Cause of and Measures against Leakage from Contaminated Water Treatment Facility's Desalination System (Reverse Osmosis Membrane System) RO-3 at Fukushima Daiichi Nuclear Power Station

< Reference >
December 6, 2013
Tokyo Electric Power Company

[Outline]

- **Time and date: At around 9:35 AM on October 9, 2013**
- **Location: Inside the temporary warehouse for the desalination system (RO-3)**
- **Leakage spot: A joint (cam lock) part of piping at the RO-3 entrance side**
- **Status over time:**

Around 9:35	During removal of pressure-resistant hoses in construction for replacement with polyethylene (PE) pipes, leakage occurred when a worker mistakenly took off a hose-connection cam lock part, which was not supposed to be taken off.
9:48	An alarm was given by the leakage detector.
9:55	A TEPCO employee checked the inside of the temporary warehouse, and found water accumulated on the floor surface. The upstream pump (the waste liquid RO supply pump), which was then performing cycle operation, was manually stopped.
Around 10:15	The entrance valve of RO-3 was “shut off”.
Around 10:45	The hose-connection cam lock part was restored.
10:50	Leakage was confirmed to have stopped.
17:15	6 of 11 workers who worked to contain the leakage left the power station after having been decontaminated since they were found to have contamination on their bodies (but have no contamination on their faces).
October 9 to 15	Recovery of the leaked water from inside the temporary warehouse, and decontamination of the inside of the temporary warehouse were carried out.
October 11	Operation of RO3-1 and 3-2 was restarted after confirmation of the restoration status of the cam lock part and confirmation of the leakage status.

- **The amount of leaked water: Approx. 11m^3 (the definite value*), none of which flowed out to the outside of the dike.**

*** On the day when the leakage occurred (October 9), we announced the provisional value of 7m^3, and later obtained the definite value on October 11 after the completion of recovery of the leaked water.**

