Measures against Radioactive Water Leakage in Unit3 Turbine Building of Fukushima Daiichi Nuclear Power Station

October 31, 2012
Tokyo Electric Power Company

This document is a report prepared as directed by the "Directions about Radioactive Water Leakage in Unit3 Turbine Building of Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company" (Nuclear Regulation Authority Direction Document No. 121016001, October 17, 2012)[*1].

[*1] Direction Document
"Directions about Radioactive Water Leakage in Unit3 Turbine Building of Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company"
(Nuclear Regulation Authority Direction Document No. 121016001, October 17, 2012)

The Nuclear Regulation Authority (hereinafter referred to as "the Authority") received a notification from Tokyo Electric Power Company on October 15, 2012 on the leakage of water containing radioactive substances in the turbine building for Reactor 3 of Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company (hereinafter referred to as "Reactor 3"). According to the notification, the leakage in question occurred from a pressure-resistant hose of the same type as the pressure-resistant hose from which the leakage on August 14, 2012 of water containing radioactive substances in the turbine building for Reactor 4 of Fukushima Daiichi Nuclear Power Station (hereinafter referred to as "Reactor 4") occurred.

In view of the fact that a leakage occurred which is similar to the one that had occurred on August 14 of the same year, the Authority hereby directs Tokyo Electric Power Company to take the actions specified below and report on the results by October 31, 2012.

Required actions:

1. Identify the causes of the leakage of water containing radioactive substances from the pressure-resistant hose in the turbine building for Reactor 3.
2. Verify whether the measures taken to prevent recurrences of the leakage on August 14, 2012 of water containing radioactive substances in the turbine building for Reactor 4 from the pressure-resistant hose transferring the water, which were reported to the Nuclear and Industrial Safety Agency (the predecessor of the Authority) by Tokyo Electric Power Company, are sufficient in the light of the incident in question.
3. Consider additional recurrence prevention measures based on the result of the verification conducted as directed in Item 2 above.

1. Overview of the Incident

(1) Time series

At about 10:00 a.m., on October 15, 2012, employees of a subcontracting company at work discovered that water was leaking near the entrance for bringing in large components on the first floor of the turbine building for Reactor 3 of Fukushima Daiichi Nuclear Power Station. They notified employees of Tokyo Electric Power Company (TEPCO) of what they had discovered and the TEPCO employees confirmed at 10:10 a.m. that it was surely a leakage (Fig.1).

The TEPCO employees examined the site and confirmed that the leakage was from a B system pressure-resistant hose transferring the resident water in the basement of the turbine building for Reactor 3 to the main building for the process and the high-temperature incinerator building via the valve unit installed in the turbine building for Reactor 4. Therefore, they stopped the pump for transferring the resident water in the turbine building for Reactor 3 at 10:18 a.m. As a result, the amount of leakage gradually decreased, and, at 11:16 a.m., they confirmed that the leakage stopped.

They confirmed that all of the leaked water remained in the turbine building and there was no leakage to the outside.

Because the transfer of the resident water using the B system was stopped because of the leakage, the transfer of the resident water using the other system, the A system, was started at 6:05 p.m., October 15.

The resident water transfer line on which the leakage in question occurred is the same line on which the leakage on August 14, 2012 in the turbine building for Reactor 4 of Fukushima Daiichi Nuclear Power Station (hereinafter referred to as “the previous leakage incident”) occurred.

(2) Details of the leakage

Size of the pool: approx. 0.09m^3 (approx. 3m (length) x approx. 6m (width) x approx. 5mm (depth))

Dose equivalent rate: 3.5 mSv/h at the water surface of the pool (at the time of the leakage)

Atmospheric dose (maximum value at a height of 1m from the sampling point):
1.5 mSv/h (at the time of the leakage)

Result of the sampling of the leaked water: Cs-134: 1.0 x 10^4 (Bq/cm^3)
Cs-137: 1.8 x 10^4 (Bq/cm^3)

(3) Effects on the equipment in the surrounding area

It was confirmed that the leaked water remained at the leakage location and did not affect the important equipment (such as electrical equipment) or other equipment or facility.

2. Reporting regarding Item 1 of the Direction Document

2.1 Analysis for the causal factors for the leakage from the pressure-resistant hose

(1) Specifications of the pressure-resistant hoses and the background of the introduction of the hoses

[1] Background of the introduction of the pressure-resistant hoses

The pressure-resistant hose from which the leakage in the turbine building for Reactor 3 occurred is one of the pressure-resistant hoses that were installed and brought into service in sequence to transfer the cooling water that had been injected into Reactors 1 to 3 after the Tohoku-Pacific Ocean Earthquake and leaked down into and remained in the basement of the turbine building for Reactor 3. The transfer from the basement of the turbine building for Reactor 3 was started on May 17, 2011.

The pressure-resistant hoses were installed to prevent the resident water from leaking out of the system. They were adopted because it was necessary to quickly install a means to transfer the resident water.

The pressure-resistant hose from which the previous leakage incident had occurred had been replaced with a new pressure-resistant hose (one spool), but the October 15 leakage occurred in a hose that had been in use since May 17, 2011 without being replaced.

[2] Specifications of the pressure-resistant hose

The hose in question is a hose made by combining “a main body made by covering aramid fiber with high strength with soft vinyl chloride (PVC)” with “a ring made of hard vinyl chloride (PVC) which serves as an external reinforcement member (hereinafter referred to as ‘the reinforcement ring’).” (Fig.2). The allowable pressure is 0.49MPa at room temperature, the operating temperature range is from -10°C to 50°C and the allowable bending radius is 375mm or more.

Specifications of the pressure-resistant hose

Internal diameter	External diameter	Pitch	Hose length	Maximum allowable pressure (at room temperature)	Operating temperature for the hose	Allowable bending radius
(mm)	(mm)	(mm)	(m)	(MPa) [kgf/cm^2]	(°C)	(mm)
76.2	91.5	15.1	20•50	0.49 [5]	From -10 To +50	375

(2) Analysis for the causal factors for the leakage from the pressure-resistant hose

We made an analysis for the causal factors for the water leakage from the pressure-resistant hose on the basis of the specifications of the pressure-resistant hose and the way the hose had been used.

The analysis was made by evaluating the possibilities for the installation phase and the possibilities for the service phase as described below.

[1] Installation phase

As the possibilities for the installation phase, we took up “selection of an inappropriate pressure-resistant hose” and “defect in the pressure-resistant hose.”

[1-1] “Selection of an inappropriate pressure-resistant hose”

We checked the specifications of the pressure-resistant hose and the way the hose had been used, and found that the design pressure for the pressure-resistant hose was 0.49MPa, which was compatible with the design pressure for the pump (0.3MPa). Therefore, we judged that selection of an inappropriate pressure-resistant hose was not a causal factor for the leakage.

[1-2] “Defect in the pressure-resistant hose”

The pressure-resistant hose in question is an ordinary general-purpose product and there is no record of an inspection of the hose made before placing the hose in service. However, because the hose had been in service since May 2011 and none of the workers saw any leakage on October 12, 2012 when they were working near the location of the October 15 leakage, it is unlikely that there had been a penetrating crack attributable to defect in workmanship.

On the other hand, we can not deny the possibility that there had been an initial defect that does not cause a leakage and the defect was aggravated during service to cause the leakage.

[2] Service phase

As the possibilities for the service phase, we took up "deterioration over time of the material due to heat or water quality," "deterioration of the material over time due to ultraviolet or radioactive rays," "vibration of the pressure-resistant hose due to the starting and stopping of the pump," "development of cracks from bends in the pressure-resistant hose," "damages caused by suction of foreign matters" and "damage caused by loads such as the load imposed when the hose is stepped on by a worker."

[2-1] "Deterioration over time of the material due to heat or water quality"

The highest and lowest outdoor temperatures recorded near Fukushima Daiichi Nuclear Power Station (Namie) since the commencement of use of the hose in question (May 2011) are 35.8°C and -10.3°C, respectively*. Although the outdoor temperature temporarily dropped (at 6:00 a.m., January 12, 2012) to -10.3°C, which is slightly below the lower bound (-10°C) of the operating temperature range, it is presumed that the temperature in the turbine building, which is the actual operating environment, was higher than the outdoor temperature. In addition, the duration of the lowest outdoor temperature of -10.3°C was short (less than 1 hour). Therefore, we judged that heat was not a causal factor for the leakage.

* Source: website of the Meteorological Agency

We also judged that water quality was not a causal factor for the leakage either, because no solvent or acid or alkali substance, which causes deterioration of the pressure-resistant hose, had been added to the fluid carried by the pressure-resistant hose (i.e. the resident water in the basement of the turbine building for Reactor 3) and the water quality (pH) was normal.

[2-2] "Deterioration of the material over time due to ultraviolet or radioactive rays"

Because the leaky hose is installed indoors and has not been irradiated with ultraviolet rays and the cumulative irradiation of the leaky hose with radioactive rays was about $1.2x10^4$Gy, which was lower than the threshold for deterioration (about 10^5 to 10^6 Gy*), we judged that ultraviolet and radioactive rays were not a causal factor for the leakage.

* Source: "Advanced Materials Series: Irradiation Effects and Materials," the Society of Materials Science, Japan (ed.)

[2-3] "Vibration of the pressure-resistant hose due to the starting and stopping of the pump"

We checked whether the leaky pressure-resistant hose vibrated during the starting or stopping of the pump connected to the hose. The leaky pressure-resistant hose was installed roughly horizontally on the floor between the valve unit for Reactor 3 and Reactor 4, where the pump was installed. Although the hose vibrated slightly when the pump was started and water started flowing through the hose, it did not vibrate thereafter even when the pump was started or stopped, because the hose was constantly filled with water. Therefore, we judged that vibration of the hose was not a causal factor for the leakage.

[2-4] "Development of cracks from bends in the pressure-resistant hose"

If a bend is made with a curvature radius that is smaller than the manufacturer's recommended value in a pressure-resistant hose, cracks may develop from the bend.

[2-5] “Damages caused by suction of foreign matters”

The pressure-resistant hoses are being used to transfer the resident water in the basement of the turbine building for Reactor 3. It is possible that a pressure-resistant hose line sucks in foreign matter together with resident water, the foreign matter damages the inside of a hose and the damage develops into a crack.

[2-6] “Damage caused by loads such as the load imposed when the hose is stepped on by a worker”

It is possible that a pressure-resistant hose overlaps another pressure-resistant hose or a pressure-resistant hose is stepped on by a walking worker. Such loading may damage the pressure-resistant hose.

