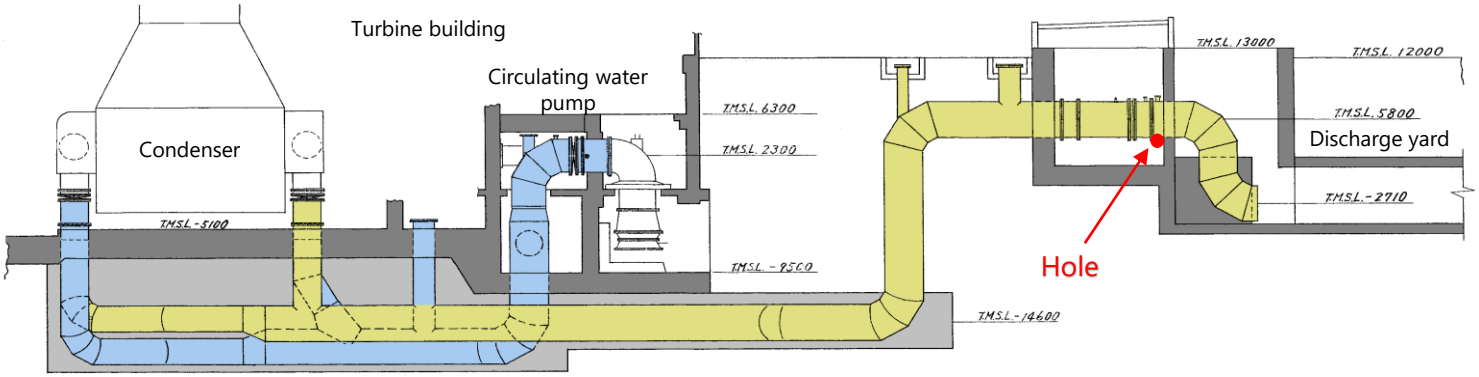
- Piping specification: Inner diameter 3.6m, thickness 16mm
- Outer coating: thickness approx. 0.7mm, epoxy coating
- Inner coating: thickness approx. 0.5mm, glass resin
- System flow: 106,200m^3/h/system

<Hole (photo taken from outside the pipe: 10/20)>



<Hole (photo taken from inside the pipes: 10/27)>

Elevation



©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社

Table of contents

I. State of TEPCO

- Plant overview
- Schedule up to restart

II. Response to equipment issues during the long shutdown period

- Self-assessment using the Maintenance Guideline during long-term shutdown
- “System health assessment”—Assessment of maintenance records by system—

III. Future initiatives

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社

TEPCO

Problems during the long-term shutdown period and their response

- Unit 7 has been in shutdown since 2011, but even during this long-term shutdown, degradation and damage have occurred.
- Facilities and equipment that have not been operated in a long time need to be assessed from various perspectives to prevent unexpected issues at startup.
  - Assess the state of maintenance against the Maintenance Guideline during Long-term Shutdown

    →It was confirmed that there was no problem in the conventional maintenance plan.
  - Conduct a System health Assessment, in which the maintenance records of each system is assessed

    →Defects were found and troubles were prevented.

Challenges after KK Unit 7 restart

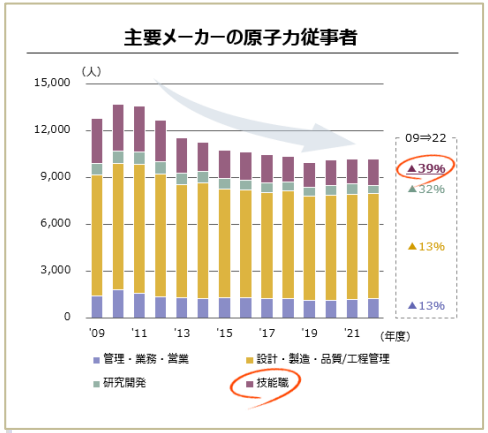
- Strategy for long-term operation
- Inspection optimization for further improving availability factor
- Management for the corrosion, fatigue and other aging degradation events
- Supply chain / obsolescence management