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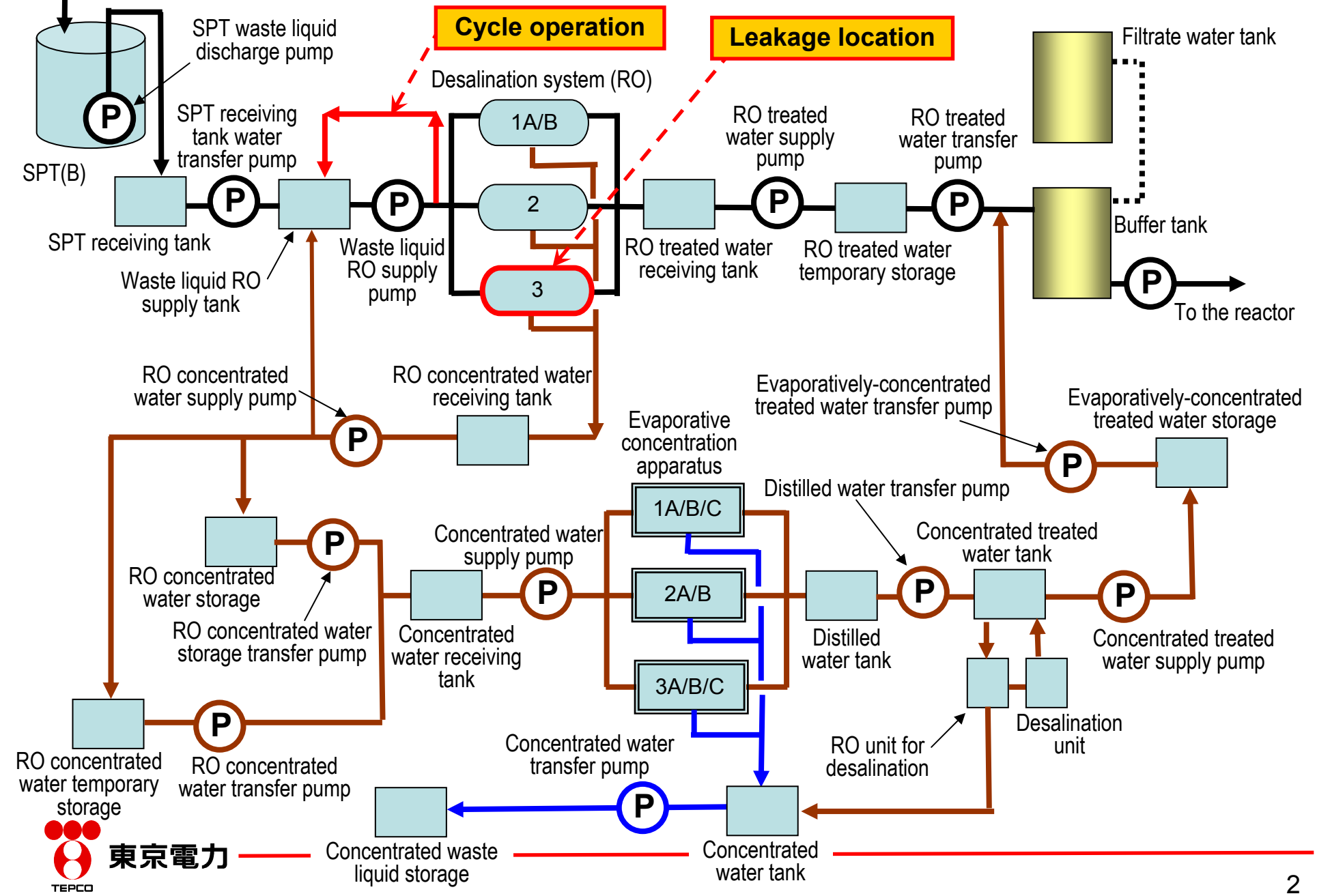
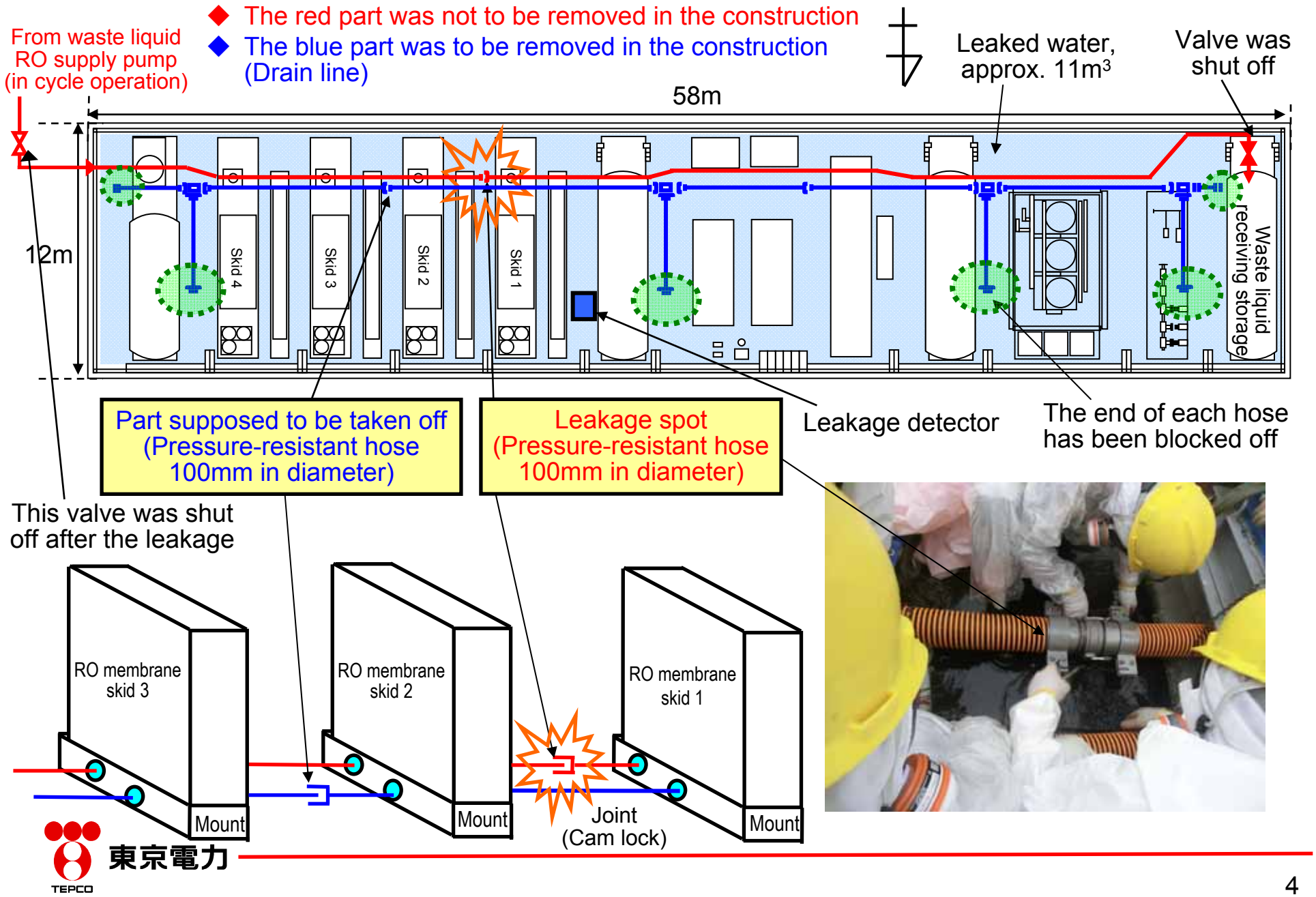
Schematic system diagram of the desalination system