2.2 Survey of the Site of the Leakage from the Pressure-resistant Hose

To identify the causes of the leakage from the hose, we conducted a survey to confirm the way the hose is installed, and located the leaking section and visually inspected it (inside and outside).

(1) Confirmation of the way the hose is installed

The pressure-resistant hoses of the transfer line for the valve unit for Reactors 3 and 4 from which the leakage occurred are installed as 2 systems on the first floor of the turbine building for Reactor 3 and the first floor of the turbine building for Reactor 4, to connect the underwater pump installed in the basement of the turbine building for Reactor 3 with the valve unit installed on the first floor of the turbine building for Reactor 4. The length of each hose is 20m or 50m, and the hoses are connected together with metal couplings attached to each hose at both ends (KAMLOK couplings attached by means of caulking). The total length is approx. 600m.

Many hoses are installed in the area of the first floor of the turbine building for Reactor 3 in which the leakage occurred. These hoses are installed in such a way that they almost cover the entire area with a width of approx. 1.5m with some of the hoses overlapping (Fig.1).

Transfer line for the valve unit for Reactors 2 and 4: 3 (80A pressure-resistant hoses)
Transfer line for the valve unit for Reactors 3 and 4: 2 (80A pressure-resistant hoses)
Other pressure-resistant hoses: 7 (80A pressure-resistant hoses)
Pressure-resistant hose for SFP make-up water: 1 (25A pressure-resistant hose)
Electrical cables (protecting tubes): 6

(2) Results of the inspection of the leaky part

We ran flushing water through the line in question to locate the leaky part of the pressure-resistant hose and inspected the leaky part of the hose. The results of the inspection are as follows:

a. Identification of the leaky part of the pressure-resistant hose

We ran flushing water through the line in question and confirmed that the leaking part of the pressure-resistant hose was the upper part of the hose located near the entrance for bringing in large components on the first floor of the turbine building for Reactor 3 (Fig.1).

b. Results of the inspection of the external surface of the pressure-resistant hose

We visually inspected the external surface of the pressure-resistant hose from which the leakage in question had occurred. The results are as follows (Figs. 3 and 5):

Number of openings:	one
Length of the opening:	approx. 7mm
Shape of the opening:	linear
Location of the leaky part:	upper part of the hose

Cracks on the hose surface: There were cracks in the upper parts of 5 reinforcement rings on the hose. Of the cracks in the 5 locations, the cracks in 3 locations were cracks inside the reinforcement rings. There was no crack in the lower part of the hose or the lower parts of the reinforcement rings.

Leakage from the connecting metal couplings: none

Bends in the hoses: No bend (There was no bend with a bending radius smaller than the allowable bending radius of 375mm.)

Others: There was no trace of the imposition of an external force such as a trace of contact.

c. Results of the inspection of the internal surface of the hose

We cut the leaky hose near the leaky part and visually inspected the internal surface. The results of the inspection are as follows (Figs. 4 and 5):

Number of openings: one

Length of the opening (inside): approx. 4mm

Shape of the opening: linear

Inside of the hose: There was dark reddish-brown scale all over the internal surface of the hose. The internal surface was smooth and there was no trace of collision or scraping or thinning of the hose wall.

2.3 Evaluations to Identify the Causes of the Leakage from the Pressure-resistant Hose

As the leakage from the pressure-resistant hose was through a crack that developed in the main body of the hose, we made evaluations, as described below, of causal factors for the installation phase of the hose and causal factors for the service phase of the hose to identify the causes of the development of the crack based on the results of the inspection of the leaky part (Fig.6).

[1] Installation phase

We selected "[1-2] Defect in the pressure-resistant hose" as the causal factor for the installation phase to be evaluated.

[1-2] "Defect in the pressure-resistant hose"

The pressure-resistant hose in question is an ordinary general-purpose product and there is no record of an inspection of the hose made before placing the hose in service. However, because the hose had been in service since May 2011 and none of the workers saw any leakage on October 12, 2012 when they were working near the location of the October 15 leakage, it is unlikely that there had been a penetrating crack attributable to any defect in workmanship.

On the other hand, we can not deny the possibility that there had been an initial defect that does not cause a leakage and the defect was aggravated during service to cause the leakage. We checked the external appearance of the leaking pressure-resistant hose and inspected the internal surface of the hose, and found that there were cracks in reinforcement rings at 5 locations near the leaking section of the pressure-resistant hose. Because all of the cracks are located in the upper part of the pressure-resistant hose and at locations where the inner circumferences of the reinforcement rings contact the external surface of the main body of the pressure-resistant hose, it is presumed that, for some unknown reasons, external forces acted that compressed the reinforcement rings vertically and this caused cracks to develop in the inner circumferences of the reinforcement rings, which are made of hard vinyl chloride, which does not elongate much. It is possible that such external forces acted on the rings before the hose and rings were brought into service. No sign of initial defects other than the cracks was observed.

[2] Service phase

We selected "[2-4] Development of cracks from bends in the pressure-resistant hose," "[2-5] Damage caused by suction of foreign matter" and "[2-6] Damage caused by loads such as the load imposed when the hose is stepped on by a worker" as the causal factors for the service phase to be evaluated.

[2-4] "Development of cracks from bends in the pressure-resistant hose"

If a bend is made with a curvature radius that is smaller than the manufacturer's recommended value in a pressure-resistant hose, cracks may develop from the bend. However, the leaking pressure-resistant hose is installed roughly straight without any bend with a curvature radius smaller than the manufacturer's recommended lower limit value (375mm). Therefore, we judged that "development of cracks from bends in the pressure-resistant hose" was not a causal factor for the leakage.

[2-5] "Damage caused by suction of foreign matter"

The pressure-resistant hoses are being used to transfer the resident water in the basement of the turbine building for Reactor 3. It is possible that a pressure-resistant hose line sucks in a foreign matter together with resident water, the foreign matter damages the inside of a hose and the damage develops into a crack. Therefore, we inspected the internal surface of the leaking pressure-resistant hose. The internal surface of the hose had linear cracks in the leaking section, but was smooth otherwise and had no scores caused by the suction of foreign matters or other causes. Therefore, we judged that "damage caused by suction of foreign matter" was not a causal factor for the leakage.

[2-6] "Damage caused by loads such as the load imposed when the hose is stepped on by a worker"

We checked the way the pressure-resistant hoses were installed and found that there was an area where many pressure-resistant hoses were installed in such a way that they almost cover the entire area. Because workers walking in the area may step on hoses in the area and the resultant loading may damage the hoses, we checked the external appearance of the leaking section of the pressure-resistant hose and the way the pressure-resistant hose was installed and checked how the measures to prevent recurrences of the previous leakage incident had been implemented.

[2-6-1] Check of the external appearance of the leaky part of the pressure-resistant hose

We located the leaking section of the pressure-resistant hose by running water through the hose. The leaking section was located in the upper part of the hose. We made a detailed examination of the opening and found that the opening was a linear crack penetrating both the reinforcement ring and the main body of the hose. Because the crack in the main body of the hose is longer on the outside of the hose than on the inside, it is considered that the crack developed from the outside to the inside.

We also checked the external surface of the hose around the leaking section. Other than the above-mentioned crack of the leaking section penetrating both the reinforcement ring and the main body of the hose, there were 3 locations where there was a crack in the inner circumferences of reinforcement rings in the upper part of the hose. The cracks at these 3 locations originated from the points where the reinforcement rings are bonded to the main body of the hose, but there was no sign of penetration on the outer circumferences of the reinforcement rings.

We checked the internal and external surfaces of the leaking pressure-resistant hose in the vicinity of the leaking section, but there was no trace on the external surface to indicate that the leaking hose had been scraped or temporarily subjected to strong external forces such as those caused by the bumping of an object against the hose. The internal surface was smooth. No thinning of the hose wall was observed, and there was no trace to indicate that foreign matter had collided against the internal surface or foreign matter contained in the fluid in transfer had imposed an external force on the internal surface.

From these facts, it is presumed that external forces acted for some unknown reasons on the pressure-resistant hose that compressed the pressure-resistant hose vertically without damaging the external surface, the external forces generated a localized tensile stress in the upper part of the pressure-resistant hose, the tensile stress caused cracks to develop in the reinforcement ring, which are made of hard vinyl chloride, whose elongation is relatively small, from the inner circumferences of the rings, the cracks gradually grew, one of the cracks penetrated a reinforcement ring, and the crack grew further and into the main body of the pressure-resistant hose, which is made of soft vinyl chloride, whose elongation is relatively large (Fig.7).

[2-6-2] Check of the way the pressure-resistant hose is installed

The leaking pressure-resistant hose was laid directly on the floor. There was no other pressure-resistant hose or cable placed on top of the pressure-resistant hose in the vicinity of the leaking section. Many hoses were installed around the location of the leakage in such a way that they almost covered all of an area with a width of approx. 1.5m, but it was possible to walk the vicinity of the location of the leakage without stepping on a pressure-resistant hose because the floor was exposed (Fig.1).

[2-6-3] Check of the implementation of the measures to prevent recurrences of the previous leakage incident

As stated in the statement of the measures to prevent recurrences of the previous leakage incident of the previous report which had been submitted to the Nuclear and Industrial Safety Agency by Tokyo Electric Power Company (see Chapter 3), our employees and subcontracting companies had been instructed not to step on pressure-resistant hoses and efforts were being made to promote consciousness among concerned people of the importance of avoiding stepping on pressure-resistant hoses, including the alerting signs set up in the area around the location of the October 15 leakage (Fig.8).

The location of the October 15 leakage was near the entrance of the entry control area that had been set up as part of the measures to prevent recurrences of the previous leakage incident. Because the inside and surrounding area of the building is a high-dose area, it is presumed that people who might pass through the location of the leakage are basically either people who enter the power center room of the turbine building for Reactor 4 (night shift workers etc.) or workers who work in the entry control area.

For the people who enter the power center room of the turbine building for Reactor 4, a walkway was secured in the part of the entry control area through which they must pass by means of partitioning (Figs. 8 and 9).

The workers who were working in the entry control area at the time of the investigation were workers engaged in the work to convert the pressure-resistant hose lines into polyethylene pipe lines. They were well instructed through TBM-KY etc. not to step on pressure-resistant hoses during work. The result of the interview with the workers who were working near the location of the leakage on the day of the leakage also indicates that the pressure-resistant hoses were not being stepped on by workers or other people.

From the fact that the measures to prevent recurrences of the previous leakage incident were being properly implemented and the floor of the area near the location of the October 15 leakage from the pressure-resistant hose was exposed, as described above, we presume that the leaking section of the pressure-resistant hose was not being stepped on after the commencement of implementation of the measures to prevent recurrences of the previous leakage incident. However, it cannot be denied that workers or other people may have stepped on the pressure-resistant hose before the commencement of implementation of the measures and that may have imposed loads repeatedly on the pressure-resistant hose.