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社

TEPCO

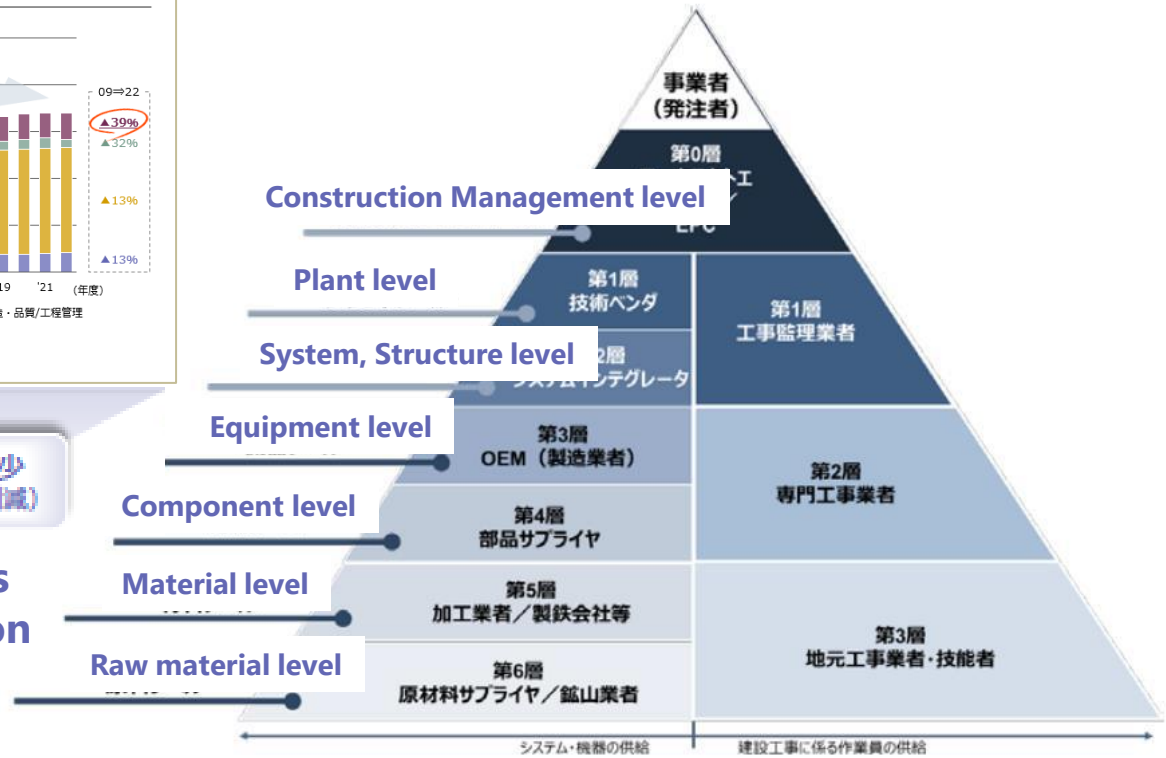
State of the nuclear supply chain in Japan

- Nuclear industry is a multi-layered structure ranging from plant level to raw material level, and supported by many suppliers.
- Since the Fukushima Daiichi nuclear accident, the number of nuclear power plants in operation has fallen sharply, and many suppliers went out of business. Due to the difficulties in technology transfer and employment for many suppliers, Japanese nuclear industry is in danger.
- In particular, BWR has not restarted yet, so supply chain for BWR is severe.



技能者の減少
(09年度比:4割減)

Skilled workers : 40% reduction



[Source] Nuclear Energy Subcommittee (https://www.meti.go.jp/shingikai/enecho/denryoku_gas/genshiryoku/037.html)

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社

Our Efforts and Consultation

- In 2023, NSCP(Nuclear Supply Chain Platform) was launched under the leadership of the national government to promote technological succession and business continuity for suppliers.

  → In order to advance private nuclear power business under the electric power liberalization, it is necessary to continuously improve the business environment such as government subsidies.

