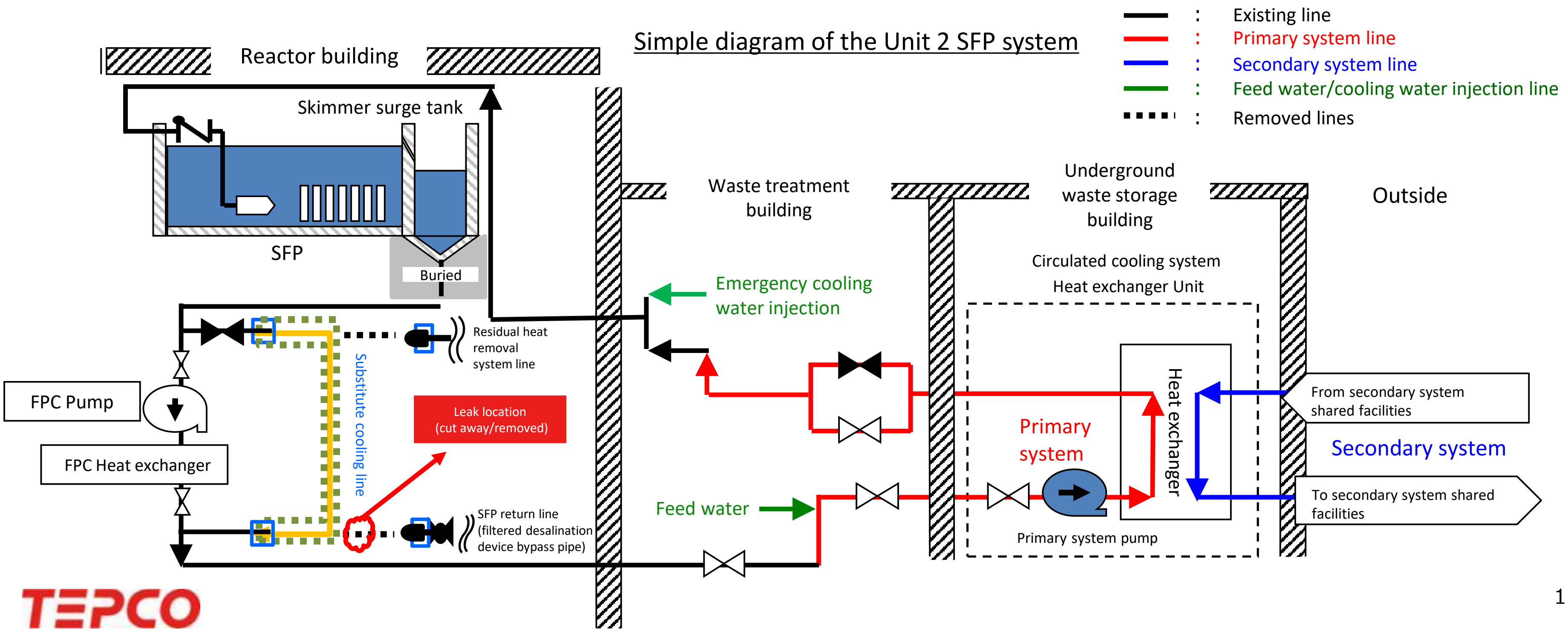
Causes and Countermeasures for the Decrease in Water Level of the Unit 2 SFP Skimmer Surge Tank and Going Forward Measures

November 28, 2024

Tokyo Electric Power Company Holdings, Inc.

1． Overview

- ✓ On August 9, 2024, it was found that the water level in the Unit 2 spent fuel pool (hereinafter referred to as, "SFP") skimmer surge tank had decreased.
- ✓ On October 1, 2024, a leak investigation performed in the FPC pump and FPC heat exchanger room found that there was a leak coming from one of the pipes branching from the pipes used for coolant circulation.
- ✓ On November 14, 2024, the leaking pipes were removed/sealed, and the configuration of a substitute cooling line (installation of pump/heat exchanger bypass line), which is one of the countermeasures for reducing leak risks, was completed.
- ✓ Now that an investigation into the cause of the leak and investigations/repairs of other similar locations (welds of dissimilar metal) have been completed, it was confirmed through leak checks and system flushing that there are no problems with equipment, so SFP circulated cooling was recommenced on November 25, 2024. There have been no problems since the recommencement of operation, and we have confirmed that SFP water levels are close to the overflow levels and that SFP water temperature is dropping. (31.2°C (actual measurement) as of 11AM on November 27).
- ✓ In order to further reduce the risk of leaks, going forward a cooling unit will be installed on the operating floor and the west side work platform, and we will deliberate the construction of a circulated cooling system that uses the SFP for intake.



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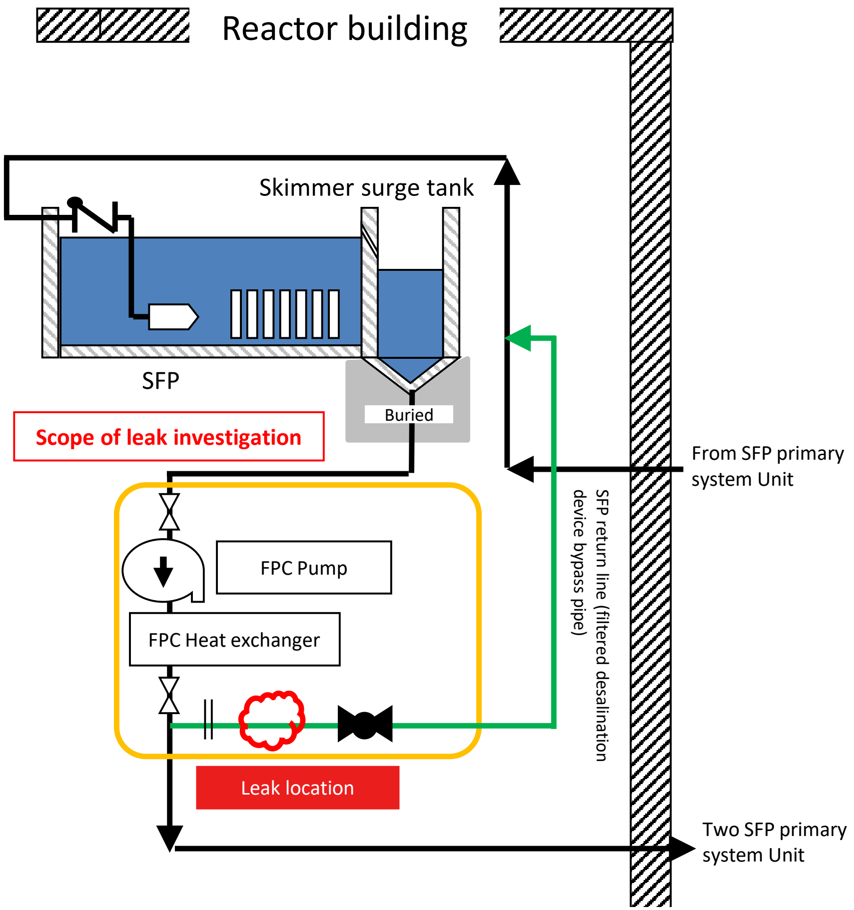
2. Leak investigation results

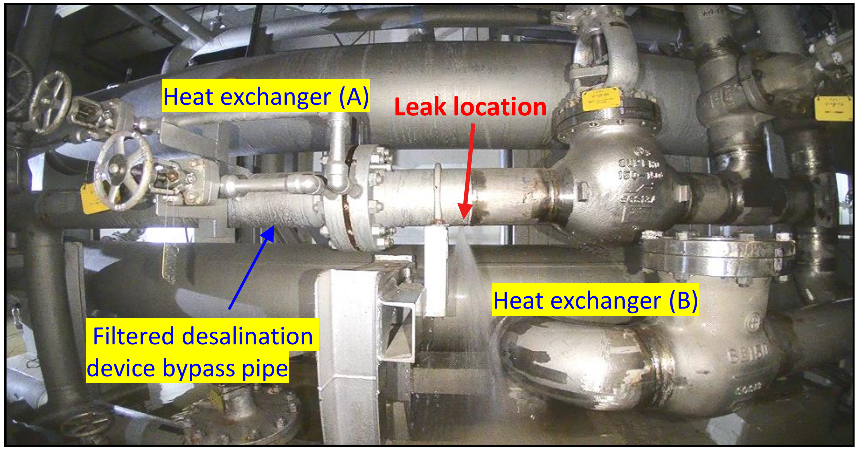
- One leak was found from the line returning directly to the SFP from the FPC heat exchanger (filtered desalination device bypass pipe ※)

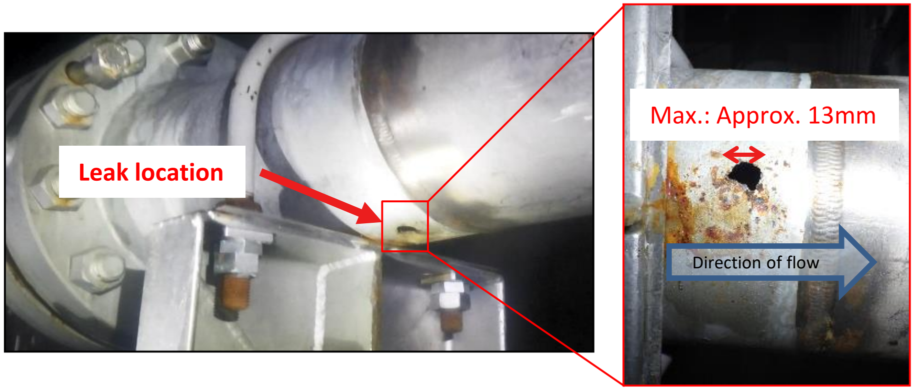
※ Line that bypasses the existing FPC system filtered desalination device. It was used during inspection of the filtered desalination device but is not being used now. The filtered desalination device purifies and desalinates system water using filters and resin



Simplified diagram of Unit 2 SFP system (leak location)

The location (for FPC heat exchanger room)





	Specifications of pipe at leak location
Pipe material	Carbon steel used for pressurized pipes（STPG370）
Pipe diameter	150A
Pipe thickness (nominal)	7.1mm

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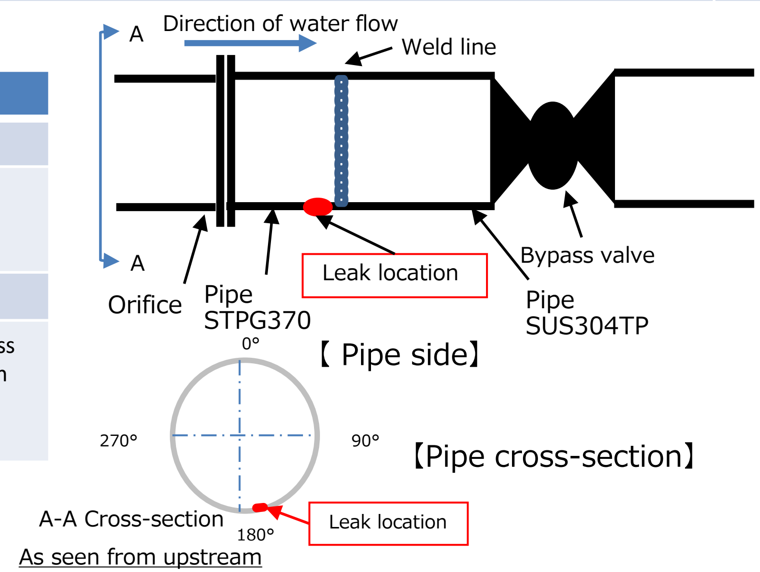
3. Cause investigation

- Cause investigation
  - ✓ The following investigations of the leaking pipe and upstream pipes from where the leak was found were implemented in order to ascertain the cause.

	Investigation details	Results	Page
①	Internal investigation using fiber scope	Deposits found inside	-
②	Checking the external inspection around the leak location	No significant corrosion found on the outside	P4
③	Sampling the outside surface of piping to check for chloride, etc.	Minuscule amounts of chloride detected	P5
④	Examination of the status of deposits found inside the pipes and elemental analysis	Reddish-brown deposits were found in the vicinity of the leak and the area underneath the deposit was found to be hollow Reddish-brown deposits were found on the surface of upstream pipes and soil-like (gray in color) deposits were found underneath As a result of the elemental analysis, it was assumed primarily iron oxide	P6 P7 P8
⑤	Pipe thickness measurements, including leak location	Hundred 180° thinning on the carbon steel side was found to be relatively large	P9
⑥	Examination of the surface of the pipes including the leak location	Extensive thinning found near the leak location The entire inside surface of the carbon steel pipe was found to be corroded (some uneven corrosion in places)	P10 P11
⑦	Investigation of similar dissimilar metal welds	Corrosion was found on the surface of pipes at three out of 11 locations (two locations could not be examined)	P12

Details about the leak location

	Leak location conditions
Dimensions of leak hole	Max: Approximately13mm
Location of leak hole	Underneath the pipe (directly underneath and extending for a width of approximately 10mm in the circumferential direction) Stretches for approximately 18mm in the axial direction from the weld
Inside the pipe	Deposits found inside the pipes
Pipe configuration	• The material used from the weld line to the motorized valve side is stainless steel for pipes (SUS304TP), and the dissimilar metal joint consists of carbon steel (STPG370) and stainless steel • A flow adjustment orifice is installed on the heat exchanger side



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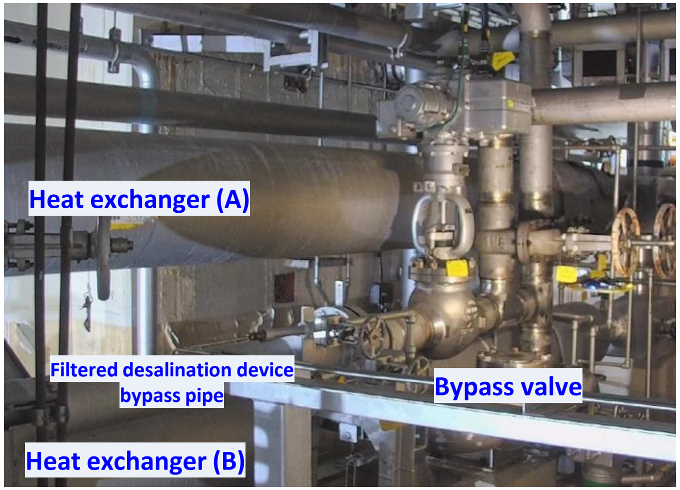
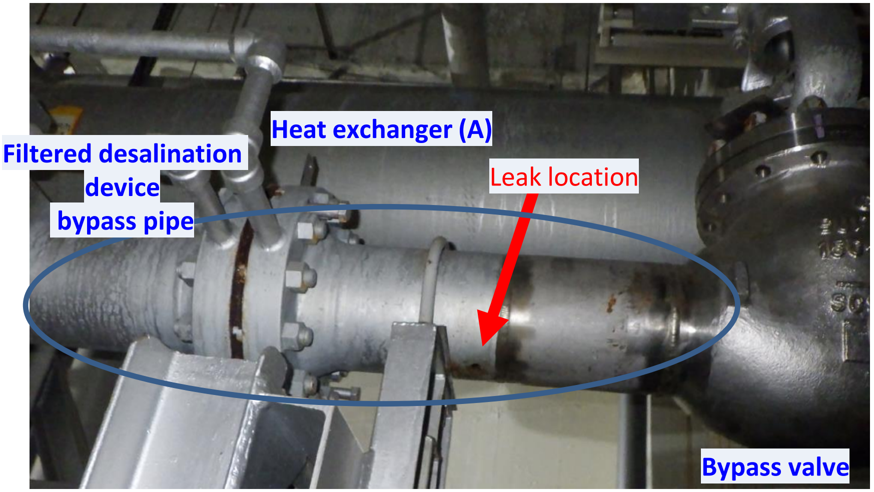
4． External investigation around leak location <Investigation item ②>

- ✓ The outside surface of the pipe was examined using drone cameras as well as via direct inspection by personnel.
- ✓ Discoloration thought to be rust was found around the hole causing the leak, but no significant corrosion was found on the outer surface of the pipe of the same line.