2.4 Conclusions

On the basis of the above-mentioned facts and analyses, we presume that the October 15 leakage occurred as a result of the development of a crack in the pressure-resistant hose due to repeated trampling of the hose by workers before the commencement of implementation of the measures to prevent recurrences of the previous leakage incident and the expansion of the crack due to the pressure imposed by the operation.

It is also possible that there had been an initial defect in the hose and the defect was aggravated as a result of repeated trampling of the hose by workers after the hose was brought into service, which resulted in the leakage from the pressure-resistant hose.

3. Reporting regarding Item 2 of the Direction Document

3.1 Measures stated in the statement of the measures to prevent recurrences of the previous leakage incident

We submitted a report on September 13, 2012 to the Nuclear and Industrial Safety Agency (the predecessor of the Authority) stating our efforts to identify the causes of the leakage on August 14, 2012 from a line to transfer the resident water in the turbine building for Reactor 4 and our measures to prevent recurrences of the leakage (hereinafter referred to as “the previous report”). Below is a summary of the recurrence prevention measures stated in the previous report.

[1] A clear plan will be created for converting the lines in which pressure-resistant hoses are used into polyethylene lines and the conversion work will be carried out. The work to convert the transfer line for Reactors 3 and 4, from which the August 14 leakage occurred, into a polyethylene line will be completed by the end of 2012 (or later if completion by that date is not possible), and the works to convert the other lines in which pressure-resistant hoses are used into a polyethylene lines will be prioritized and carried out in a systematic manner.

[2] For the transfer line for Reactors 3 and 4, from which the August 14 leakage occurred, measures will be taken to ensure that the pressure-resistant hoses will not be stepped on by workers or other people, because it will be necessary to use the pressure-resistant hoses until the polyethylene line is completed. Specifically, signs to advise people not to step on the pressure-resistant hose will be urgently set up, and a walkway or partitioning to isolate the pressure-resistant hose will be provided as soon as the preparation is completed.

[3] To limit the extent of the contamination by high-level resident water in the event of a leakage from a pressure-resistant hose of the transfer line for Reactors 3 and 4 so that the restoration work can be performed smoothly, partitioning by means of sandbags etc. to isolate the area in which the pressure-resistant hoses are installed to limit the extent of leakages will be provided as soon as the preparation is completed.

[4] With regard to the other lines that require the pressure-resistant hose to be used until the polyethylene line is completed, signs to advise people not to step on the pressure-resistant hose will be set up and a walkway or partitioning to isolate the pressure-resistant hose will be provided by the end of 2012.

[5] When it is necessary to use a pressure-resistant hose, the external surface of the hose will be visually inspected prior to using the hose to confirm that there is no initial defect in the hose.

3.2 Verification of the recurrence prevention measures stated in the previous report

[1] Plans to convert lines in which pressure-resistant hoses are used into polyethylene lines and the present statuses of the conversion works

Plans to convert the lines in which pressure-resistant hoses are used into reliable polyethylene lines were formulated and the conversion work is being carried out according the plans and the priority we determined taking into consideration such factors as the risk of releases out of the system and exposure of workers.

Monitoring of the states of nearby piping and valves through visual inspection (to detect leakages) etc. during the operation of valves etc. to switch the resident water transfer destination and maintenance activities suitable for the site are being performed continuously, to detect equipment damage and signs of failures at an early stage to ensure the reliability of the facilities and equipment.

(a) Transfer line for Reactors 3 and 4: To be completed by the end of 2012

As stated in the previous report, the work to convert the transfer line for Reactors 3 and 4 into a polyethylene line is being carried out as a leakage prevention measure. The work is scheduled to be completed by the end of 2012. The work schedule is as shown in Fig.10.

(b) Other lines

The plan to convert the resident water transfer equipment-, processing equipment- and desalination equipment-related lines into polyethylene lines stated in the previous report is being implemented in a systematic manner as shown in Figs. 11 to 13.

[2] Measures to prevent people from stepping on pressure-resistant hoses of the transfer line for Reactors 3 and 4

The following measures were taken to prevent people from stepping on pressure-resistant hoses of the transfer line for Reactors 3 and 4, on which the previous leakage incident had occurred, because it is necessary to use the pressure-resistant hoses until the polyethylene line is completed (Figs. 8 and 9):

(a) Alert signs to advise people not to step on the pressure-resistant hoses were set up near the entrances of the buildings and near the areas in which many pressure-resistant hoses are laid close to each other. The meaning of these signs was conveyed to our employees and subcontracting companies through our intranet, which is a common electronic bulletin board for TEPCO and the subcontracting companies. The workers involved in converting lines into polyethylene lines near the location of the leakage are instructed not to step on the pressure-resistant hoses by TEPCO employees during the TBM-KY meeting held prior to commencing work.

(b) As a measure to isolate pressure-resistant hoses through partitioning, the area from the boundary between the turbine building for Reactor 3 and service building for Reactors 3 and 4 to the boundary between the turbine building for Reactor 4 and service building for Reactors 3 and 4, in which pressure-resistant hoses are laid in a manner similar to that in the area in which the August 14 leakage occurred, was designated as an entry control area.

For people who have to pass through the entry control area to enter the power center room of the turbine building for Reactor 4 (night shift workers etc.), a walkway was secured in the part of the entry control area through which they must pass by means of partitioning. Judging from the above-mentioned measures and efforts, we consider that the measures to prevent people from stepping on the pressure-resistant hoses of the transfer line for Reactors 3 and 4 are effective.

The identification of the areas in which installation of a walkway or isolation of pressure-resistant hoses through partitioning is required in relation to the transfer line for Reactors 3 and 4 has already been completed, and the installation of the walkways and the isolation of the pressure-resistant hoses through partitioning will be started according to the schedules. As temporary measures, entry control areas were set up and passages were secured through partitioning (Fig.14 [1] and Fig.15.)

[3] Measures to limit the extent of leakages from pressure-resistant hoses of the transfer line for Reactors 3 and 4

To limit the extent of the contamination by high-level resident water in the event of a leakage from a pressure-resistant hose of the transfer line for Reactors 3 and 4 so that the restoration work can be performed smoothly, partitioning by means of sandbags etc. to isolate the area in which the pressure-resistant hoses are installed to limit the extent of leakages was provided (Figs. 16 and 17).

The amount of water leaked as a result of the October 15 leakage incident was approx. 0.09m^3, which was smaller than the amount of water leaked as a result of the previous leakage incident. For this reason, the extent of the October 15 leakage was not large. However, it is considered that, even if the amount of leaked water had been large, the isolation of the area in which the pressure-resistant hoses are installed through partitioning with sandbags etc. would have been effective in limiting the extent of the leakage.

[4] Measures to prevent people from stepping on pressure-resistant hoses of lines other than the transfer line for Reactors 3 and 4

For lines other than the transfer line for Reactors 3 and 4, too, alert signs to advise people not to step on the pressure-resistant hoses were set up near the entrances of the buildings and near the areas in which many pressure-resistant hoses are laid close to each other. As stated in [2], we consider that these signs are effective in preventing people from stepping on pressure-resistant hoses.

The identification of the areas in which installation of a walkway or isolation of pressure-resistant hoses through partitioning is required has already been completed, and the installation of the walkways and the isolation of the pressure-resistant hoses through partitioning will be started according to the schedules (Fig.14 [2]).

[5] Visual inspection of the external surfaces of pressure-resistant hoses before placing them into service

The leaky part had not been subjected to a visual inspection of external surface prior to being placed into service, because it has been in use since May 2011, which is earlier than the introduction of visual inspection of the external surfaces of pressure-resistant hoses as a measure to prevent recurrences of the previous leakage incident.

Incidentally, the B system pressure-resistant hoses of the transfer line for the valve unit for Reactors 3 and 4 were reinstalled before the identification of the causes as a tentative measure because the October 15 leakage incident was similar to the previous leakage incident. The external surfaces of the new pressure-resistant hoses were visually inspected before installing the hoses to confirm that the hoses are free of defects, in order to reduce the risk of leakages due to initial defects.

3.3 Summary of the Verification Results

As described in [1] to [5] above, the pressure-resistant hoses currently in use are being replaced with polyethylene pipes as planned as part of the measures to prevent recurrences of the previous leakage incident. We consider that, in the areas where pressure-resistant hoses will be used until the polyethylene lines are installed, measures to prevent people from stepping on pressure-resistant hoses and measures to limit the extent of leakage in the event of a leakage will be sufficiently effective.

The provision of means to detect leakages at an early stage such as leakage detection equipment and the elimination of effects on important equipment through relocation of power sources etc., which were stated in the previous report as measures other than the measures to prevent recurrences of the previous leakage incident, are also being progressed so that they can be completed as planned.

As mentioned above, we consider that the recurrence prevention measures stated in the previous report are effective to a certain degree in preventing people from stepping on pressure-resistant hoses and limiting the extents of leakages. However, it is not possible to completely eliminate the risk of leakages because only the leaking hose of the line on which the previous leakage occurred (one spool) was replaced with a new pressure-resistant hose.