- In order to deal with obsolescence, we are working on the identification, the assessment, and the countermeasures, based on the industry-wide guidance (published by ATENA).

  → Continuous efforts to deal with obsolescence are necessary for the upcoming plant restarts and new constructions in the future.

- Through frameworks such as JBOG(Japan BWR Owners Group), utilities are working together on sharing information, jointly developing alternatives for discontinued products, and benchmarking good practices.

  → Through the proactive activities to prepare for the plant restarts, subsequent outage maintenance, and equipment renewal, all BWR utilities are working together to overcome the harsh supply chain environment.

What we would like to know:

- Good practices of prevention & mitigation measures for supply chain and obsolescence management

(Examples: Commercial Grade Dedication, Procurement from overseas, Share of spare parts between utilities, governance by plant vendors, etc.)

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社

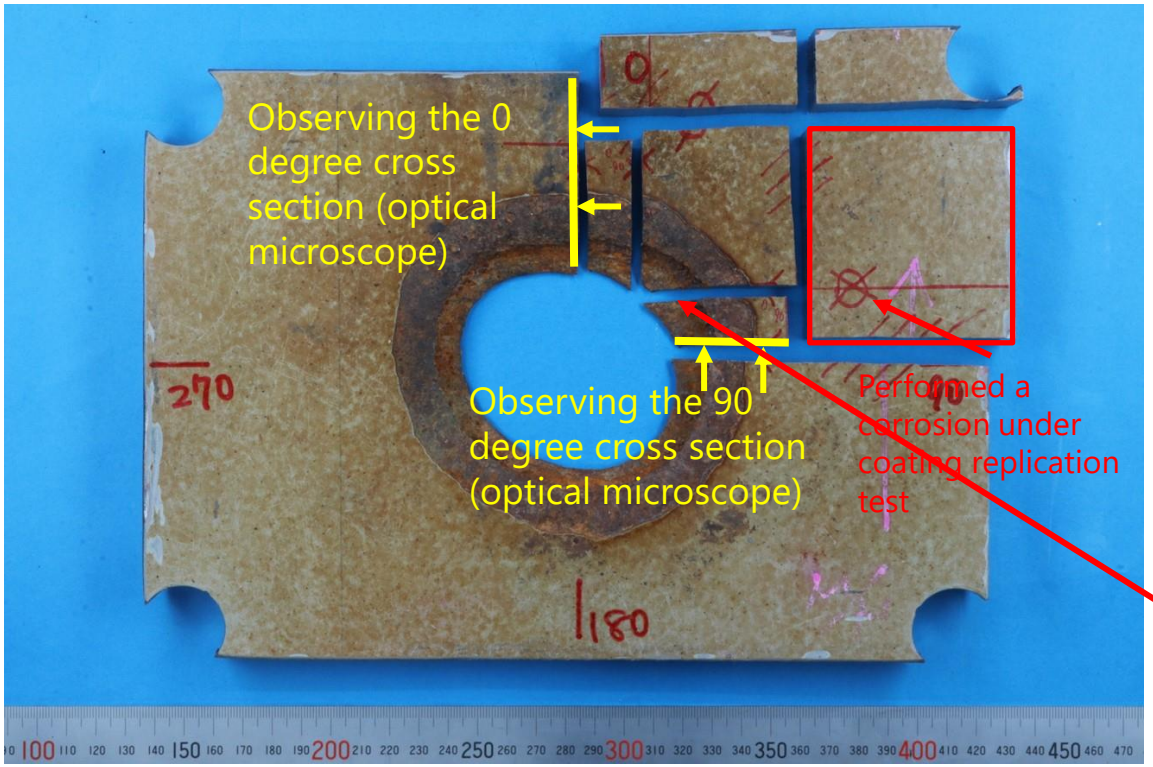
TEPCO

Reference

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社

Severing investigation of the hole

The area of the pipe with the hole was severed and the cause of the hole was analyzed (in a TEPCO laboratory).



- The area with the hole was severed as in the photo
- The cross section was observed with an electronic microscope from 0 to 90 degrees.
- The sample was used in a corrosion-under-coating replication test.