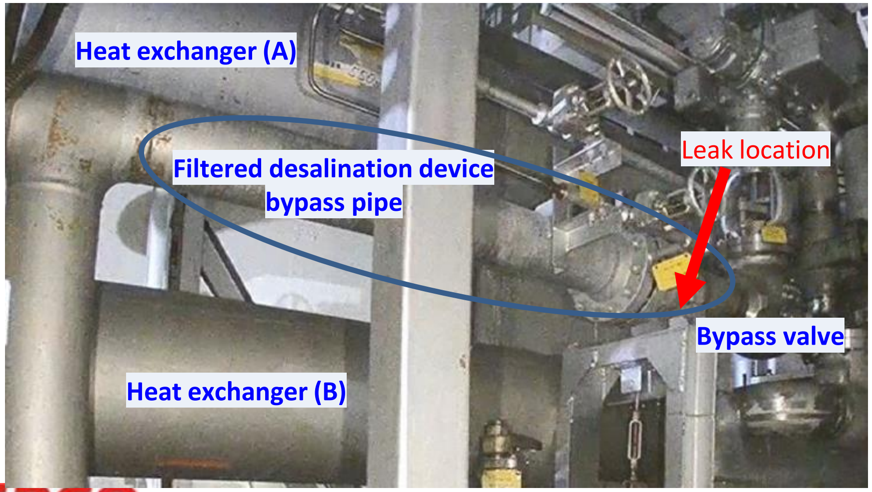
FPC Heat exchanger room



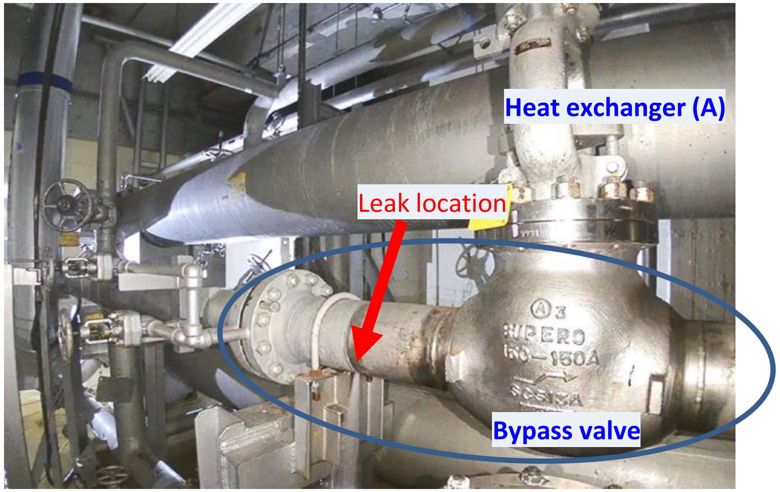
Area around the leak location



From bypass pipe side

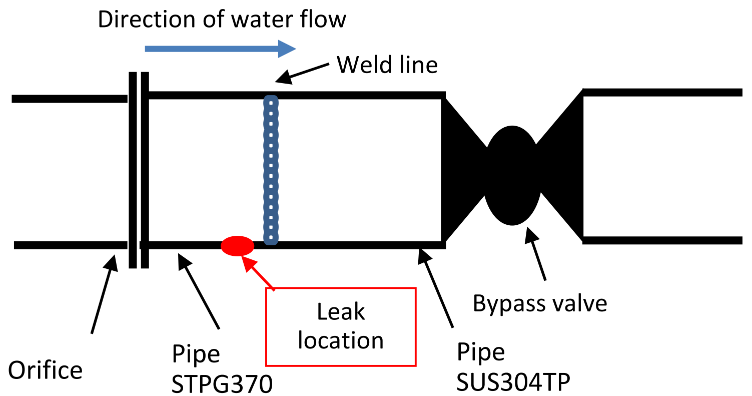


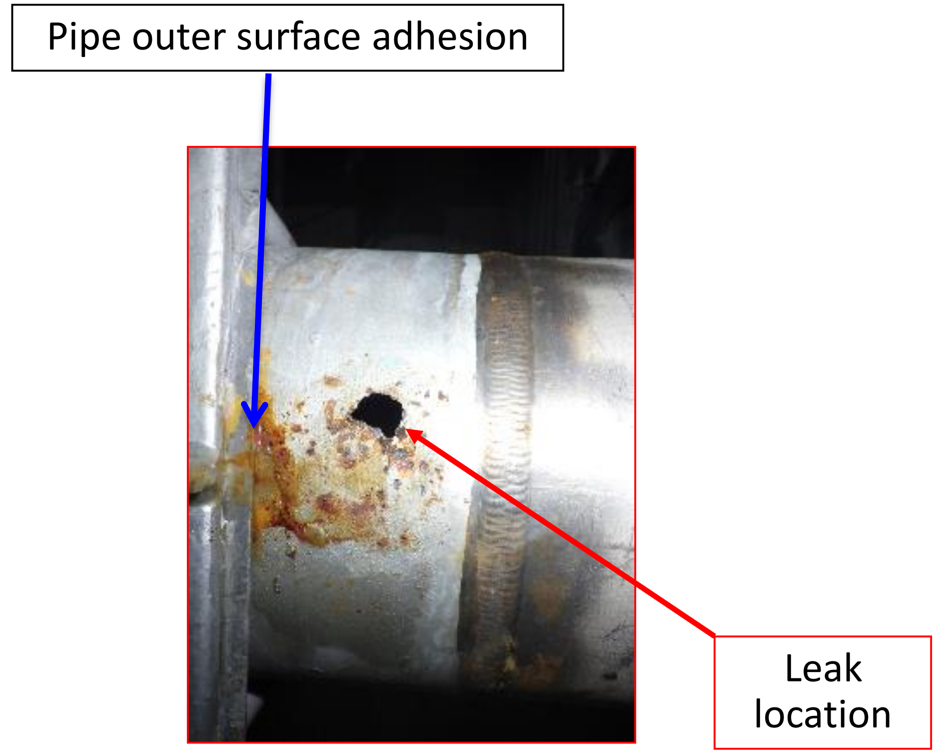
From bypass valve side



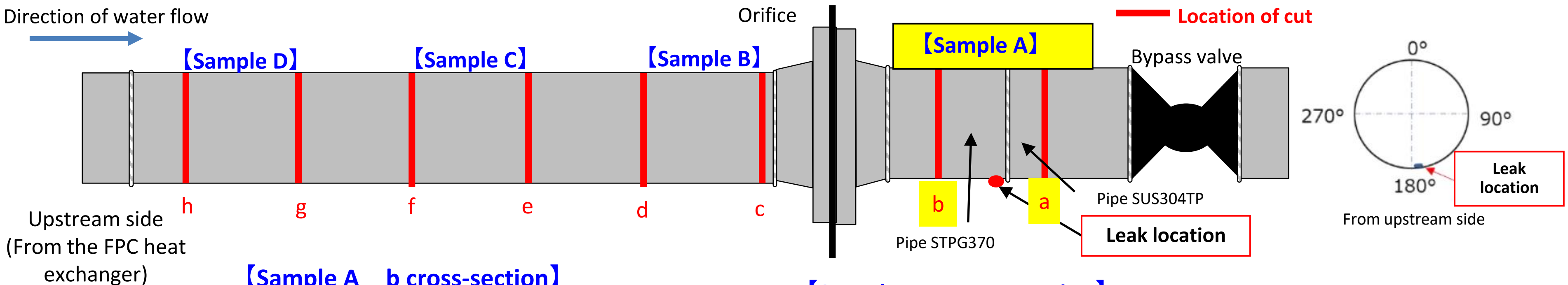
5． Searching for chloride on the outside surface of the pipe ＜Investigation item ③＞

- ✓ Adhesions on the outside of the pipe near the leak location were sampled and subjected to SEM－EDX analysis (elemental analysis).
- ✓ As a result of the elemental analysis, 0.6% chloride was detected.
- ✓ It is assumed that system water leaking from the leak location caused chloride to adhere to the outer surface of the pipe.





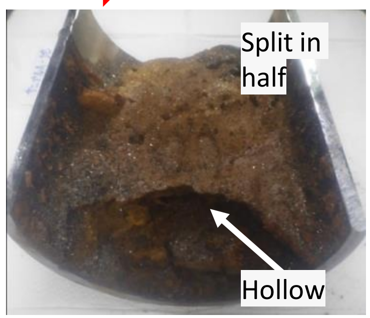
6-1. . Examining deposits inside the pipe <Investigation item ④>



【Sample A b cross-section】

Direction of photo

【Front】



Collapsed deposits removed

【Sky-side 0°】

【Ground-side 180°】

【Sample A a cross-section】

Direction of photo

【Front】

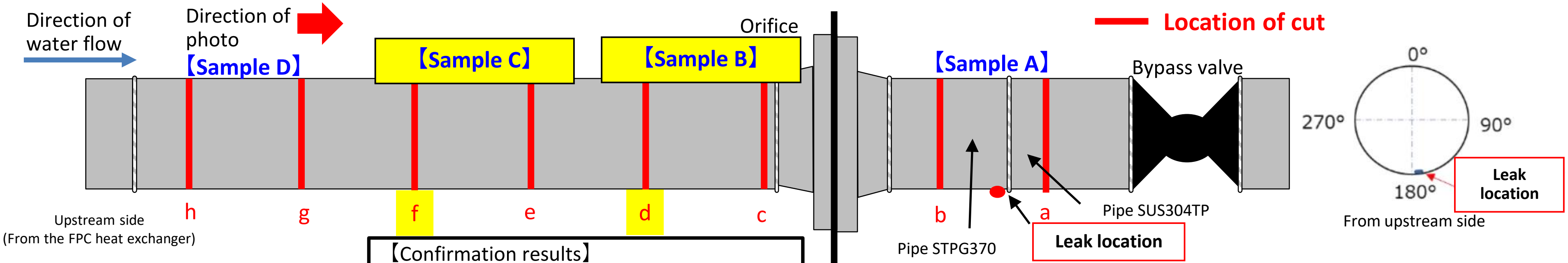
【Confirmation results】
Reddish-brown adhesions were observed along the entire circumference of the inner surface of the carbon steel, and some clump-like adhesions were seen on the sky-side. There were bridge-like deposits on the ground-side, and the area below it was hollow. There were deposits on the ground-side on the stainless steel pipe side, and the area below it was hollow, but no deposits were found on the sky-side side.

(red circle): The green material above the deposits is iron powder generated during the cutting process (the same applies for the cut cross-sections)

【Sky-side 0° s】

【Ground-side 180°】

6 − 2． Examining deposits inside the pipe <Investigation item ④>

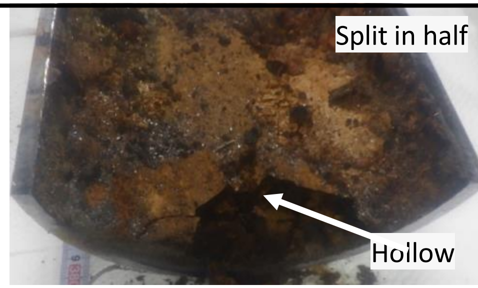


【Sample C f cross-section】

Direction of photo

【Front】

【Confirmation results】
Reddish-brown adhesions were observed along the entire circumference of the inner surface, and some clump-like adhesions were seen on the sky-side. There were bridge-like deposits on the ground-side, and soil-like (gray) deposits were found below them. This area below was hollow.



【Sky-side 0°】

【Ground-side 180°】

【Sample B cross-section】

Direction of photo

【Front】

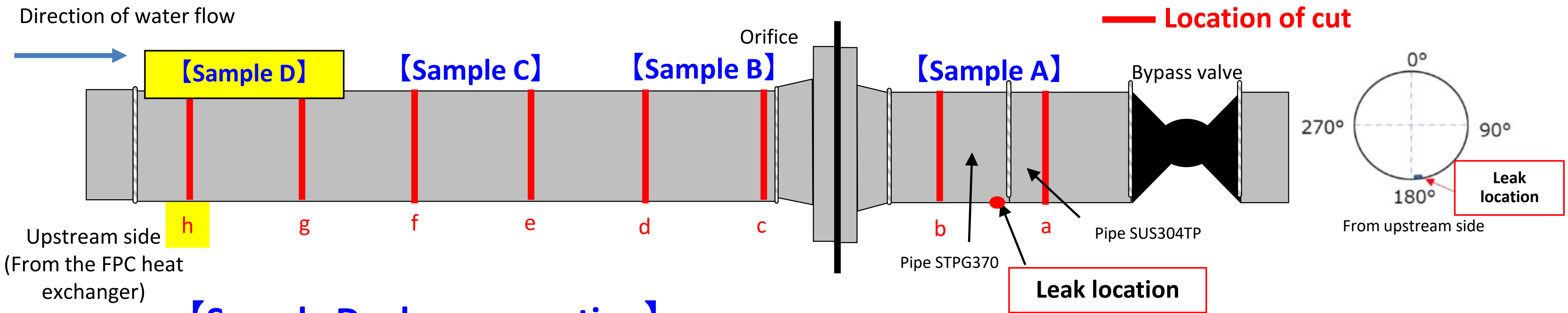
【Confirmation results】
Reddish-brown adhesions were observed along the entire circumference of the inner surface, and some clump-like adhesions were seen on the sky-side. There were bridge-like deposits on the ground-side, and soil-like (gray) deposits were found below them. This area below was hollow.