4. Reporting regarding Item 3 of the Direction Document

4.1 Additional recurrence prevention measures based on the results of the present verification

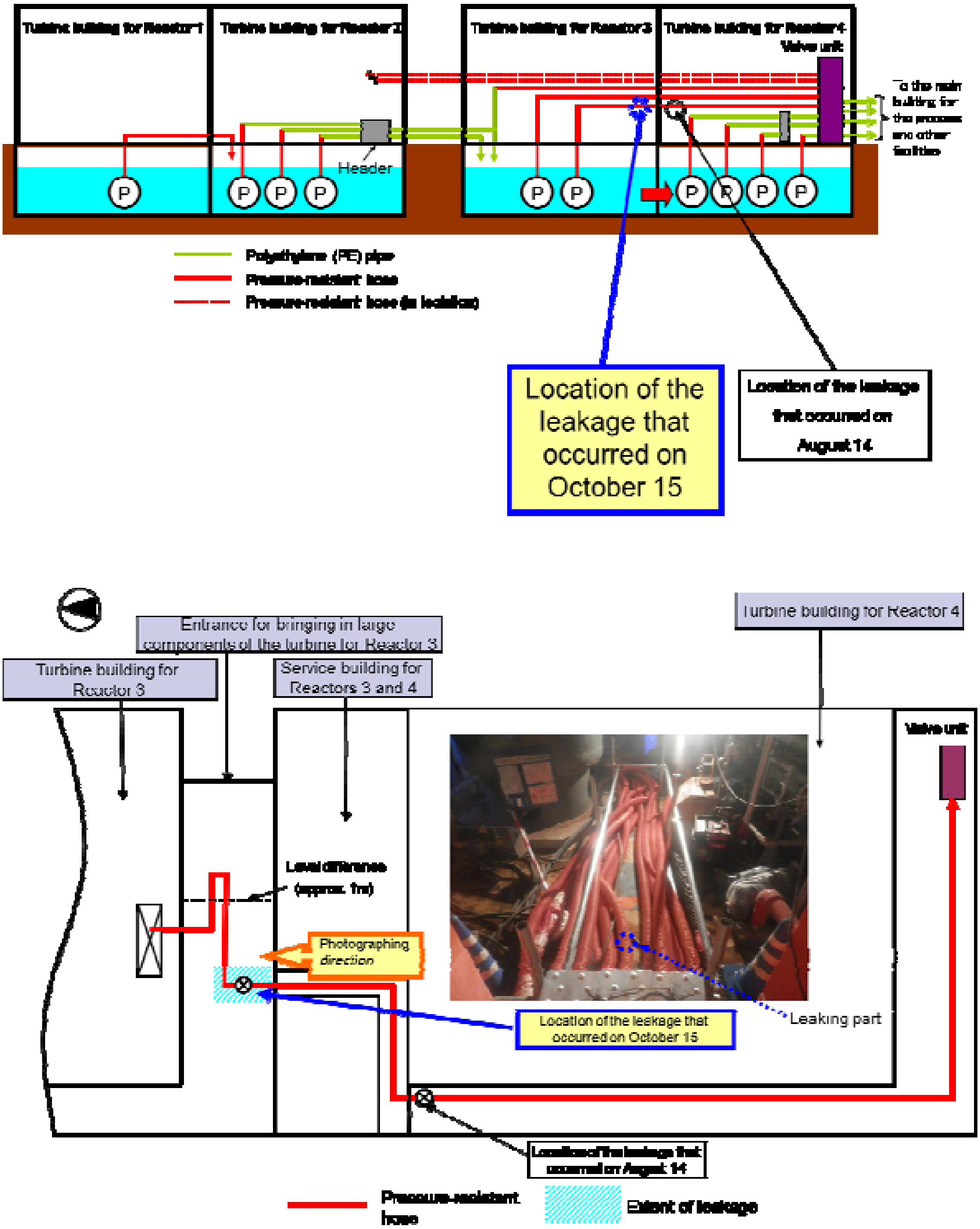
As stated in Chapter 2, it is considered that the crack in the pressure-resistant hose that caused the October 15 leakage from the pressure-resistant hose developed as a result of repeated loading on the pressure-resistant hose due to trampling of the pressure-resistant hose by people passing by the area and the crack grew as a result of the operating pressure.

As stated in Chapter 3, the pressure-resistant hoses of the transfer line for Reactors 3 and 4 will be replaced with polyethylene pipes by the end of 2012, and it is necessary to use the pressure-resistant hoses until the installation of the polyethylene pipes is completed in order to control the water level in the building. For this reason, only the leaking hose of the line on which the previous leakage occurred (one spool) was replaced with a new pressure-resistant hose, which means that it is not possible to completely eliminate the risk of leakages. We consider that the recurrence prevention measures stated in the previous report are effective to a certain degree in preventing people from stepping on pressure-resistant hoses and limiting the extents of leakages. However, we took the following additional recurrence prevention measures to reduce the risk of leakages from pressure-resistant hoses of the transfer line for the valve unit for Reactors 3 and 4 in consideration of the fact that the October 15 leakage incident occurred, because the hoses had been placed into service before the implementation of the recurrence prevention measures stated in the previous report and it is possible that cracks exist in the hoses (Fig.18):

* The pressure-resistant hoses of the transfer line for the valve unit for Reactors 3 and 4 (B system) from which the October 15 leakage had occurred were replaced with new pressure-resistant hoses (The replacement work was completed on October 26, 2012).

In addition, the following action was taken to ensure that the recurrence prevention measures stated in the previous report will remain effective:

* The efforts to advise the TEPCO employees and subcontracting companies not to step on pressure-resistant hoses that had been made as part of the measures to prevent recurrences of the previous leakage incident were made again.



Volume of the pool of the leaked water: approx. 0.09m³ (approx. 3m (length) x approx. 6m (width) x approx. 5mm (depth))

Fig.1 Location of the Leakage in the Turbine Building

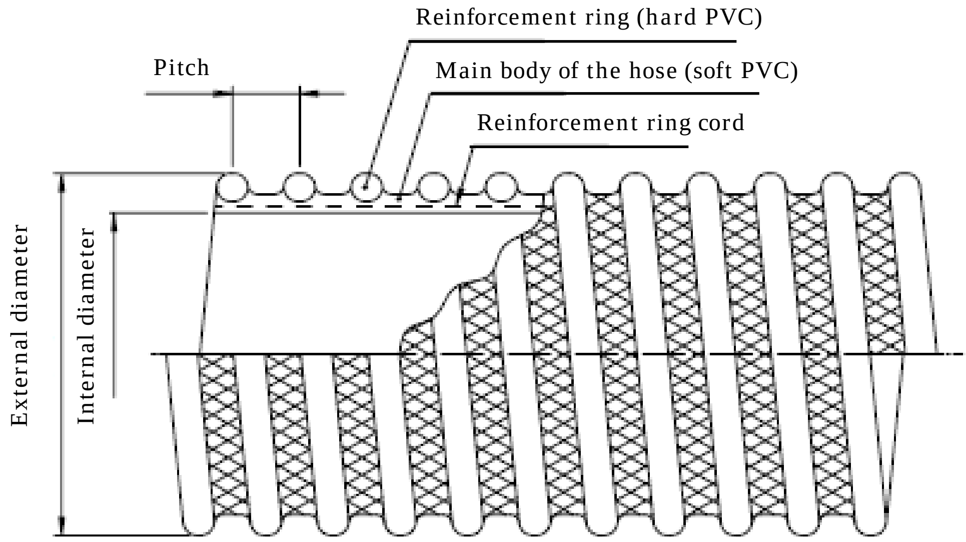


Fig.2 Structure of a Pressure-resistant Hose

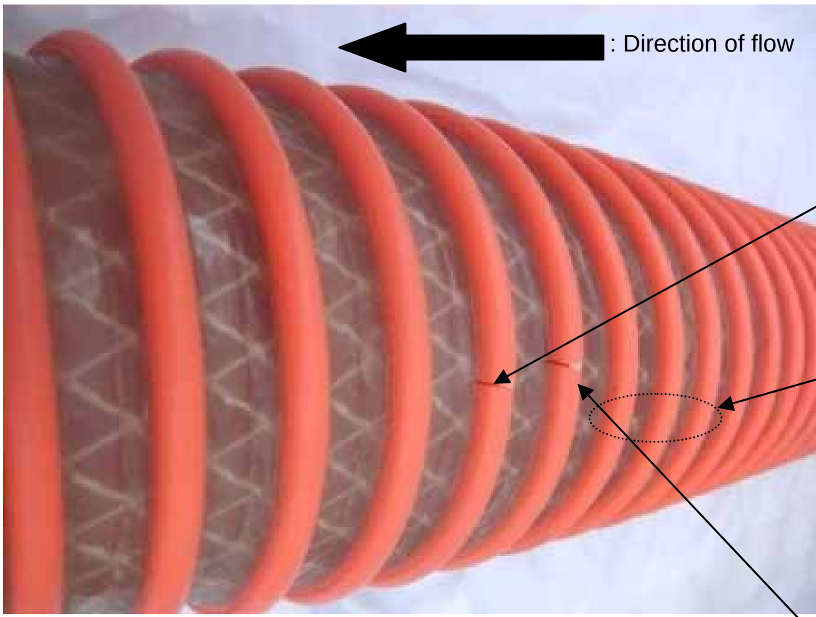


Fig.3 External Surface of the Pressure-resistant Hose from which the Leakage Occurred (the Leaky Part)

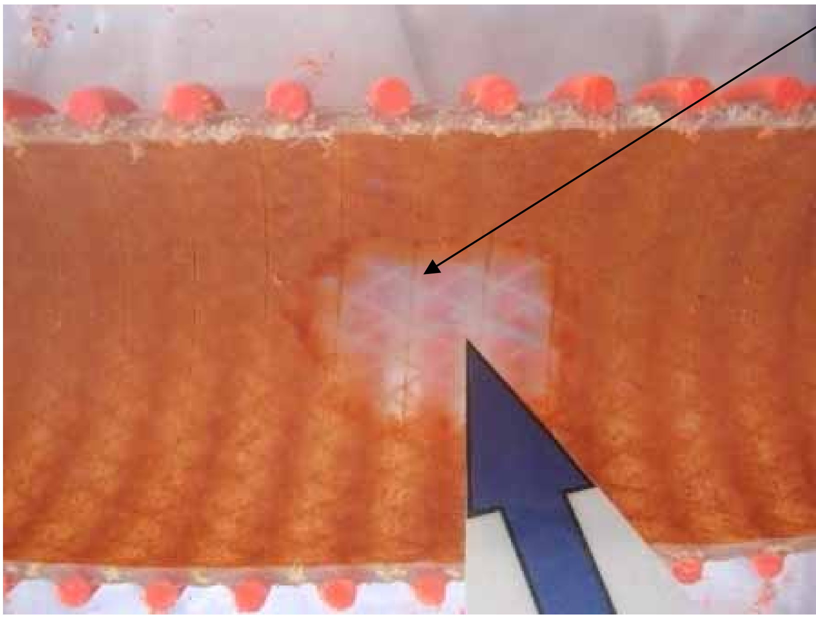


Fig.4 Internal Surface of the Pressure-resistant Hose from which the Leakage Occurred (the Leaking Section)