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社

Summary of the outside visual inspection and observation by microscope

- Presumed to be “a hole due to corrosion” from the following.

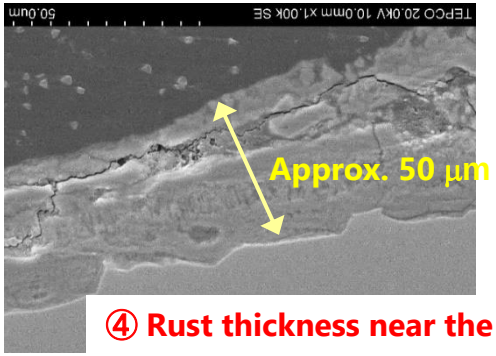
①Random bumps on the inside of the hole ⇒Typical for a dissolving metal surface

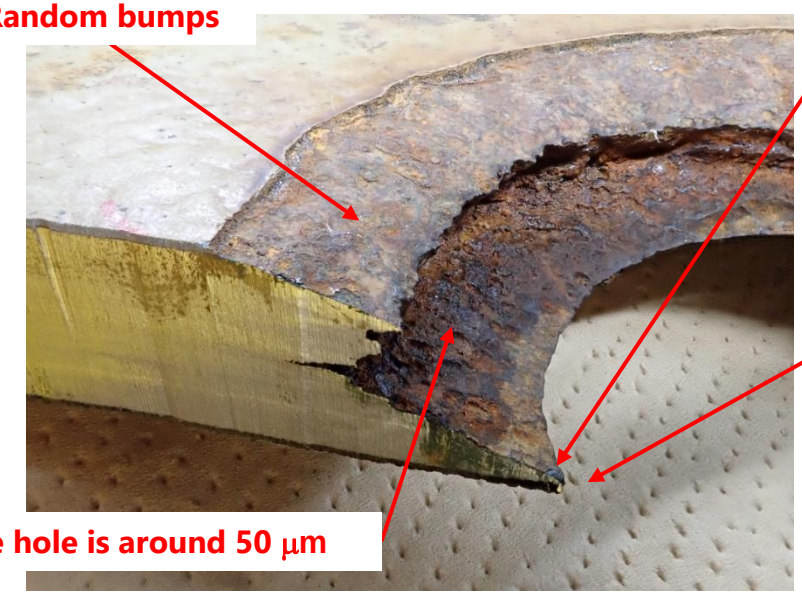
②The edges of the hole are sharp ⇒Typical for a corrosion hole

③Corrosion progressed near the outer coating surrounding the hole ⇒ Indicates that the corrosion might have started a while ago

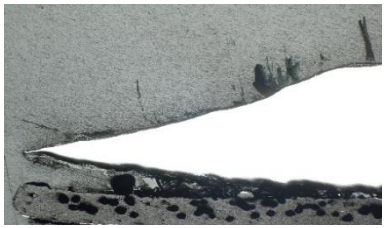
④ The thickness of the rust in the inner side of the hole is around 50 μm ⇒ Does not get this thick in the few days after the hole was found

[Background] The area was very moist during the long-term shutdown which spanned around 10 years