(red circle) ： The green material above the deposits is iron powder generated during the cutting process (the same applies for the cut cross-sections)

【Sky-side 0°】

【Ground-side 180°】

6－3．Examining deposits inside the pipe <Investigation item ④>



【Sample D h cross-section】

Direction of photo

【Front】

【Sky-side 0°】

【Ground-side 180°】

【Confirmation results】
Reddish-brown adhesions were observed along the entire circumference of the inner surface, and some clump-like adhesions were seen on the sky-side. There were deposits on the ground-side (surface is reddish-brown, with gray deposits underneath)

SEM-EDX analysis results of deposits found inside the pipe

An element analysis (SEM-EDX※, ion chromatograph analysis device) was conducted on the deposits found inside the pipe (specimens Samples A~D)

※Energy dispersive x-ray spectroscopy

- Deposits inside the pipe consist primarily of iron oxide with Fe: Approx. 61～87%, O: Approx. 7～29%, C: Approx. 2～5%
- Impurities were detected from the deposits inside the pipe （Cl^-, SO_4^{2-}, NO_3^-, Na^+, Mg^{2+}, Ca^{2+}など）

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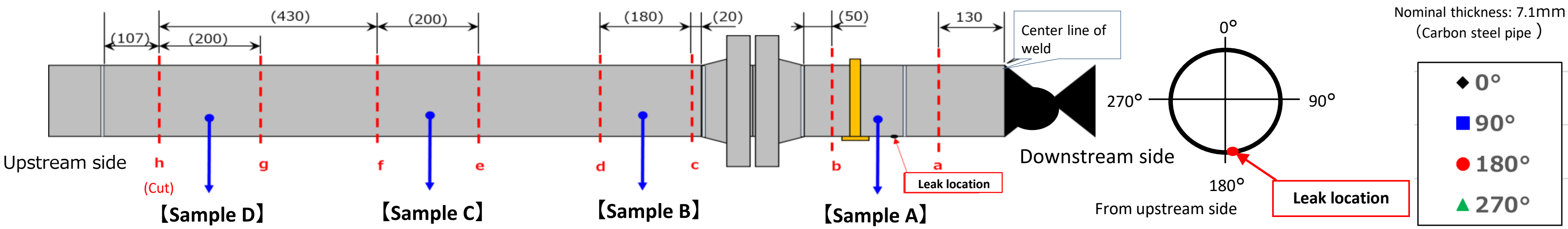
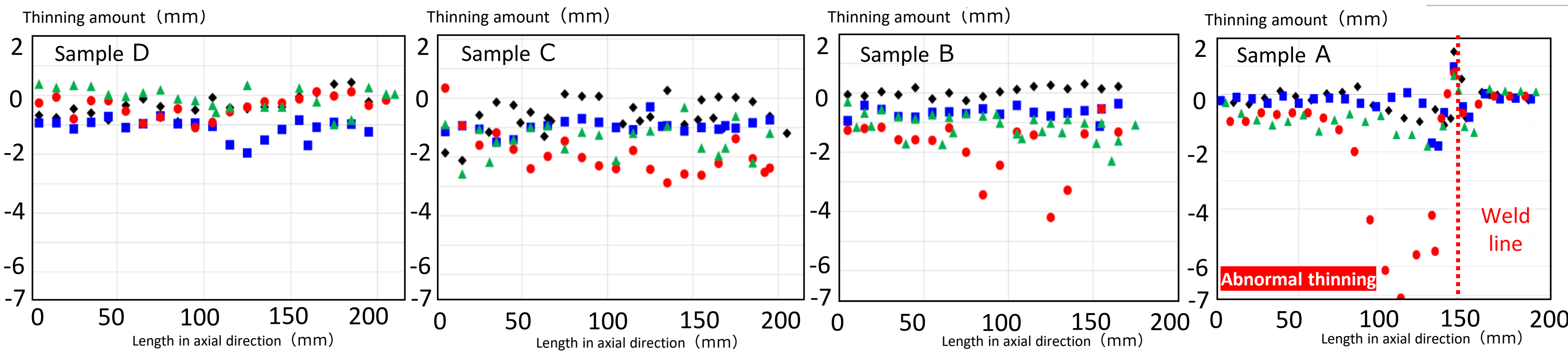
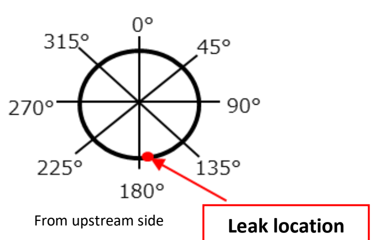
7． Pipe thickness measurement results＜Investigation item ⑤＞

- ✓ Sample A：Thinning on the sky-side 0° and 90° was minimal, but other thinning was observed. The amount of thinning on the ground-side 180° was relatively large, and an abnormally large amount of thinning was found on the carbon steel side approximately 100mm from the weld line. No significant thinning of the stainless steel pipe was observed.
- ✓ Sample B：Thinning on the sky-side 0° was minimal, but other thinning was observed. The amount of thinning on the ground-side 180° was relatively large, and fairly uniform.
- ✓ Sample C：Thinning on the sky-side 0° was minimal, but other thinning was observed. The amount of thinning on the ground-side 180° was relatively large
- ✓ Sample D：Thinning was observed around the entire circumference, and there was little non-uniformity in each direction.

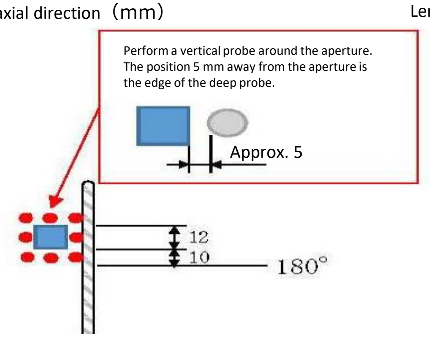






1.9	2.2	1.5
1.8	aperture	2.0
1.9	1.2	2.4

Units（mm）



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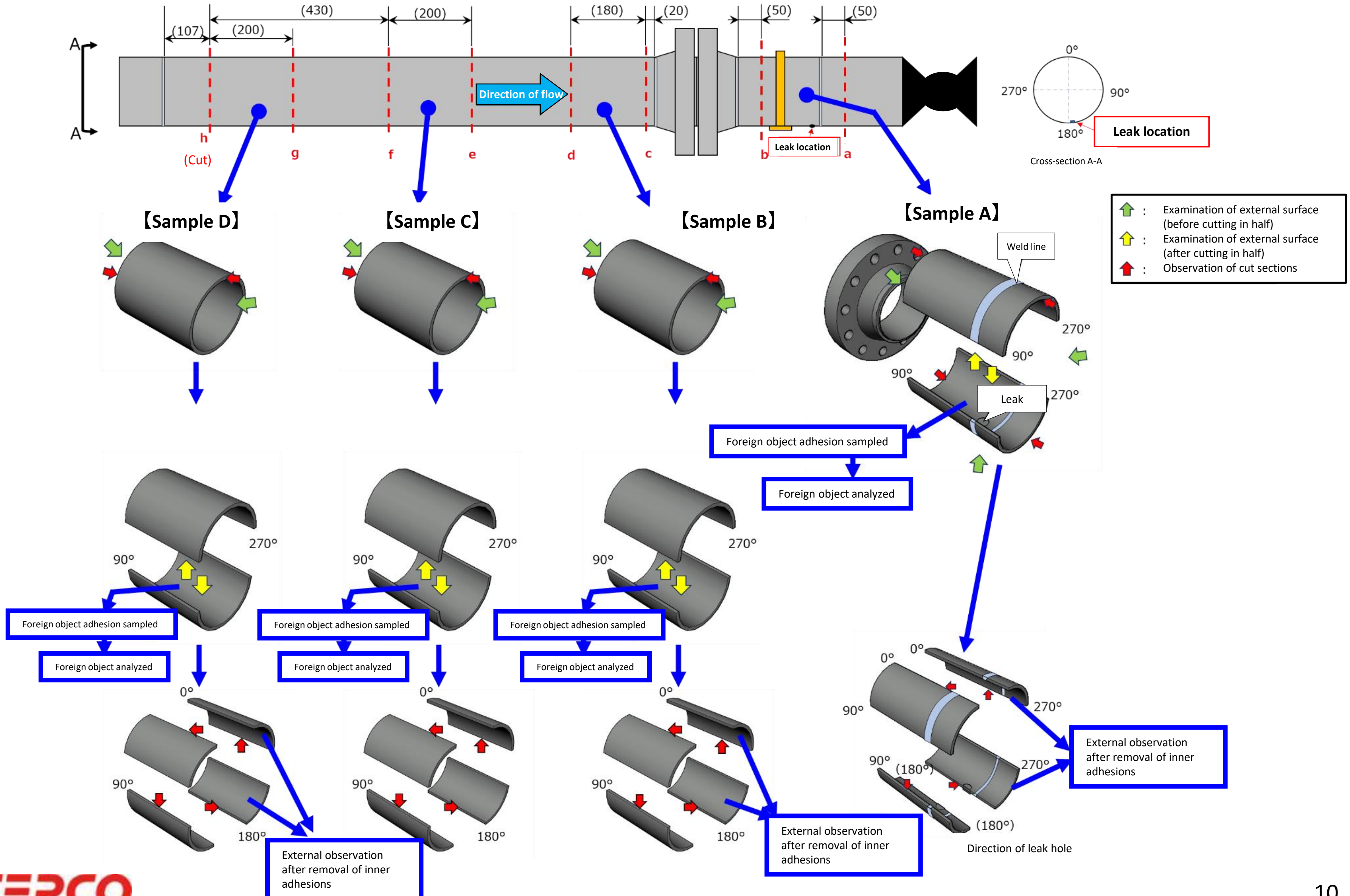
8-1. Inner pipe surface investigation ＜Investigation item ⑥＞

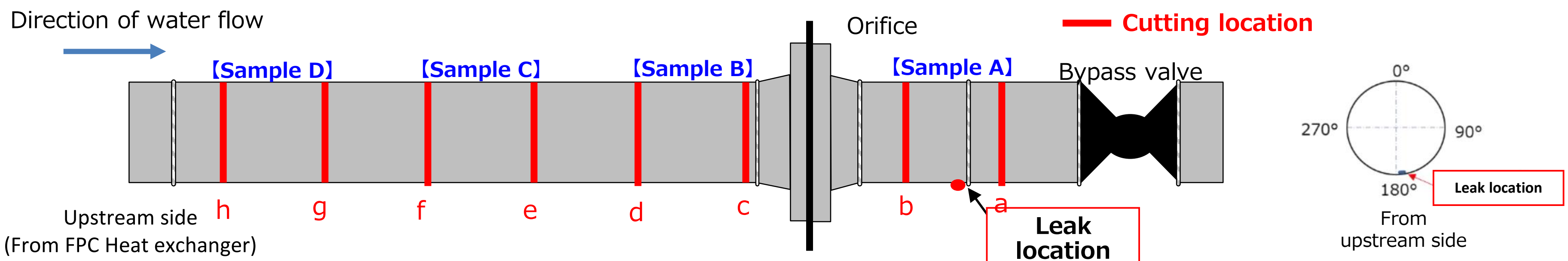
✓ In order to examine the inner surface of the pipes, Samples A~D were cut on the lines shown below after which they were split into four sections along the axis of the pipe.

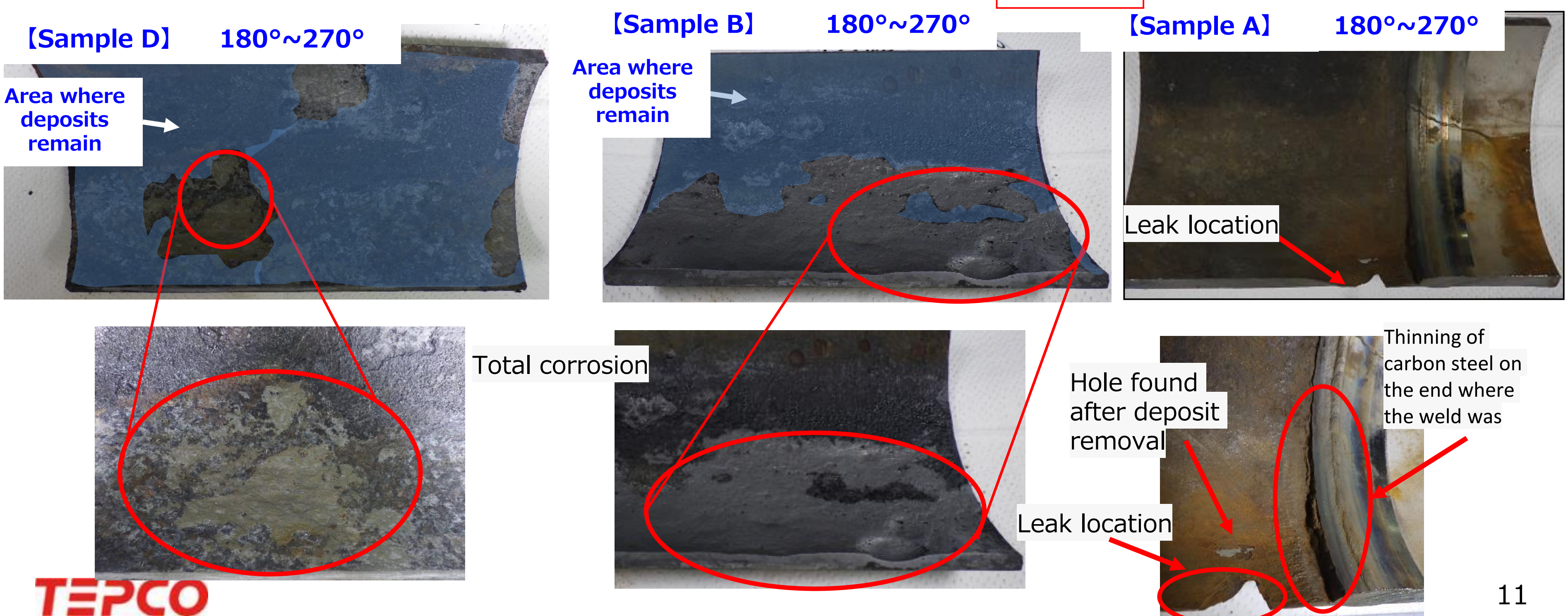


8－2． Internal pipe surface investigation <Investigation item ⑥>

- ✓ The internal surface of the pipe was observed after removing the deposits.
- ✓ The internal surface of pipe samples A, B, D confirmed corrosion throughout.