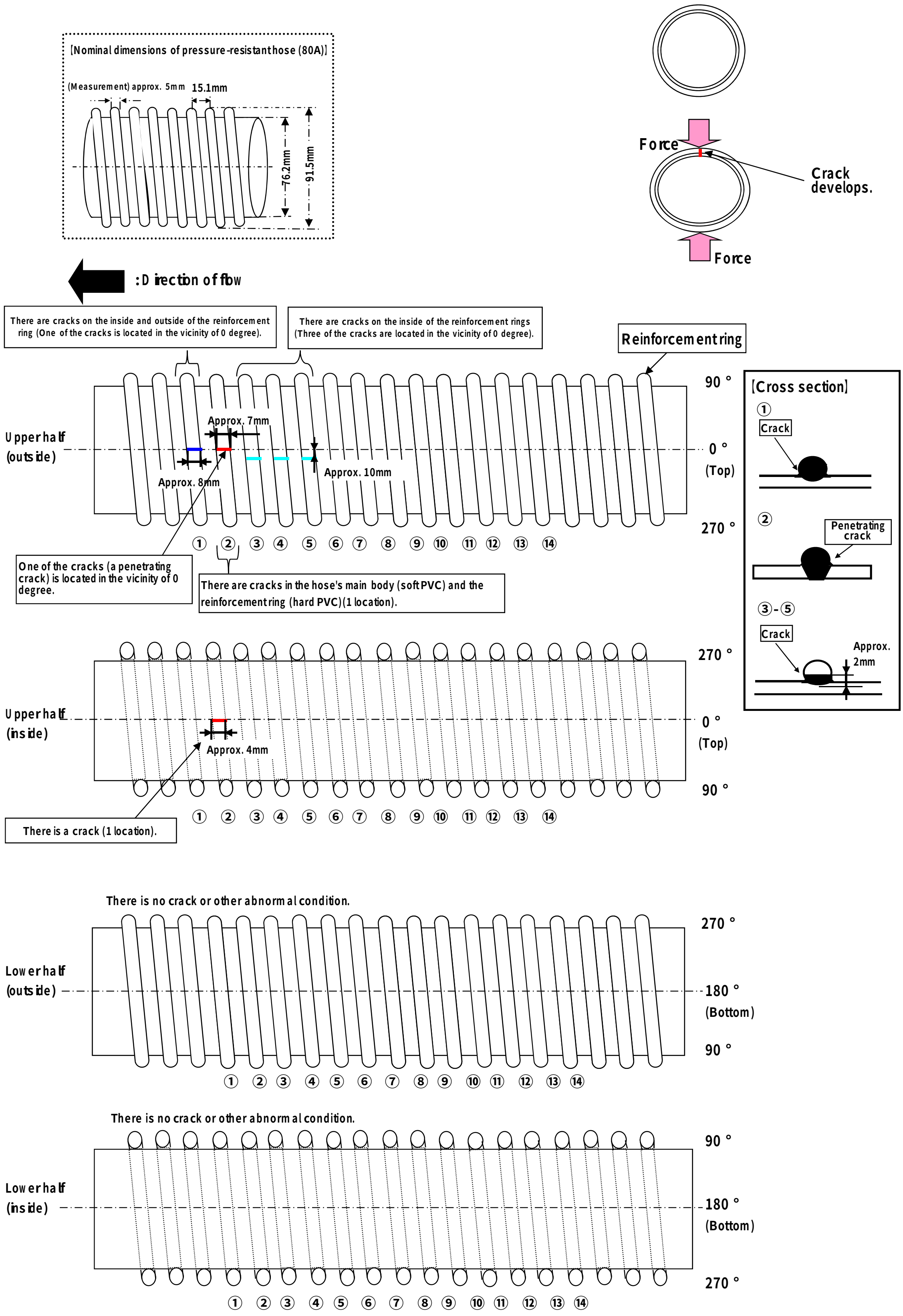


Fig.5 Results of the Inspections of the External and Internal Surfaces of the Pressure-resistant Hose

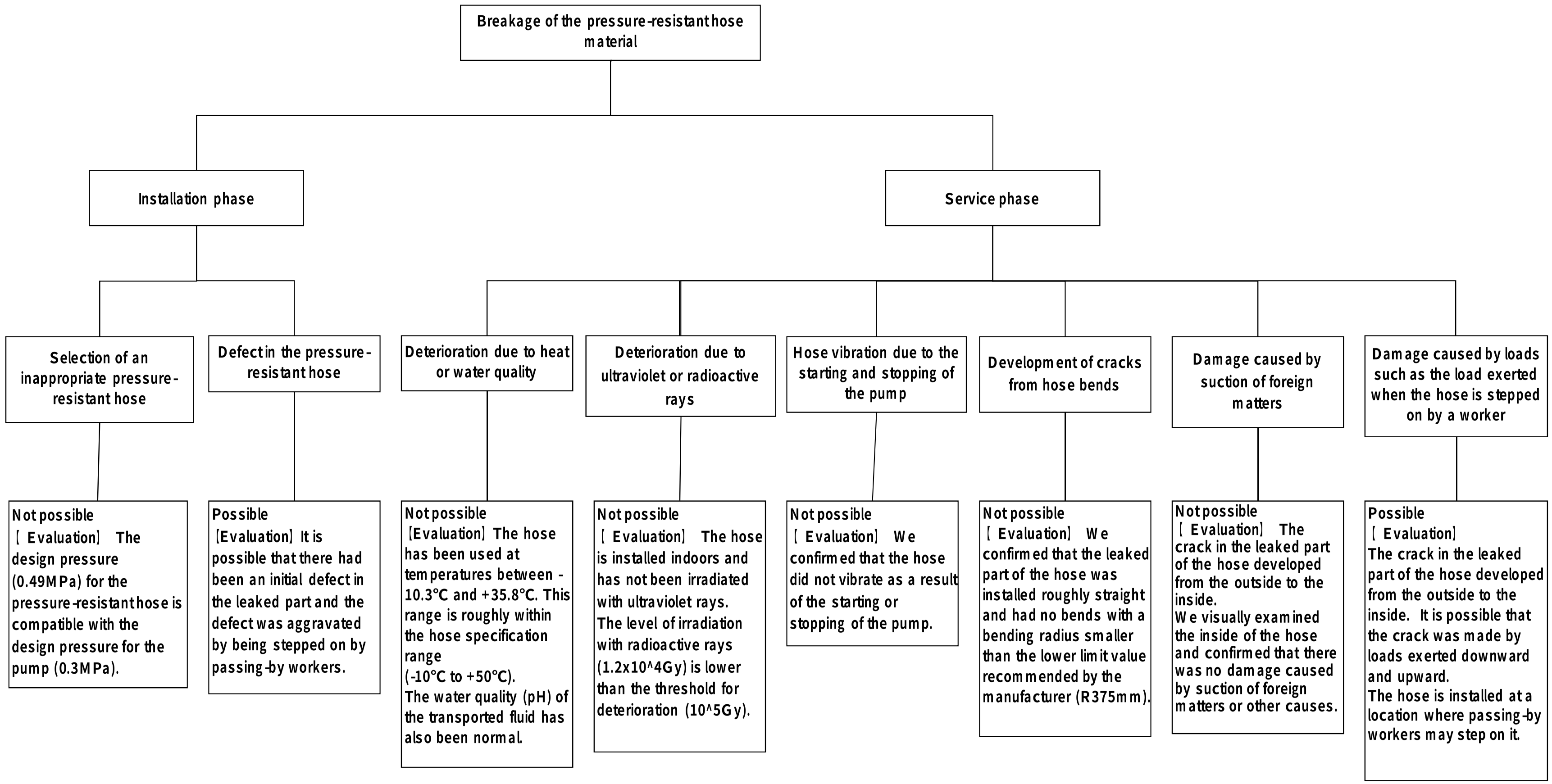


Fig.6 Causal Factors for the Hose Damage

About the Development of the Crack in the Pressure-resistant Hose

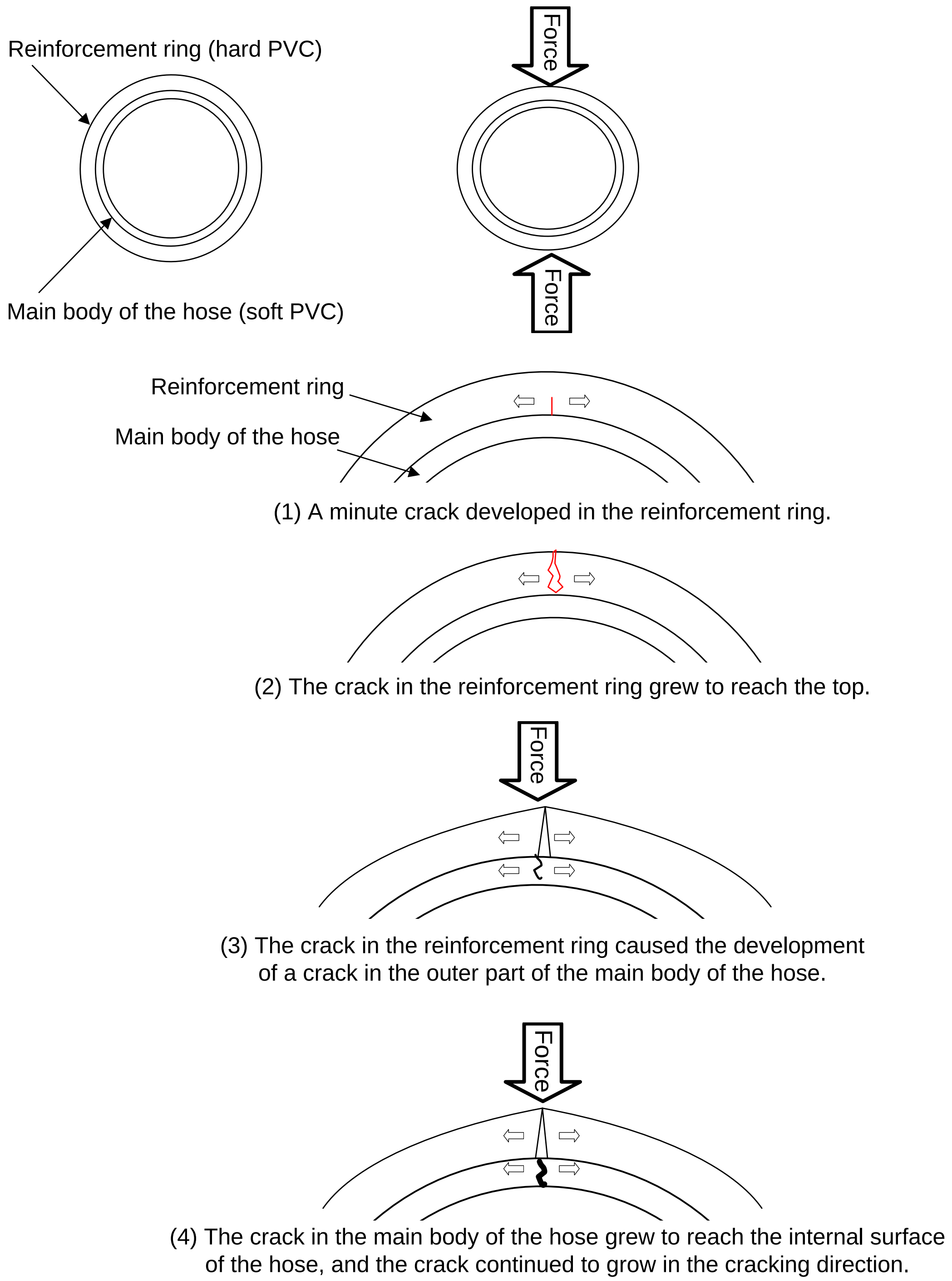


Fig.7 Schematic Diagram of the Development and Growth of the Crack in the Pressure-resistant Hose