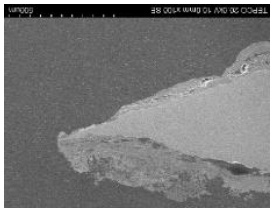




② Edges of the hole are sharp



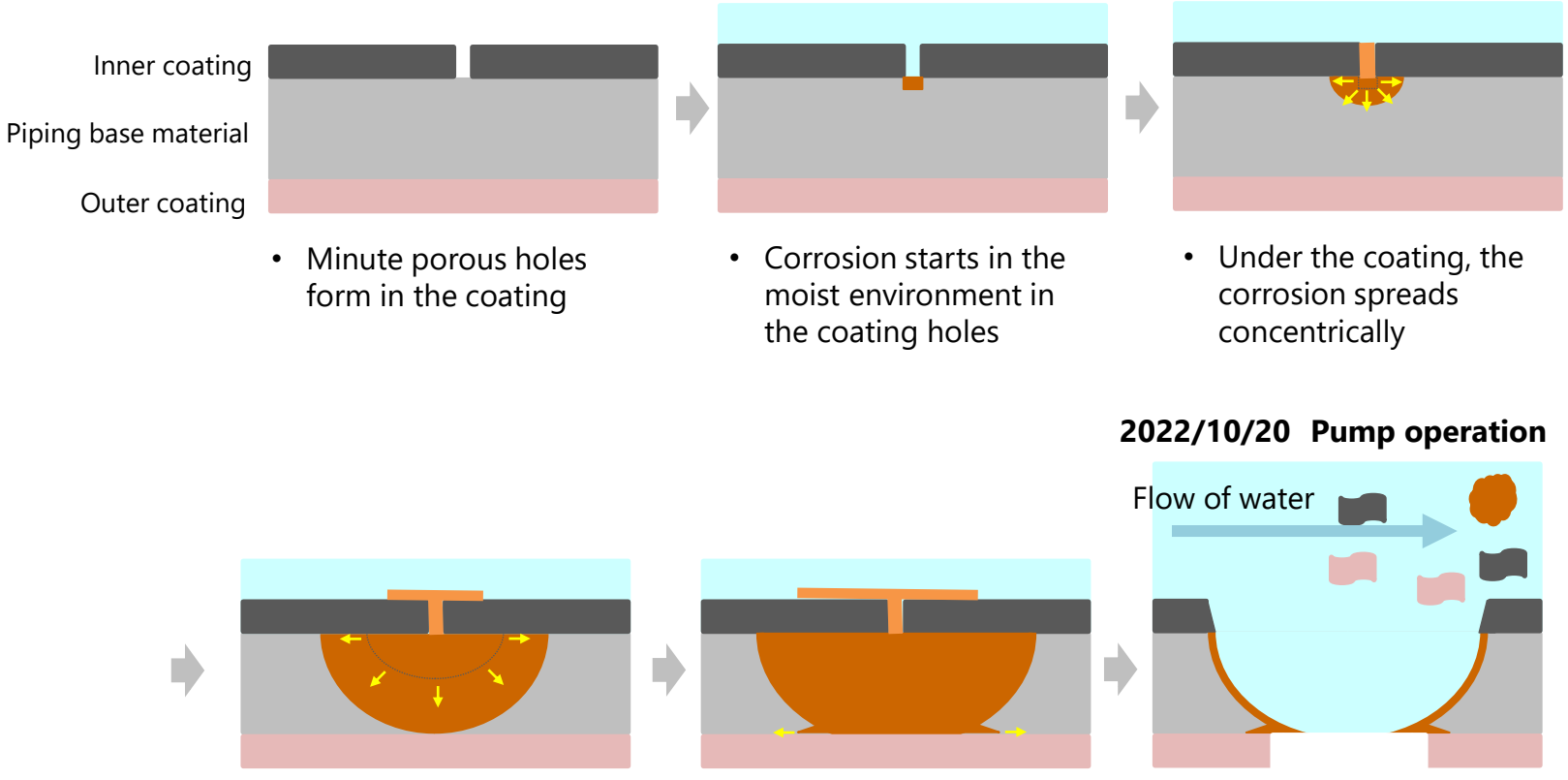
③ Corrosion near the outer coating



©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社

Estimated factors that led to the round hole

- Since the plant had shut down, the area had been very moist. It is presumed that corrosion of the inner surface of the pipes started where there were small porous defects in the coating, which progressed and led to these holes.



- Minute porous holes form in the coating
- Corrosion starts in the moist environment in the coating holes
- Under the coating, the corrosion spreads concentrically
- The corrosion hole reaches the outer coating
- Corrosion progresses and expands under the outer coating
- Flakes of the remaining coating is pulled inward by the negative pressure during the integrity verification operation, and is lost

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved. 無断複製・転載禁止 東京電力ホールディングス株式会社