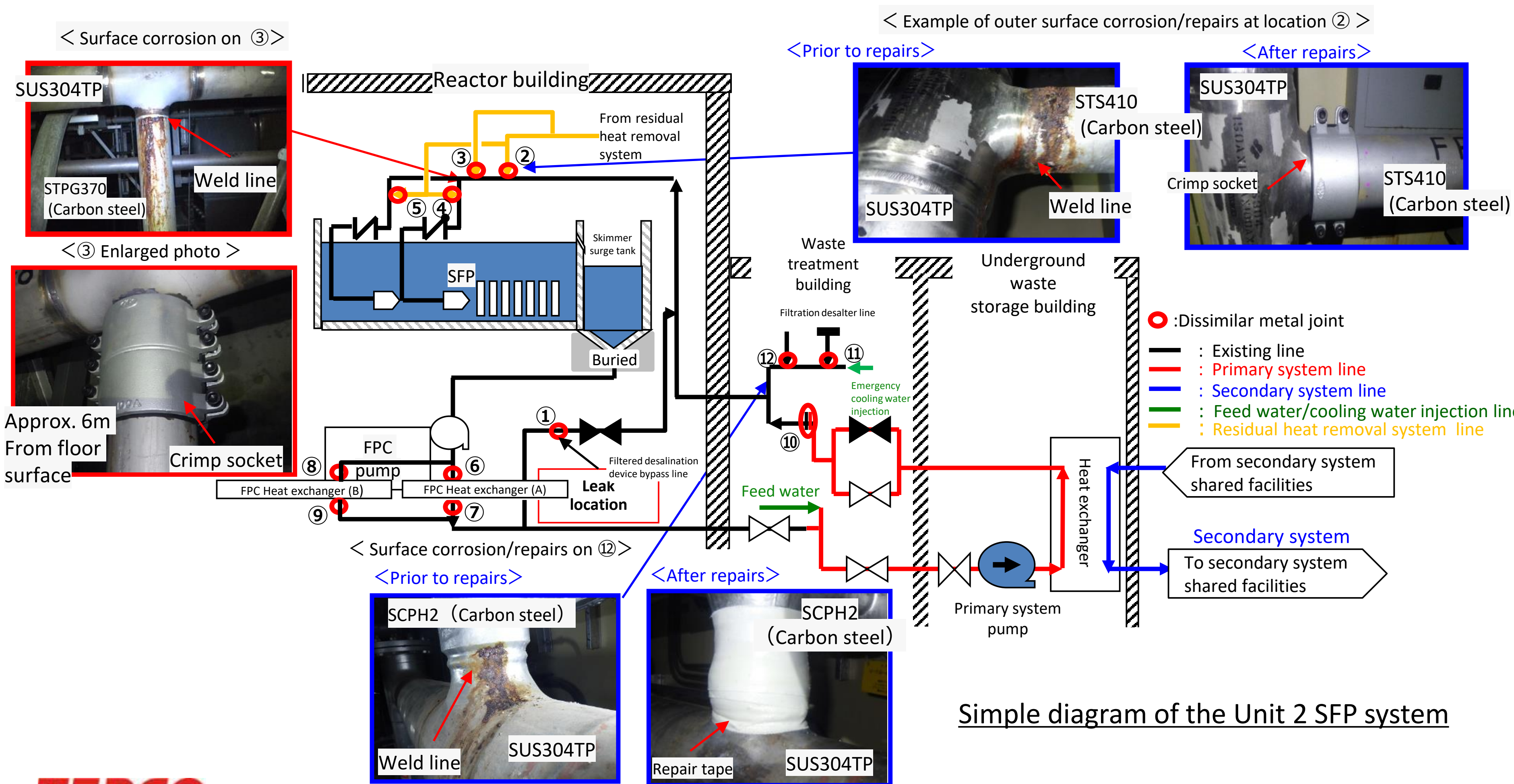
【Sample A】 Abnormally large thinning was confirmed approximately 100mm from the weld line on the 180° side
【Sample B】 Thinning on the 180° side was uniform with localized deeper thinning
【Sample D】 Corrosion confirmed throughout





9． Results of investigation of similar pipes and corrosion repairs <Investigation item ⑦>

- ✓ Including the leak location, 12 joints similar to the pipe where the leak was found (dissimilar metal welds) were confirmed
- ✓ Corrosive elements were found adhered to the outer surface of welds ②, ③, and ⑫ so repairs were made.
- ✓ Since welds ④ and ⑤ are buried in the concrete of the operating floor, the state of corrosion of the outer surface of the pipes could not be observed.
  (Skimmer surge tank water level monitoring and stagnant water level monitoring will be employed to determine if there is a leak since the leaking water would flow through the floor funnel into the stagnant water in the building)
- ✓ A visual inspection of the outside of the pipes and thickness measurements were conducted for welds ⑥～⑪ and no significant thinning was found.



Simple diagram of the Unit 2 SFP system

10. Cause analysis

✓ The following chart shows the results of cause analysis of the leak after examining the position of the leak location, the shape of the hole, the environment in the heat exchanger room, pipe configuration, and system usage status.

	Condition	Assumed cause	Possible phenomena	Investigation item	Investigation results	Assessment
Field environment	Since the air-conditioning system is shut down, signs of condensation were found on the walls and pipes, etc., assumedly caused by the humid environment	Surface corrosion caused by condensation	• The outer surface may corrode as condensation drips onto the pipes	②Examination of outer surface around the leak location ③Samples taken from the outer surface of the pipe to check for chloride	No significant corrosion was found in areas other than around the leak hole. Chloride was detected on the outer surface around the hole but in very small amounts.	×
Type configuration and system usage status	Seawater was injected into the SFP during the disaster as cooling water	Uniform corrosion (corrosion along the entire surface)	• Uniform corrosion may have occursince the pipes contained water with seawater elements	①Internal investigation using a fiber scope ⑤Thickness measurements ⑥Inner pipe surface investigation including leak location	Corrosion found along the entire inner surface of the bypass pipe Abnormally large thinning found in the vicinity of the dissimilar metal weld (around the leak location)	○
	Stagnant system water exists					
	The leak was located on the carbon steel side of a STPG370(Carbon steel) and SUS304TP(Stainless steel) dissimilar metal weld	Dissimilar metal contact corrosion (galvanic corrosion)	• It is possible that localized acceleration of corrosion on the carbon steel side of the weld ensues due to contact with stainless steel and the increased conductivity of the water contained within			
	Installation of orifice on the upstream side of the leak location	The flow of water promoted corrosion on the inside of the pipe (FAC: flow-accelerated corrosion)	• It is possible that pipe thinning occurs on the downstream side of the orifice	①Internal investigation using a fiber scope ⑤Thickness measurements ⑥Inner pipe surface investigation including leak location	No scaly thinning was seen due to the existence of the orifice (no water has passed through the pipe since the disaster)	×
	Deposits found inside the pipe	Corrosion accelerated due to deposits (Concentration cell corrosion)	• It is possible that corrosion under the deposits accelerates due to the formation of concentration cell corrosion under and around the deposits	①Internal investigation using a fiber scope ④Confirming the status of accumulation of deposits found inside the pipes and perform elemental analysis	Deposits found on the ground-side throughout the entire pipe system. However, no substantial thinning like that resulting in the leak hole was found anywhere else, and it is assumed that deposits were not the primary cause of the corrosion-induced hole since it was only found in the vicinity of a dissimilar metal weld	△ (Not primary cause, however)

11. Assumed causes

✓ Investigation conclusions

The conclusions of the investigation are as follows:

① **Corrosion was confirmed along the entire inner surface of the aforementioned pipe**, which includes the leak (**system water was stagnant**)

② An abundance of deposits were found on the ground-side inside the pipe. An analysis revealed them to the iron oxide (iron rust)

③ **Impurities were detected from the deposits on the inside of the pipe** （Cl^-, SO_4^{2-}, NO_3^-, Na^+, Mg^{2+}, Ca^{2+} etc,）

④ The location of the leak is on the carbon steel side of a dissimilar metal weld joining carbon steel to stay in the steel. **Abnormally deep thinning was found approximately 100mm from the weld line** and in some instances had completely penetrated the pipe. Post-disaster average corrosion speed was found to exceed 0.5mm/year.

✓ Corrosive attributes of carbon steel

The general corrosive attributes are as follows:

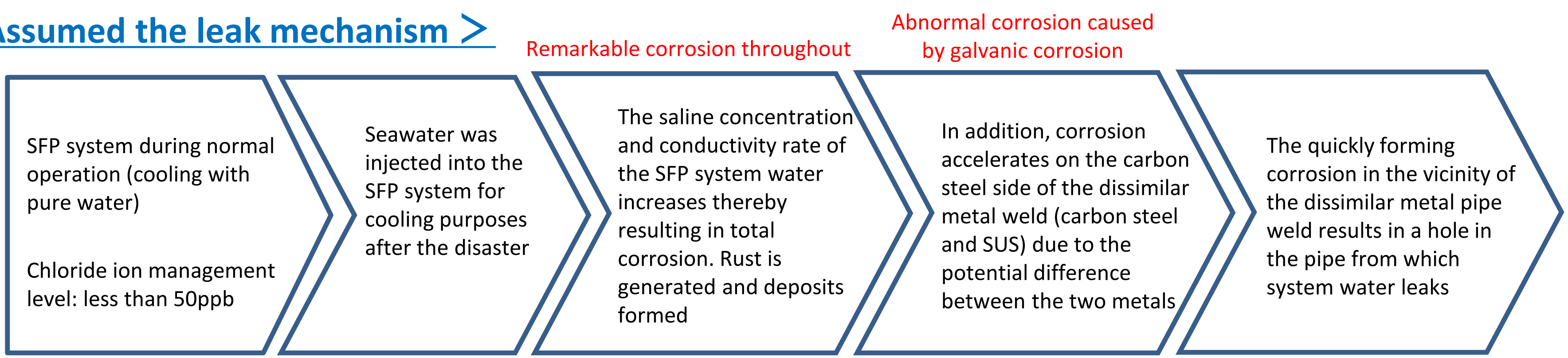
① **Almost no corrosion when exposed to pure water.** *1

② However, **total corrosion will occur when exposed to water that contains impurities**. The speed of total corrosion is approximately 0.1mm/year in a freshwater/saltwater environment at room temperature.

③ **Total corrosion speed in the vicinity of a dissimilar metal weld is accelerated several times~several tens of times depending on the conductivity rate, etc.** *2 （Galvanic corrosion）

In consideration of the results mentioned above, it is assumed that galvanic corrosion occurred on the carbon steel pipe in the vicinity of the dissimilar metal weld with SUS since circulated cooling water that included impurities had been stagnant inside the aforementioned pipe due to the injection of seawater as cooling water immediately following the accident, thereby resulting in the leak.

＜ Assumed the leak mechanism ＞



*1) Pure water is an insulator and does not cause corrosion (no electrochemical reaction)

*2) The rate of acceleration of corrosion depends on conductivity rate, the area ratio of the dissimilar kuwa materials, and the potential difference of the dissimilar metals

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✓ Assumed main causes of damage

The causes of damage and points estimated in the previous page are as follows.

① Since seawater, etc. injected after the disaster, the system water in the Unit 2 SFP contained impurities and had increased conductivity (the pure water environment in which carbon steel does not corrode was destroyed).

② The system contains dissimilar metal weld (carbon steel/SUS), which are susceptible to accelerated corrosion caused by galvanic corrosion when exposed to water with high conductivity rates

③ At the leak location, system water with a high conductivity rate resulting from the injection of seawater as coolant water remained stagnant thereby making it easier for galvanic corrosion to form compared to locations where water was flowing.

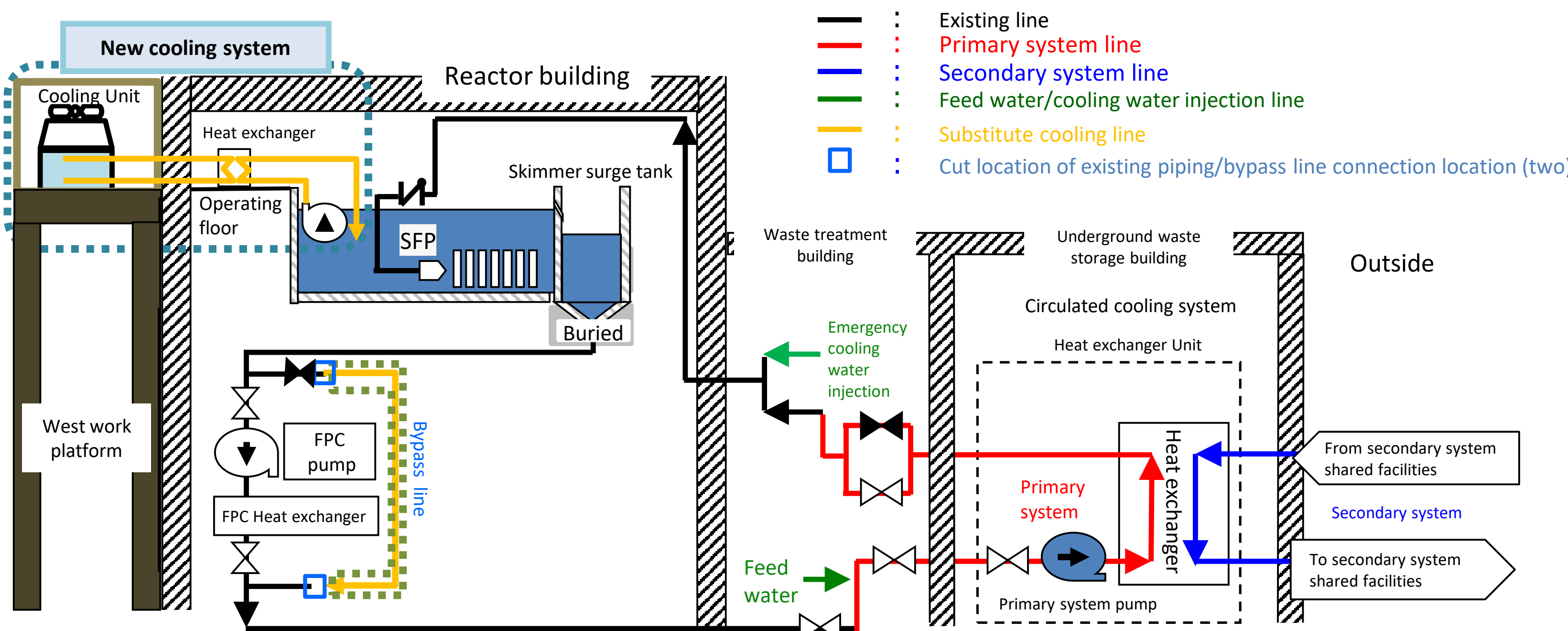
12. Countermeasures and going forward

＜Countermeasures＞

- ✓ Pipes where leaks were found have been removed/sealed.
- ✓ A substitute cooling line（FPC pump/Heat exchanger bypass line) has been configured.
- ✓ The adhesion of corrosive materials was found on the outer surface of three other similar welds (dissimilar metal welds) and repairs have been made.
- ✓ A leak check was conducted utilizing the operating pressure of the substitute cooling line, and it was confirmed that there are no abnormalities.