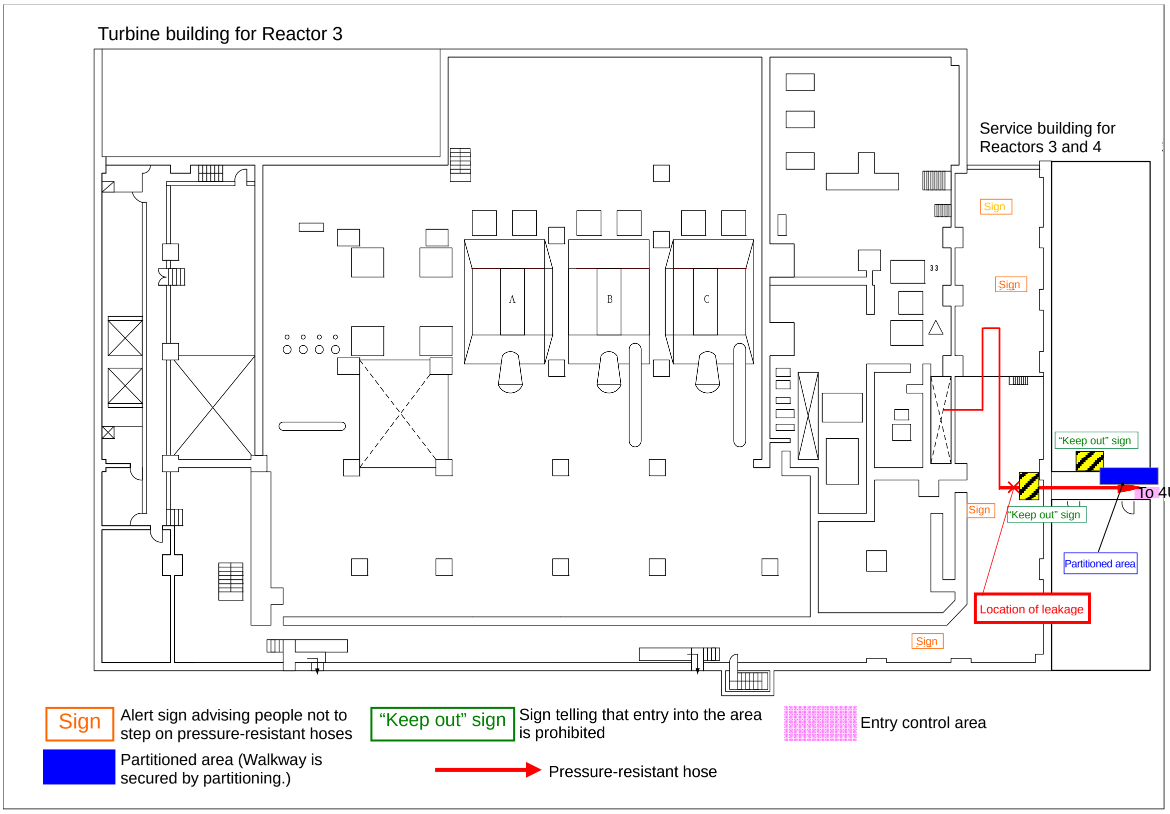


Fig.8 Entry Control Area and Alert Signs for Reactor 3

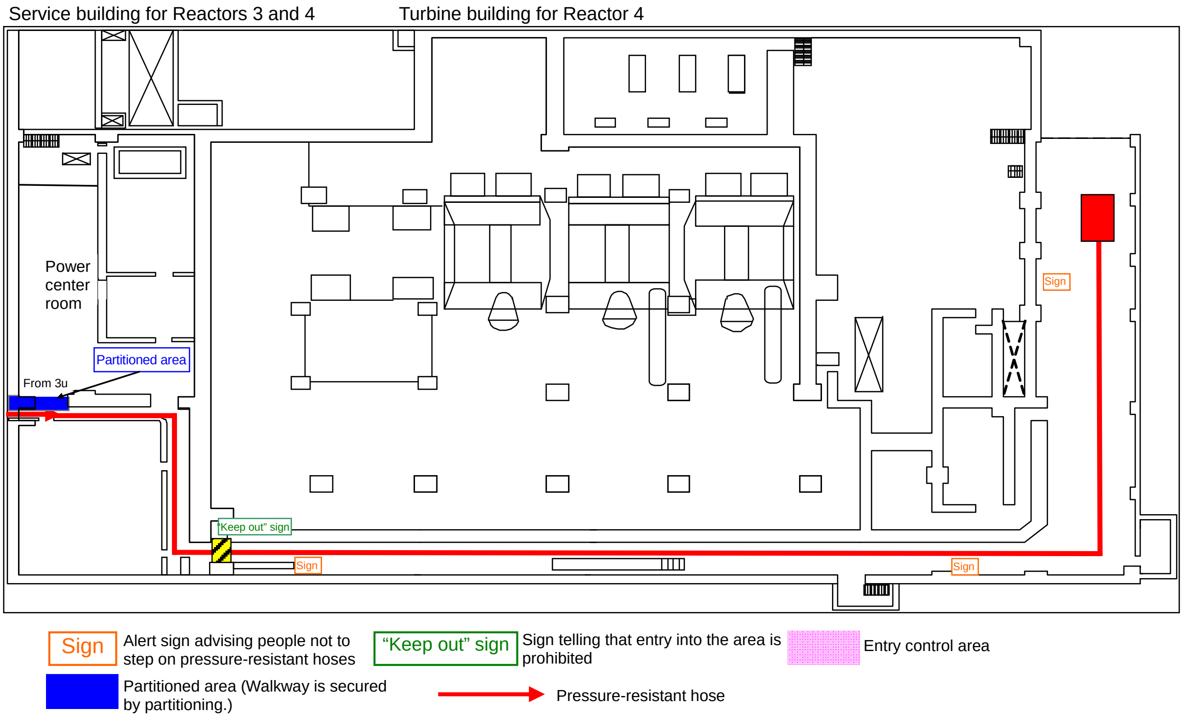


Fig.9 Entry Control Area and Alert Signs for Reactor 4

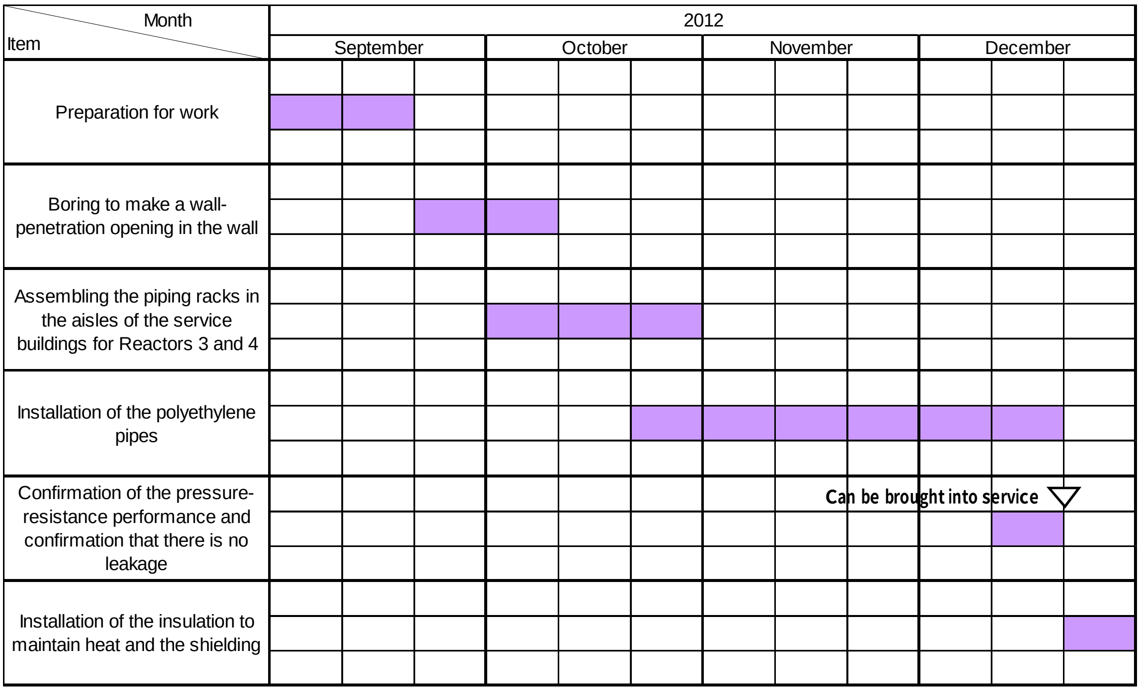


Fig.10 Schedule for the Work to Convert the Transfer Line for Reactors 3 and 4 into a Polyethylene Line

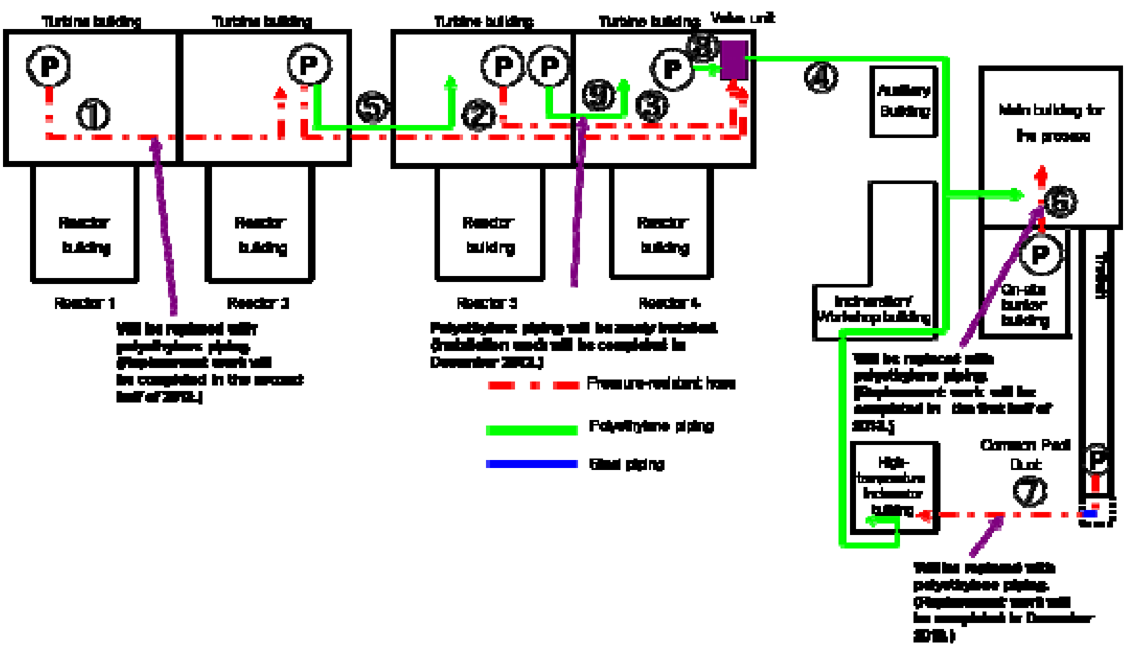


Fig.11 Plan to Convert the Transfer Line of the Resident Water Transfer Equipment into a Polyethylene Line