＜Going forward＞

- ✓ SFP circulated cooling will be recommenced using the existing lines after flushing the existing and primary system lines. (The substitute cooling line will be used as a backup line)
- ✓ Skimmer surge tank water level monitoring and stagnant water level monitoring will be employed to determine if there is a leak from similar locations (dissimilar metal welds) that cannot be checked since the leaking water would flow through the floor funnel into the stagnant water in the building.
- ✓ We will deliberate the construction of a circulated cooling system that takes in water from the SFP on the operating floor and west side platform since a substitute cooling line would restrict the scope of leak risks.
- ✓ As part of information sharing, an investigation of similar locations at Unit 1, where fuel still remains inside the SFP, will be conducted in consideration of the assumed main causes of damage.



Unit 2 SFP system diagram (substitute cooling system proposal)

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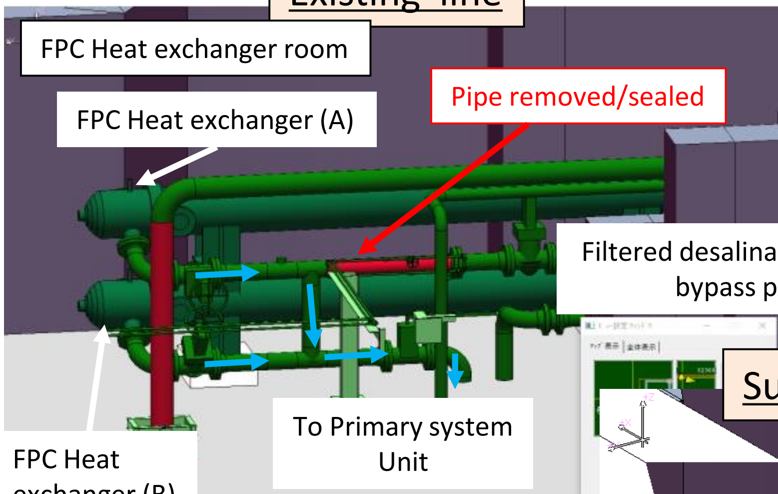
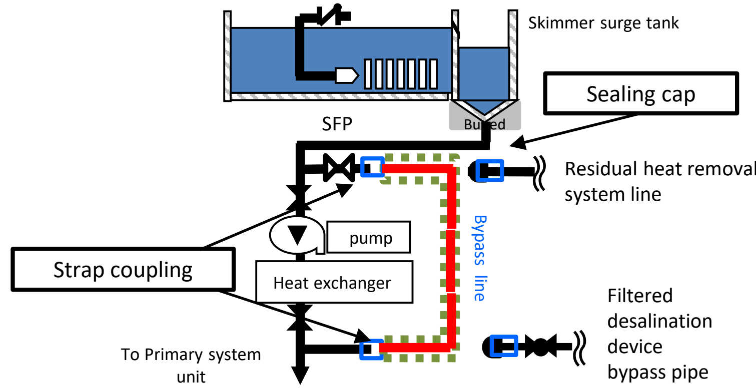
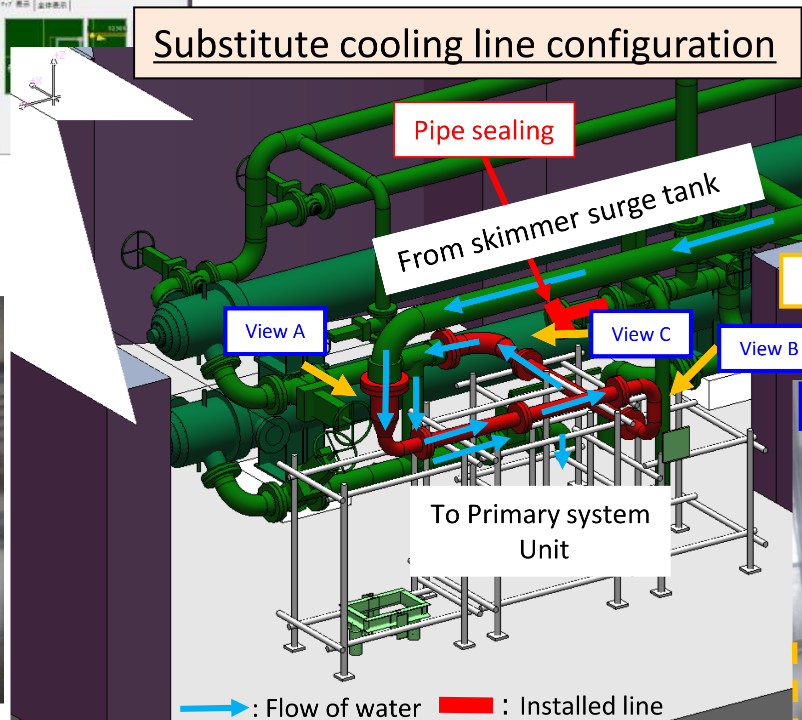
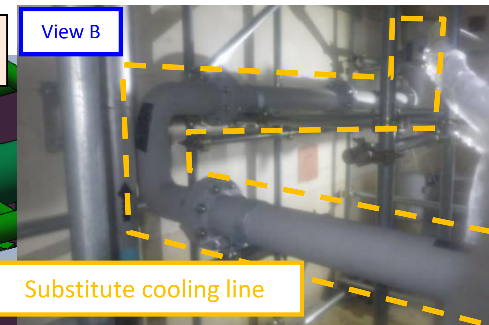
＜Supplement＞ Sealed the leak location and installation a substitute cooling line

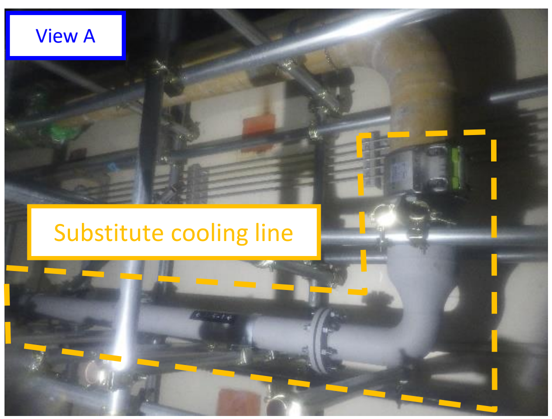
- ✓ Substitute cooling line connection has been completed. (Newly installed pipe spools: Six spools)
- ✓ The pipe at the leak location has been cut away and removes, and the pipe has been sealed.

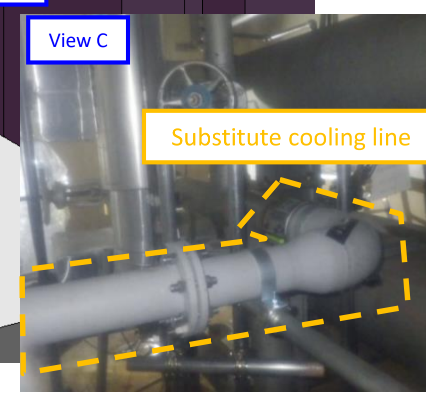




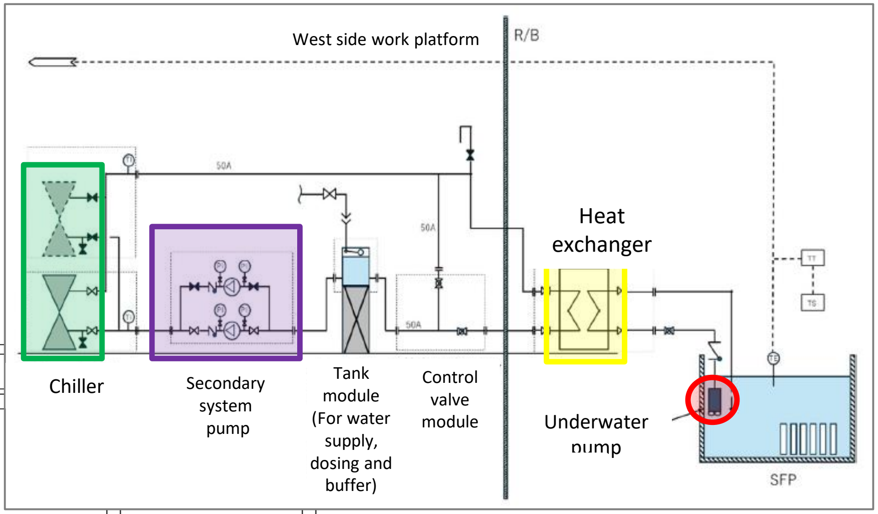


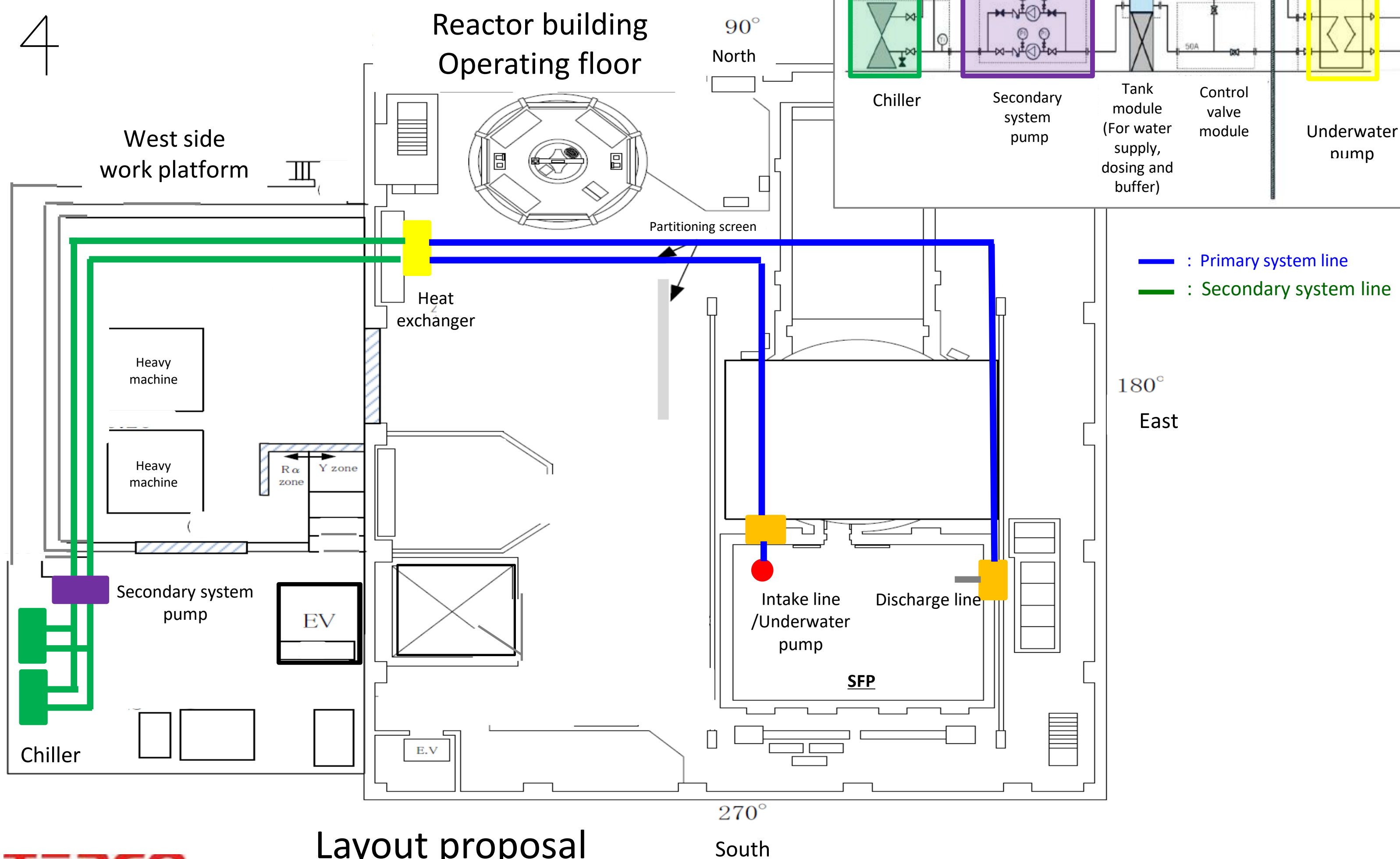






We will construct a circulated cooling system that takes in water from the SFP on the operating floor and west side platform (Proposal ③)





Layout proposal

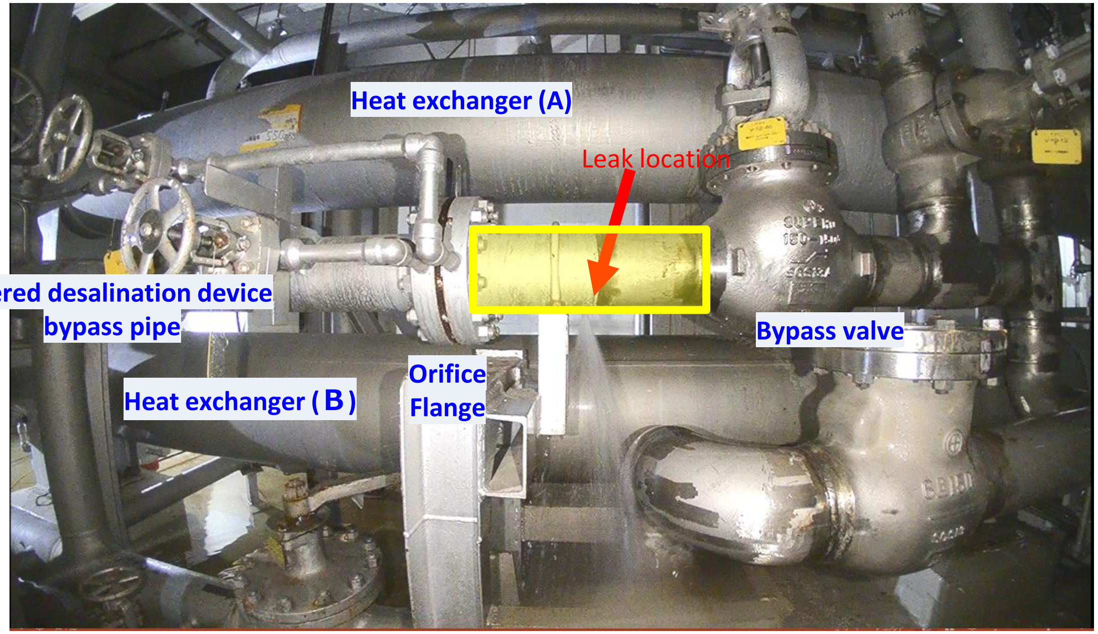
<Supplement> Managing risks until installation of the substitute cooling system on the operating floor

✓ Until installation of the substitute cooling system on the operating floor risks shall be managed as follows:

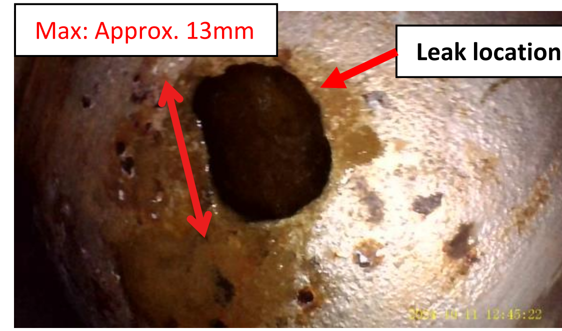
Equipment	Forcing risk	Risk countermeasures	Detection method
Existing pump/Heat exchanger	Leak in the vicinity of the existing pump/Heat exchanger	Using of substitute cooling line	・Skimmer surge tank water level monitoring ・Stagnant water level monitoring
Substitute cooling line	Leak from substitute cooling pipe flange	Tightening or packing replacement	・Skimmer surge tank water level monitoring ・Stagnant water level monitoring
Similar pipes (repair locations)	Leak from repair locations	Further tightening or strap coupling replacement and repair tape	・Skimmer surge tank water level monitoring ・Stagnant water level monitoring
Similar pipes (locations not yet checked in the field)	Reduce pool water levels through siphoning if there is a leak from dissimilar metal welds	Flexibly respond by utilizing SFP feedwater	・Skimmer surge tank water level monitoring ・Stagnant water level monitoring ・Pool water level monitoring
SFP primary system line	Pipe leak caused by corrosion	Repair using strap coupling	・Skimmer surge tank water level monitoring ・Stagnant water level monitoring

The following are reference materials

＜Reference＞ Internal investigation of pipes using a fiber scope ＜Investigation item ①＞



【Examining the leak location with a fiber scope】



【Location of deposits inside type ()】

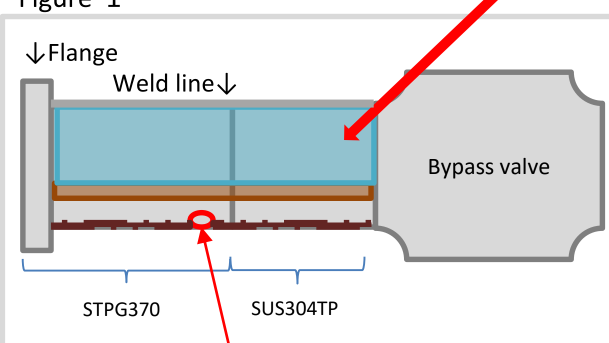
: The top of the pipes cannot be examined due to deposits

: Deposits

: Fiber scope investigation

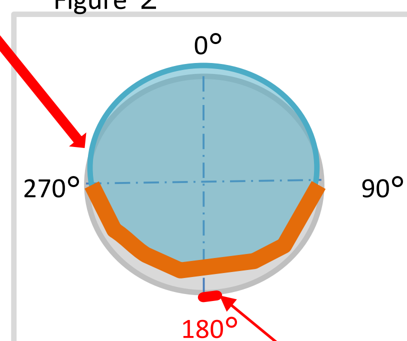
The top of the pipes cannot be examined due to deposits

Figure 1



Leak location

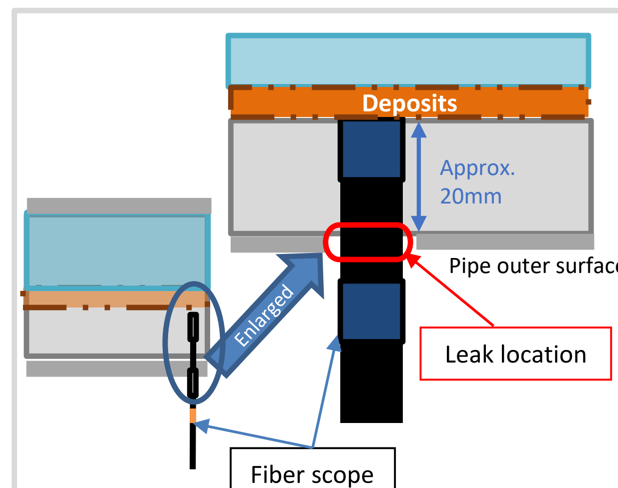
Figure 2



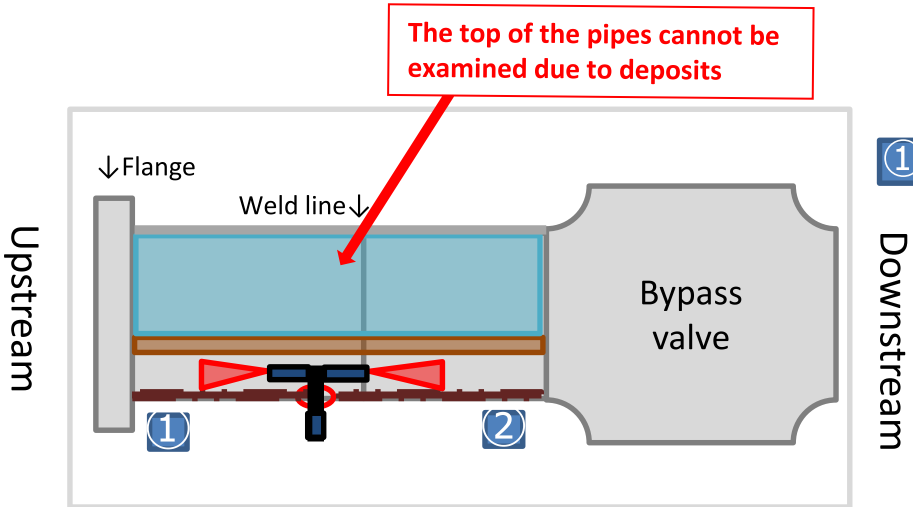
As seen from the upstream side

Leak location

Fiber scope cannot be inserted upwards due to deposits



<Reference> Conditions inside the pipe (fiber scope) <Investigation item ①>



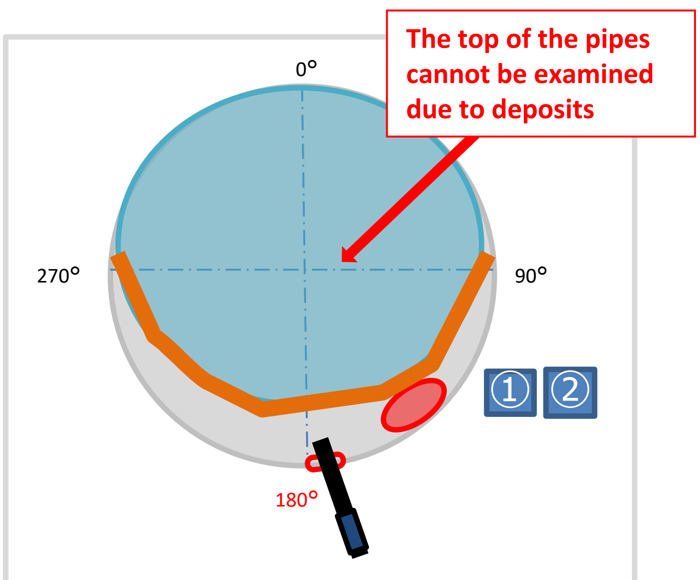
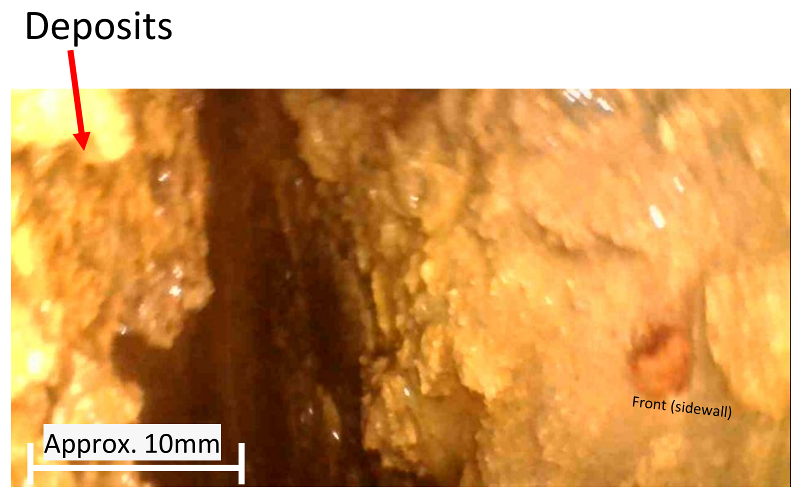
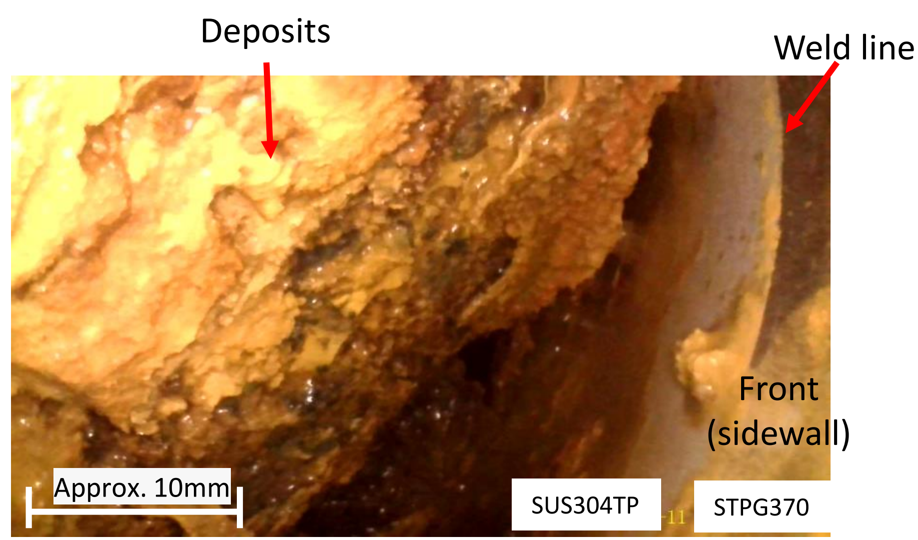


Photo taken from upstream side

①



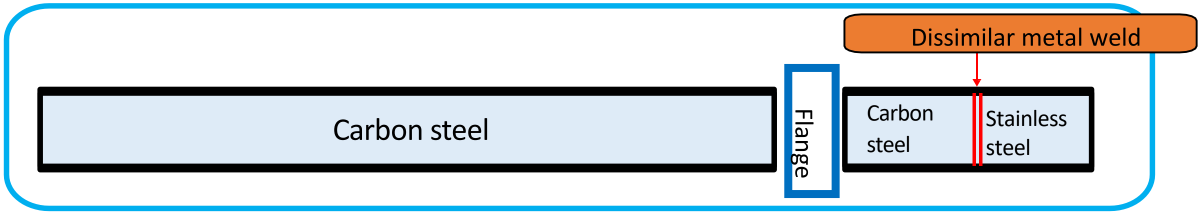
②



＜Reference＞ Assumed deposit formation mechanism

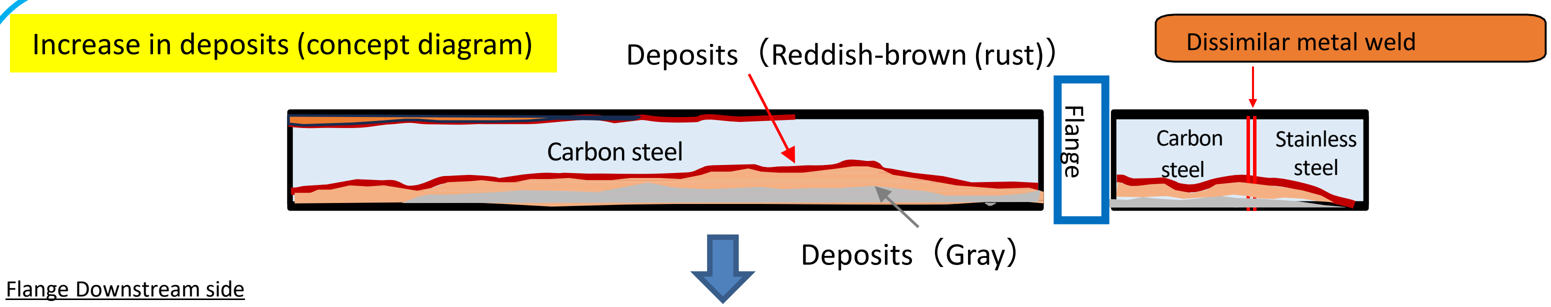
✓ 【Prior to the disaster】 Pure water environment

- Corrosion, which is an electrochemical reaction, hardly occurred within pure water, which is an insulating environment, so rust and deposits did not form. Furthermore, galvanic corrosion also did not occur because the insulation prevented dissimilar metal welds from acting like a battery.