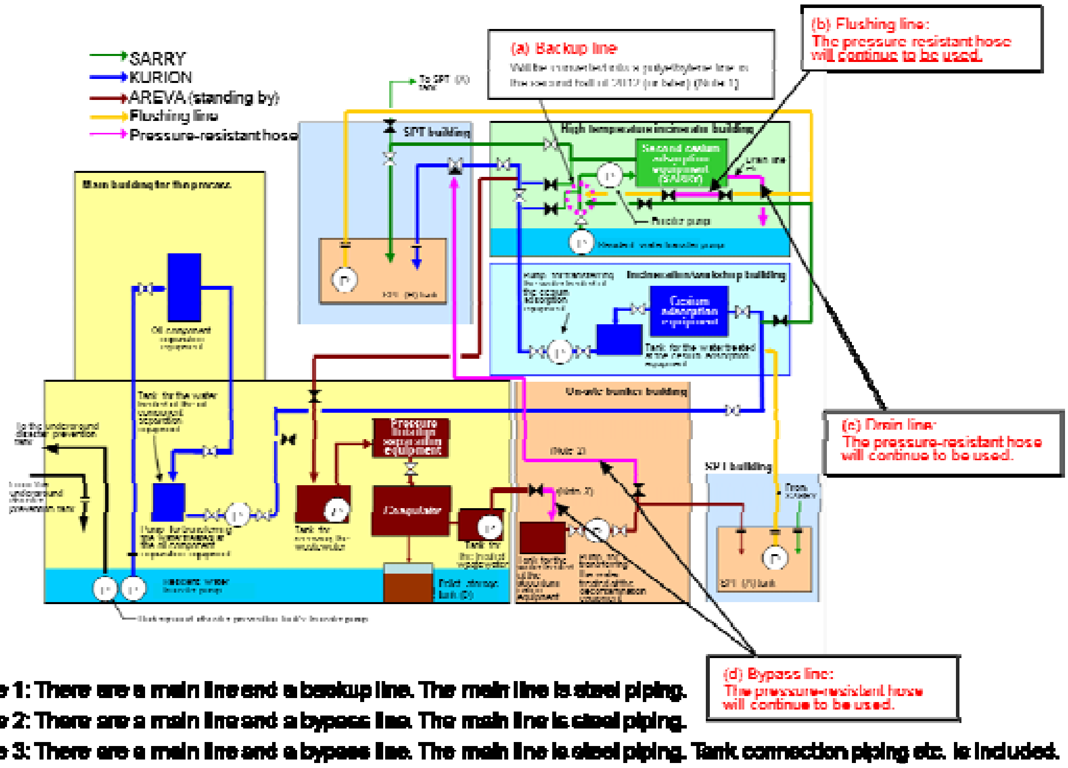
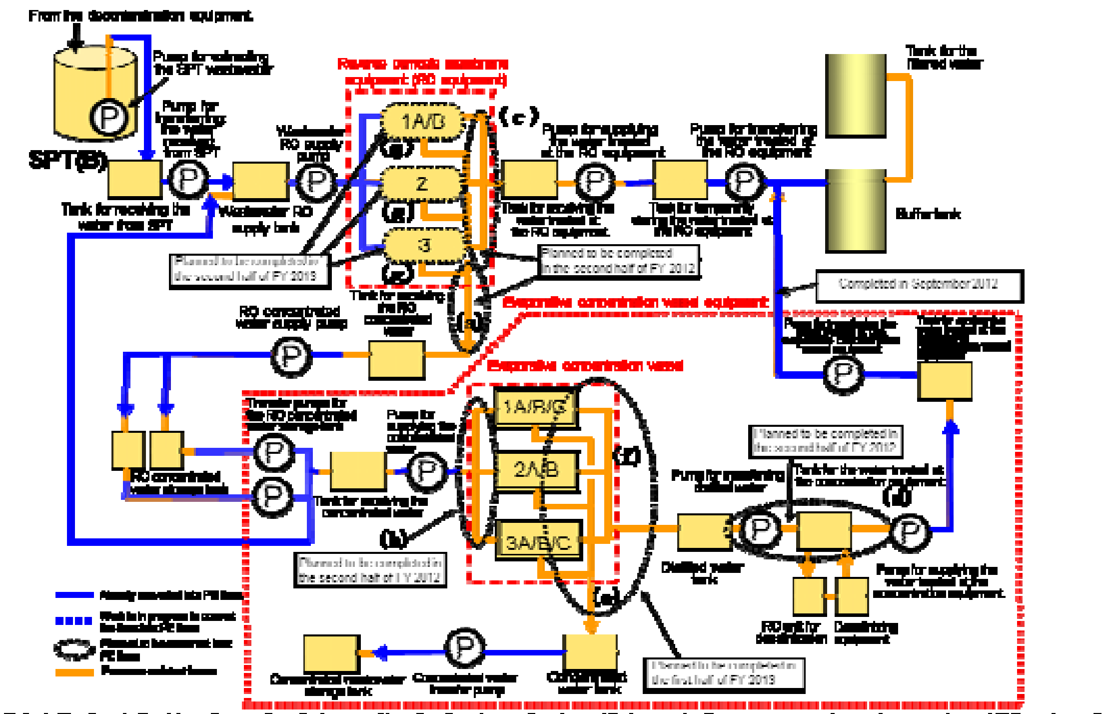


Fig.12 Plan to Convert the Processing Equipment Lines into Polyethylene Lines



Note 1: The lines in the (g) section are lines that connect together the planned equipment that comprise the reverse osmosis membrane equipment (RO equipment).
Note 2: In the areas where pressure-resistant hoses are left, such as inlets and outlets of storage tanks and tanks, the hoses will continue to be used without being replaced with polyethylene pipes, because resilience and flexibility are required. However, the hoses will be superseded as the other areas by means of bypass, etc.

Fig.13 Plan to Convert the Desalination Equipment Lines into Polyethylene Lines

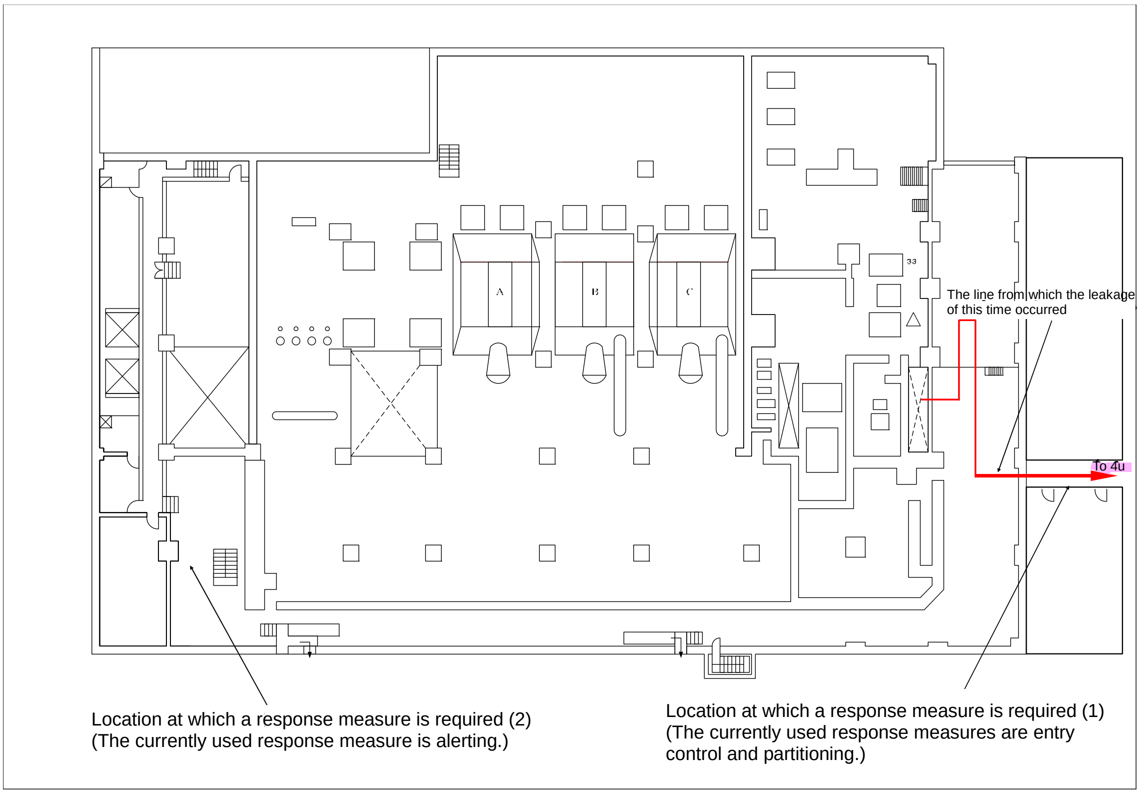


Fig.14 Locations at which a Response Measure Is Required (First Floor of the Turbine Building for Reactor 3)