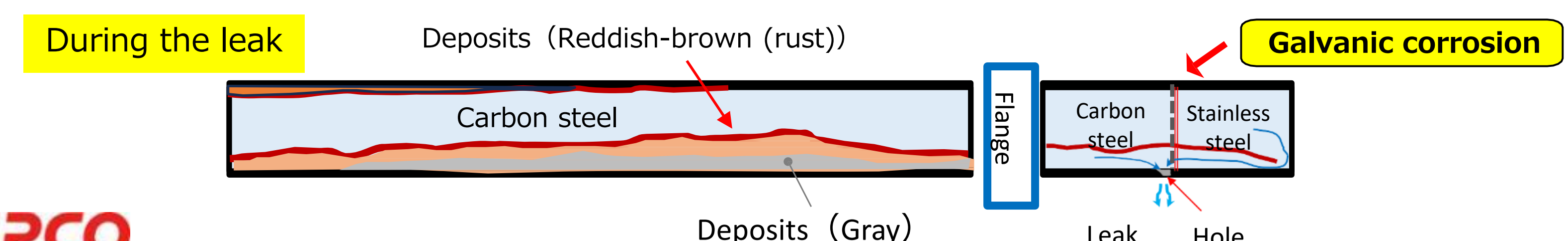
✓ 【After the disaster】 After the injection of seawater as coolant

- Seawater is injected into the SFP as coolant. The seawater flows through the aforementioned pipe causing total corrosion (rust) along the surface of the carbon steel.
- In conjunction with this, galvanic corrosion occurs on the carbon steel side of the dissimilar metal welds between carbon steel and stainless steel.
- The aforementioned pipe branches off from the SFP circulated cooling system and the water in it is stagnant for the most part. Accordingly, rust, dirt and foreign objects in the water accumulated on the ground-side.
- SFP water was purified, but it will never be pure again, so corrosion continued along the entire surface of the carbon steel and rust continued to form thereby increasing the amount of deposits.



<u>Flange Downstream side</u>

- Galvanic corrosion progresses on the downstream side of the flange and water starts to leak from the hole
- Relatively soft gray deposits on the ground-side gradually flow outside the system
- Part of the relatively hard and reddish-brown bridge-like deposits collapses causing the water leak to gradually grow and allowing almost all the great deposits to leak out
- Meanwhile, since of the reddish-brown (rust) deposits are hard, there remained in place resulting in hollowing of the area

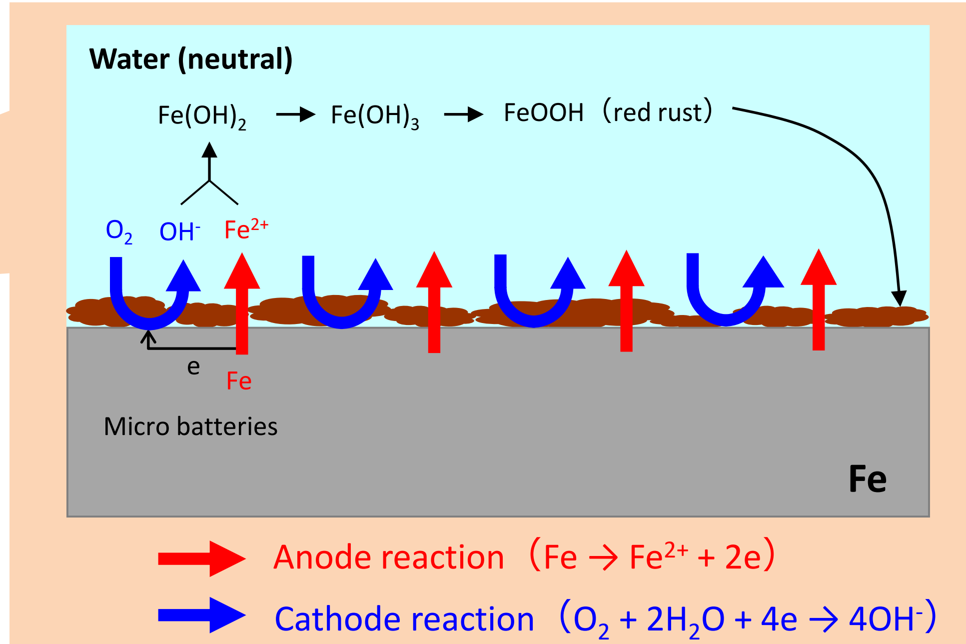


TEPCO

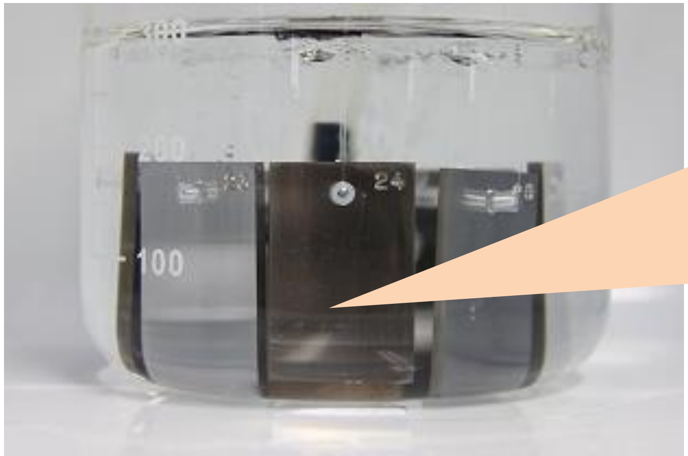
<Reference> Corrosion (Uniform corrosion of carbon steel) (1/3)

Uniform corrosion of carbon steel (total surface corrosion)

Corrosion speed: Approx. 0.1 mm/year
(room temperature, neutral environment)

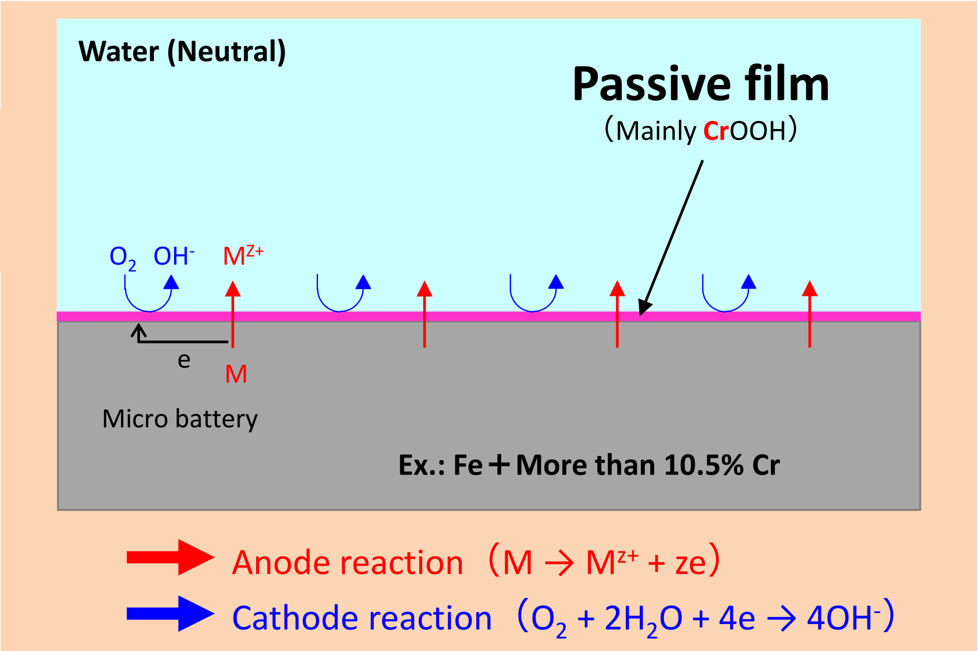


- Oxygen (O_2) dissolving in water steals electrons from iron (Fe) thereby dissolving the iron (= corrosion)
- Accordingly, the corrosion speed of the Fe = Anode reaction (O_2 reduction speed) speed.
- As shown in the diagram on the upper right, Numerous **micro batteries** form on the surface of the iron and are distributed evenly thereby causing **almost uniform corrosion** along the entire surface.



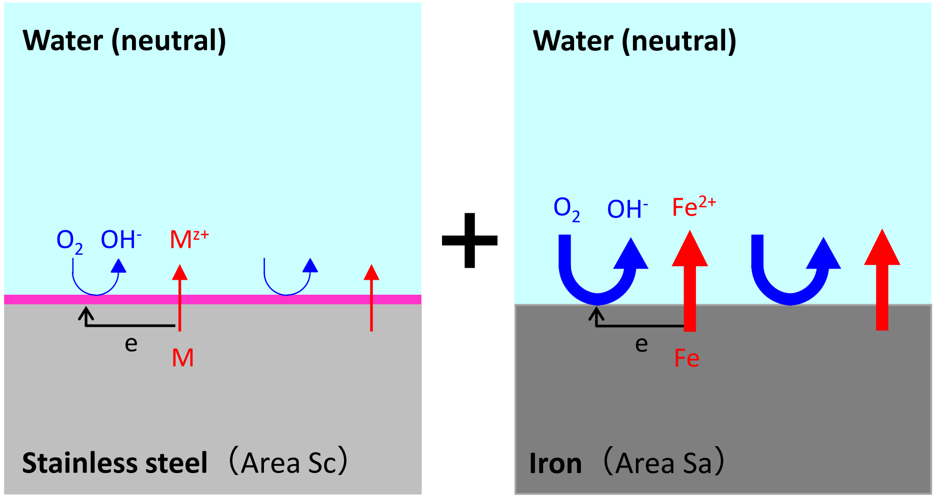
Intact stainless steel (passive)

Corrosion speed: Almost 0

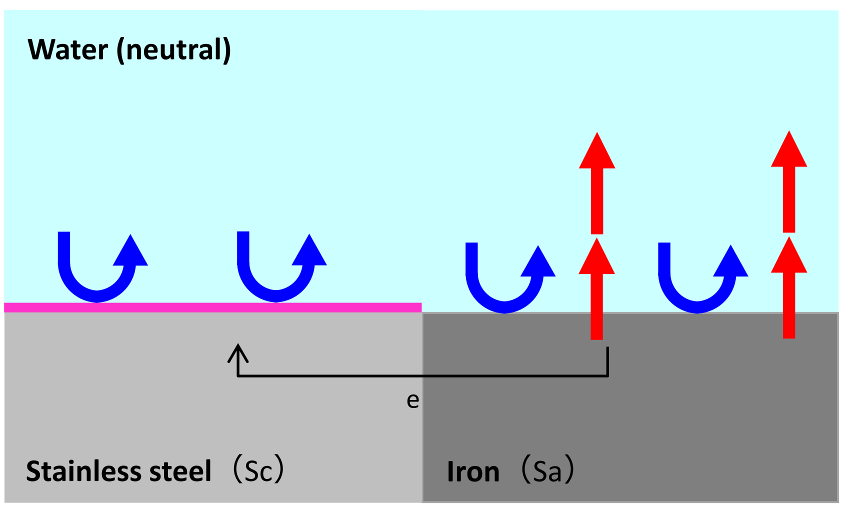


- As the oxygen (O_2) dissolving in water steals electrons, metals (M: Fe, Cr, Ni, etc.) corrode, and carbon steel is no exception.
- However, since a protective membrane (**passive film**) forms on the surface of the material, the anode reaction speed **decreases to a level that can practically be ignored**, and in conjunction, the cathode reaction speed also decreases.
- As a result, corrosion is almost imperceptible to the human eye (called "passive").

＜Reference＞ Corrosion (galvanic corrosion (to dissimilar metal contact corrosion)) (3/3)



Electrical contact when the areas are equal (Sa = Sc)…

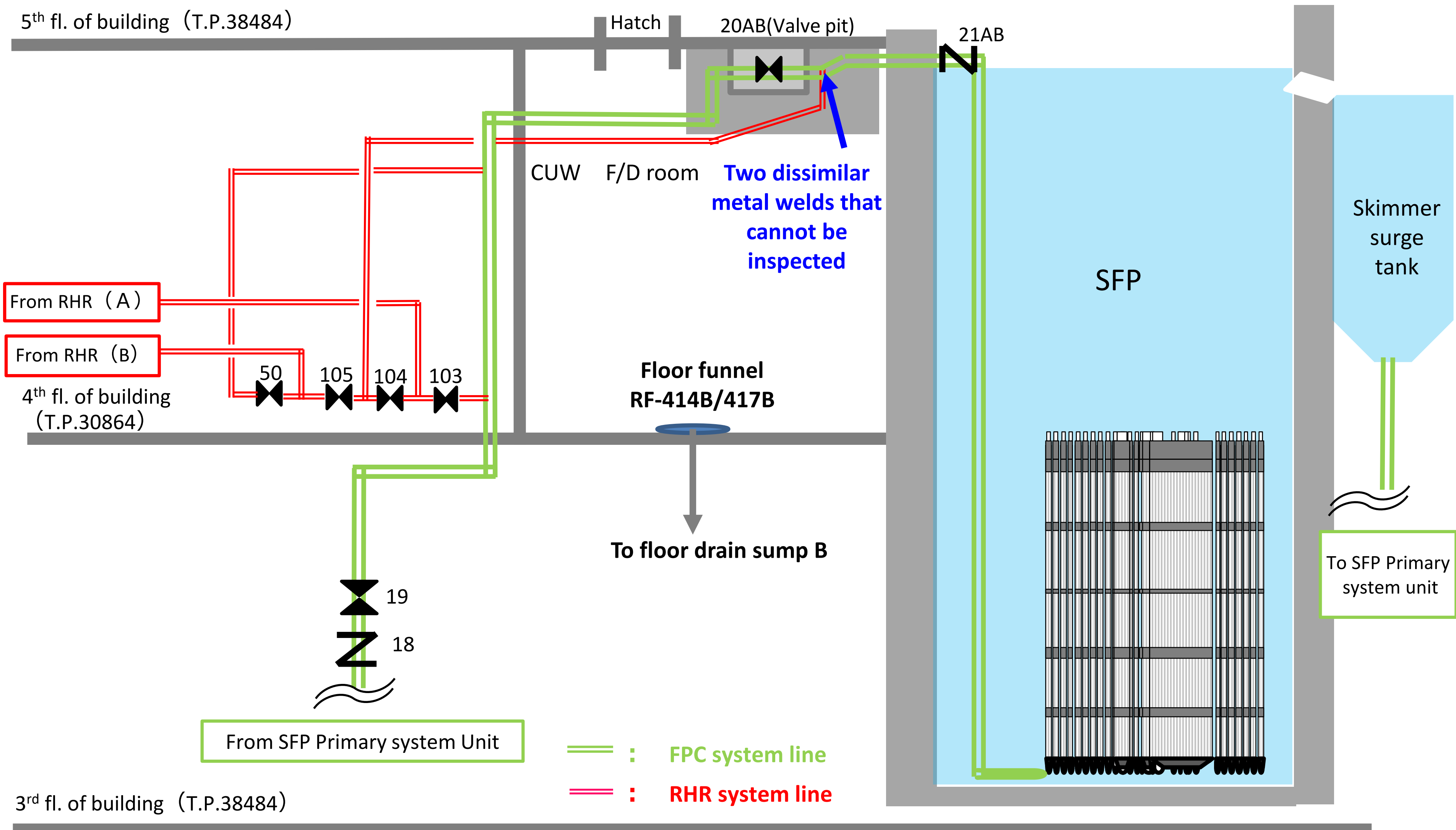


- When carbon steel (steel) and stainless steel of the same size are in contact underwater, the potential on the base carbon steel side causes an anode reaction to accumulate.
- As a result, the cathode reaction on the stainless steel side can progress at normal speed.
- This causes the anode reaction speed on the carbon steel side to **increase twofold when on its own** (the numbers shown by the red arrows double).
- This phenomenon of base metal corrosion caused by the electric potential when it is in contact with a rare metal is called **galvanic corrosion**.
- The speed of corrosion of the base metal caused by galvanic corrosion changes as follows:
  - Corrosion is promoted as the **conductivity rate** of the water increases
  - Corrosion is promoted as the **area ratio(Sc/Sa)** of the dissimilar metals increases
  - Corrosion is promoted as the **potential difference** of the dissimilar metals increases

※ The figure on the left shows an example where the speed of corrosion doubles, but this is actually a complicated process and the acceleration ratio varies differently depending on the environmental conditions and the parts.