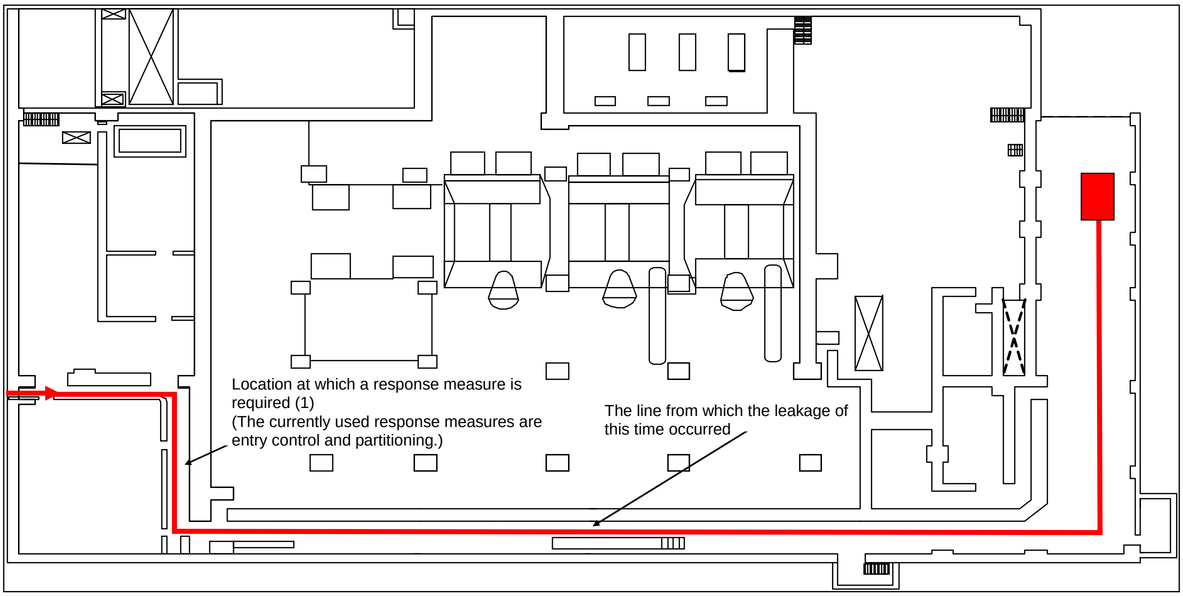


Fig.15 Locations at which a Response Measure Is Required (First Floor of the Turbine Building for Reactor 4)

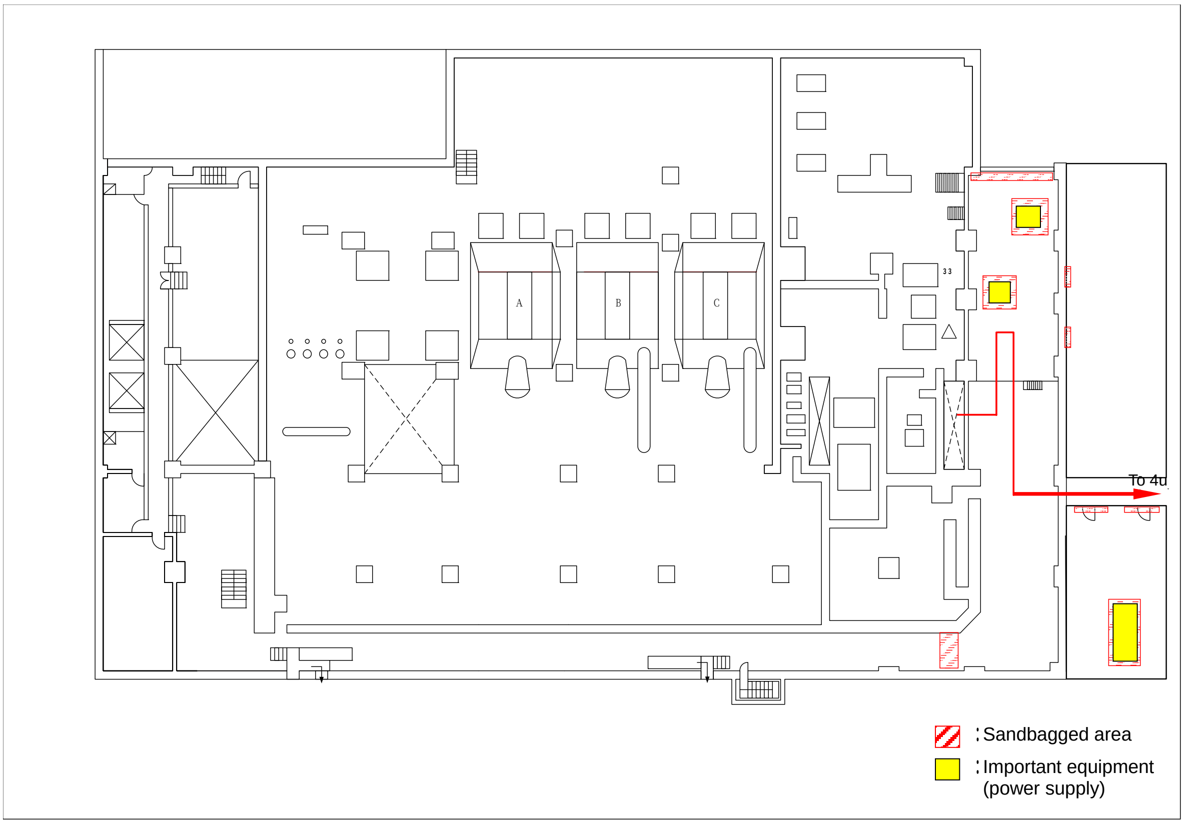


Fig.16 Areas Isolated by Partitioning with Sandbags in the Turbine Building for Reactor 3

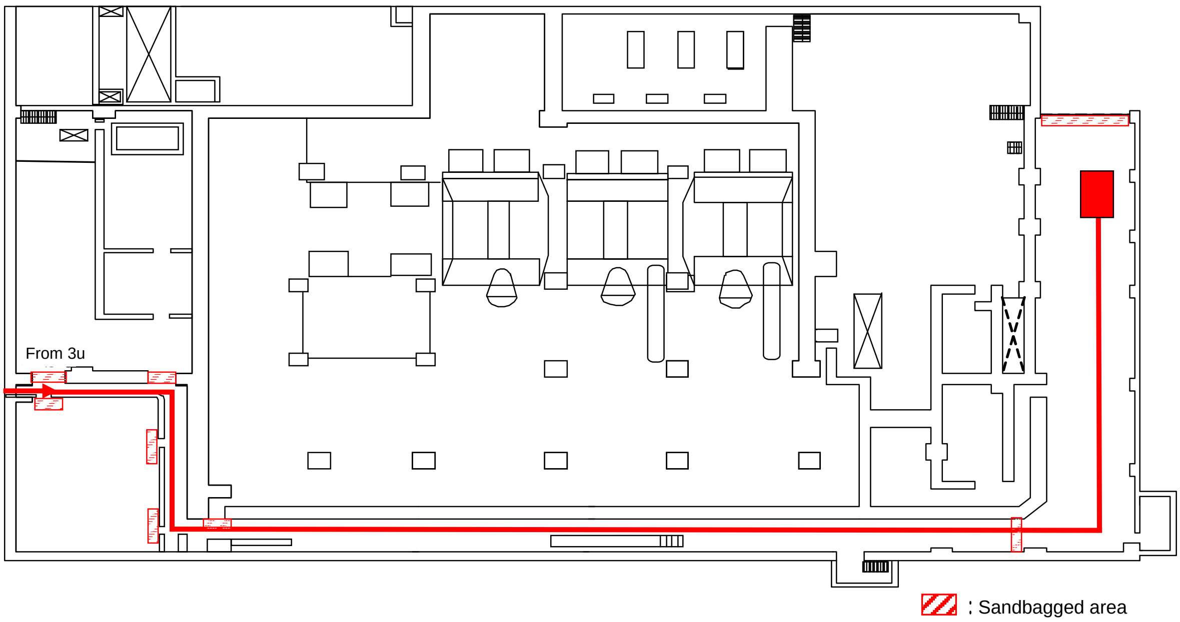


Fig.17 Areas Isolated by Partitioning with Sandbags in the Turbine Building for Reactor 4

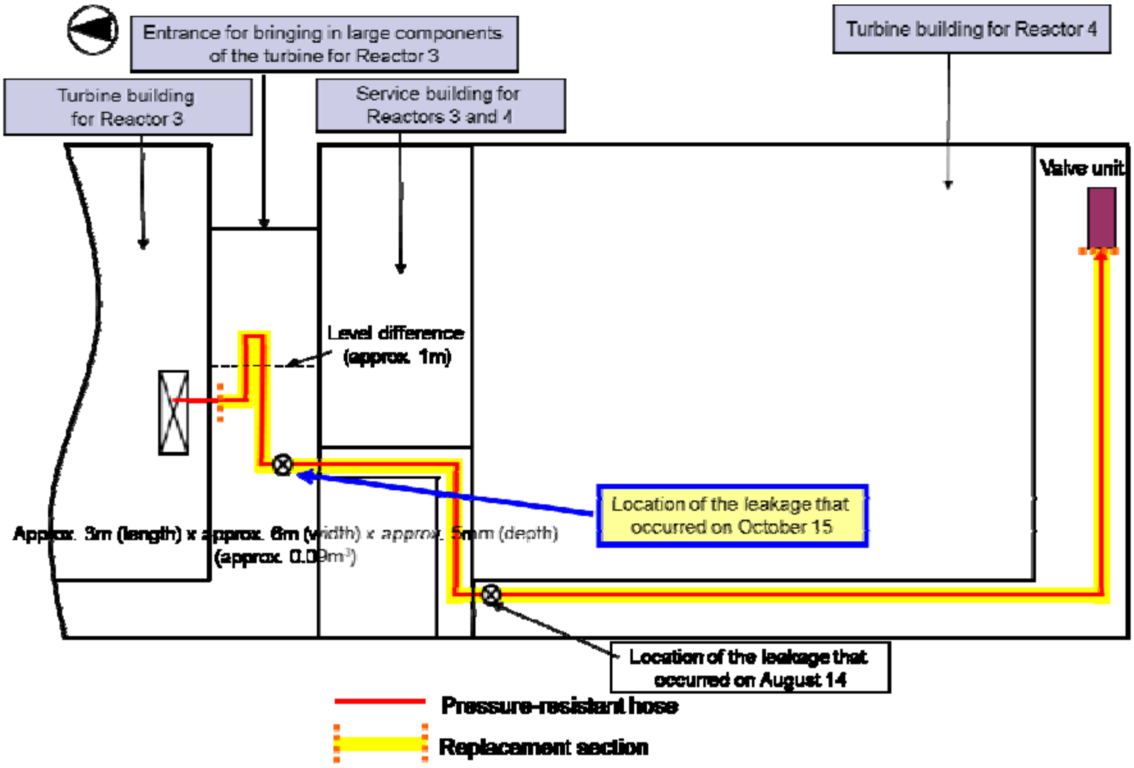


Fig.18 Recurrence Prevention Measure (section in which the B system pressure-resistant hoses are to be replaced)