＜Reference＞ SFP water level during siphoning

✓ Two of the similar dissimilar metal welds are buried in concrete and cannot be inspected. If there was a leak from either of these welds, the leaking water would flow down the gaps between the concrete and the pipe and flow into the CUWF/D room. The water would flow via the floor funnel into the stagnant water in the building. If siphoning were to occur, the leak would stop several centimeters below the NWL.



<Reference> Current conditions at the Unit 1~6 SFP and common pool

- ✓ The following chart shows the status of fuel removal from the Unit 1~6 SFP and common pool
- ✓ Furthermore, the Unit 5 and 6 SFP and the common pool having used the same way as prior to the accident, and there is little possibility of galvanic corrosion. Out of SFP 1~4, the fuel has been removed from Units 3 and 4, and Unit 1 is under investigation. Countermeasures, such as repairs, etc., shall be made as necessary.

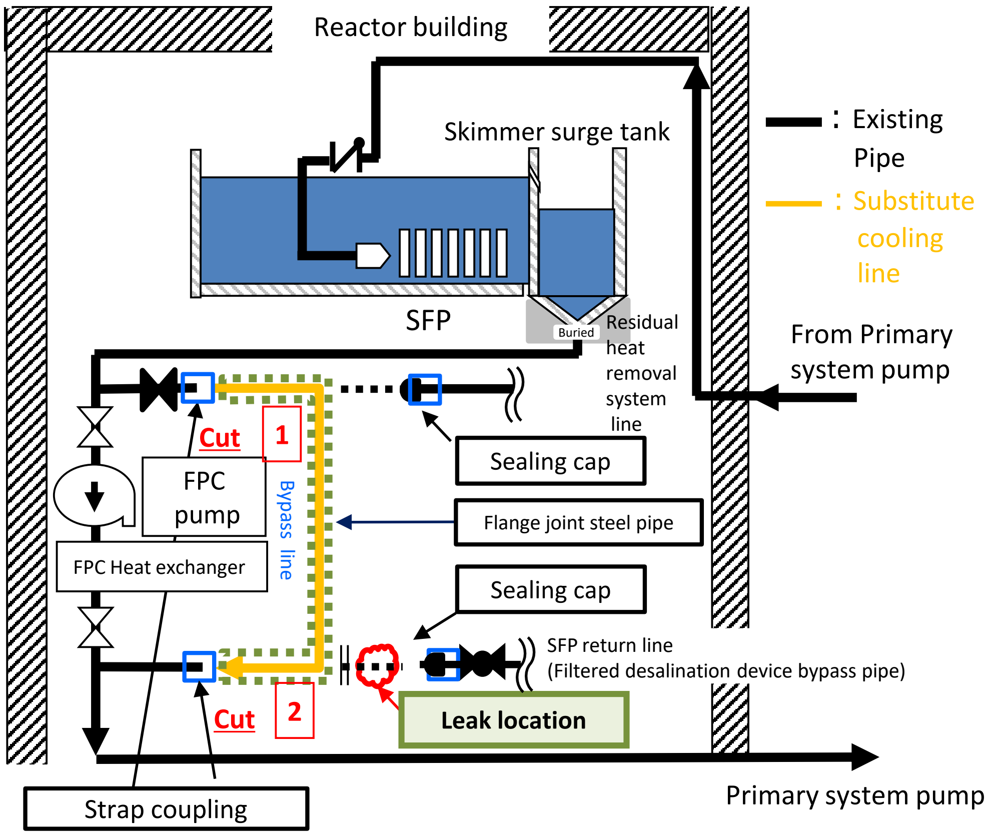
Unit	Spent fuel (removal status)	SFP water quality※			Dissimilar metal welds? (Galvanic corrosion possibility)	Impact of leak	Seawater used as cooling water?
		Conductivity rate	Chlorine	P H			
Unit 1	Yes	39 mS/m	29 ppm	8.5	Yes Detailed investigation underway	Yes If there is a leak, the water will flow into the building subfloor and become stagnant Flexible handling through SFP water level and temperature monitoring	No
Unit 2	Yes	24 mS/m	18 ppm	8.4	Yes 12 locations	Yes If there is a leak, the water will flow into the building subfloor and become stagnant Flexible handling through SFP water level and temperature monitoring	Yes
Unit 3	No (Removal completed)	24 mS/m	34 ppm	8.1	Yes Detailed investigation underway	Yes If there is a leak, the water will flow into the building subfloor and become stagnant Flexible handling through SFP water level monitoring	Yes
Unit 4	No (Removal completed)	28 mS/m	23 ppm	8.5	Yes Detailed investigation underway	Yes If there is a leak, the water will flow into the building subfloor and become stagnant Flexible handling through SFP water level monitoring	Yes
Unit 5	Yes	1.0 µS/cm	0.4 ppb	5.8	Yes Pure water used so there is no chance of galvanic corrosion	No Siphon break hole countermeasures implemented	No
Unit 6	Yes	1.0 µS/cm	3.9 ppb	5.8	Yes Pure water used so there is no chance of galvanic corrosion	No Siphon break hole countermeasures implemented	No
Shared facilities	Yes	100 µS/cm	260ppb	8.2	Yes Pure water used so there is no chance of galvanic corrosion	No Siphon break hole countermeasures implemented	No

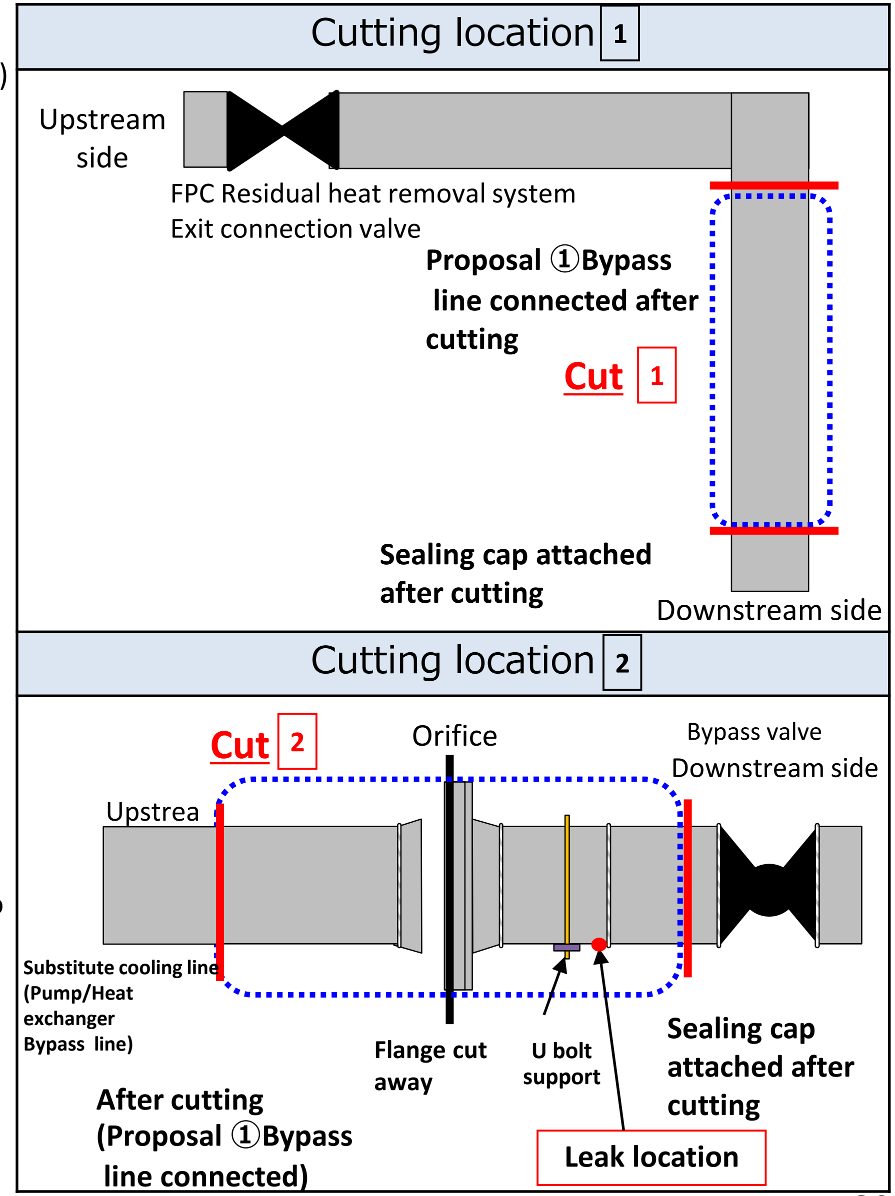
＜Reference＞ Substitute cooling line installation pipe cutting locations (concept diagram)

✓ Proposal ①Bypass line constructed after cutting/removing existing pipes. The cut locations are shown below.

Cutting location 1 : Residual heat removal system ※ line

Cutting location 2 : SFP return line(Filtered desalination device bypass pipe)





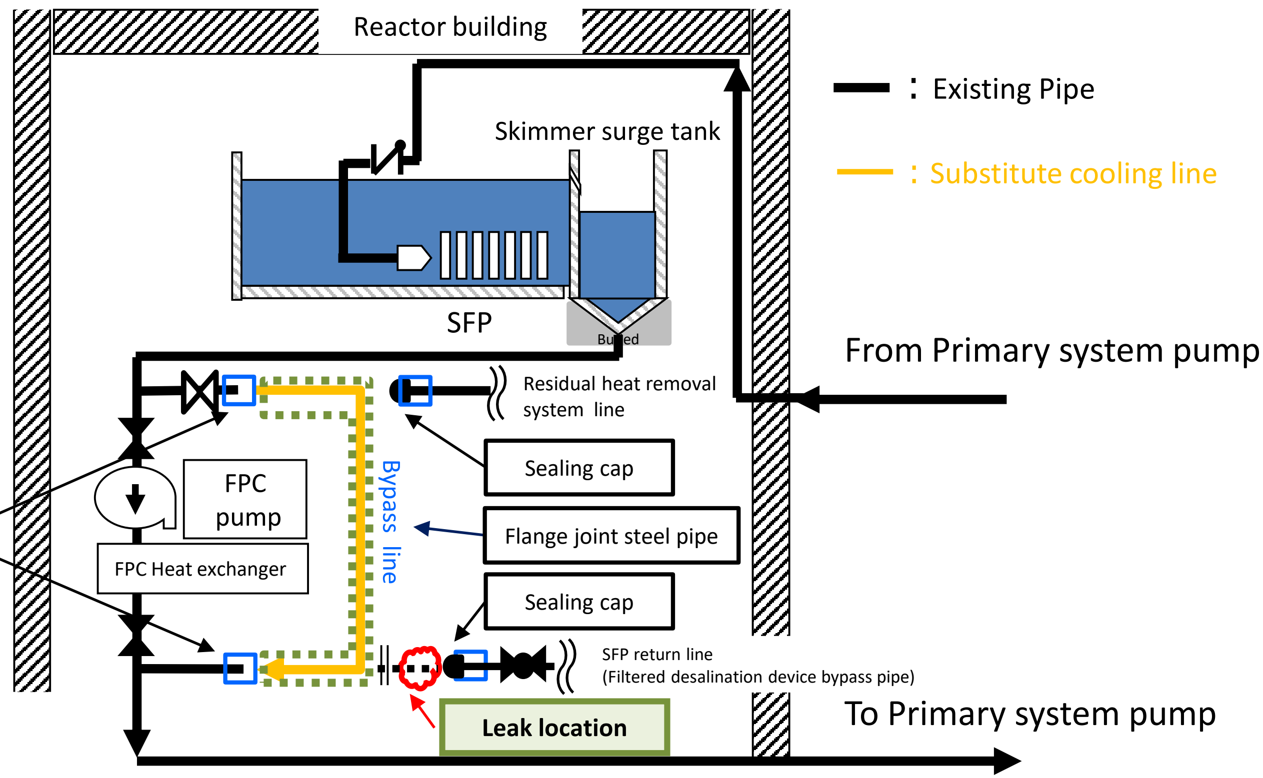
※Residual heat removal system
After a reactor is shut down, this system removes reactor decay heat and potential heat from the reactor pressure vessel, pipes, and coolant, and cools the reactor during a loss of reactor cooling function, etc.
If the FPC cannot be used due to inspection, etc., this line is switched over to from the FPC

<Reference> Proposal ①Bypass line construction

Work overview

- ✓ The existing pipe branching from the main pipe will be cut and the line configured using strap couplings and a steel pipe flange joint.
- ✓ In order to reduce exposure and the burden on workers, work will be done in the FPC heat exchanger room only using the shortest route possible and efforts made to shorten the work period.

Schematic of work (work area: FPC heat exchanger room)



<Reference> Method for replenishing the Unit 2 SFP

- ✓ Even under current circumstances the temperature of the Unit 2 spent fuel pool has not reached 65°C, which is the limiting condition of operation. Furthermore, as shown below, the amount of water evaporated can be made up for with the feed water system.
- ✓ Even if the water level of the Unit 2 SFP decreases due to natural evaporation, the following method would be used to replenish it with filtered water thereby making it possible to maintain the water level of the SFP.
  - Normally used skimmer surge tank replenishing line (① in the figure below) ※ The pool can be replenished whether the primary pump is in operation or not
  - Replenishing line from emergency cooling water injection lines (②,③ in the figure below)