Structures in RO-3 temporary warehouse and leakage spot

Status of the pressure-resistant hose joint part

Leakage-related conditions inside RO-3 temporary warehouse



Cause analysis results on and measures against leakage from the cam lock

	Cause analysis results	Measures
Direct causes	<Lack of identification marking to indicate what to remove, and false recognition> ① The cam lock to be taken off was not marked for identification. ② Work Team Leader B took off the wrong cam lock thinking that was the correct one. <Inadequate safety protection for the wrong cam lock> The waste liquid transfer line was in service (was having pressure applied).	(1) Clarification of requirements concerning identification marking at the procurement stage ① In a case where modification or other construction involves detachment or attachment of a component such as a cable or pipe of an important line, TEPCO stipulates in the construction common specifications or the construction additional specification that the component shall be marked for identification without fail and that a construction supervisor of TEPCO shall confirm the marking, so that the marking can clearly identify and prevent misidentification of the component. ② TEPCO requests each contract company to, based on the procurement requests, stipulate in the construction manual procedure that the contract company shall regard meeting requirements concerning identification marking and having relevant components marked for identification as a hold point in quality management in the work process and shall have it confirmed by a construction supervisor of TEPCO whether the requirements have been met and whether the relative components have been properly marked. (2) TEPCO provides identification of the skid numbers (put up the skid numbers) at easy-to-see locations on the RO system with large-enough characters. (3) Clarification of how to determine the need to conduct a pre-work safety evaluation and how to conduct a pre-work safety evaluation In terms of attitudes towards how to determine the need to conduct a pre-work safety evaluation and how to rank a specific case in the evaluation, TEPCO revises the Fukushima Daiichi pre-work safety evaluation guide (hereinafter "the evaluation guide") to enable the guide to function to appropriately detect risks in consideration of the 3 Hs. Specifically, the evaluation guide will be revised to include: a requirement that risks shall be detected at each step in a series of work steps in consideration of each of the 3 Hs; and case examples of pre-work safety evaluations, which are intended to serve as references in determining the need to conduct a pre-work safety evaluation and in selecting a rank. (4) Establishment of a scheme for conducting a safety measure examination TEPCO establishes a scheme (including an organization) by which a group responsible for facilities, the control of which is yet to be transferred to the operation section, can appropriately administer work permits.
Indirect causes	<Lack of identification marking> ① A construction supervisor of TEPCO thought that identification marking, which was provided by Cooperative Company B for the purpose of clearly indicating the pressure-hoses to be removed, were applicable also to this work, which was conducted by Cooperative Company A. ② While each cam lock was not marked for identification, Construction Chief A thought that he would be able to find the correct cam lock by tracking a line marked for identification. ③ Worker Team Leader B knew beforehand the correct cam lock. However, the skid numbers on the RO system's skids were so small that the leader had difficulty in having a clear view of the numbers and grasping the accurate positional relationship between each of the RO system's skids and the correct cam lock. <Inadequate safety measures for the line of the wrong cam lock> ① Because the line to be removed was marked for identification, the construction supervisor of TEPCO did not expect the risk of having the correct cam lock misidentified. Without considering the need to separate the nearby pressure-resistant hoses, the supervisor requested the operation management section only to stop RO-3 for the safety and protection of the facilities. ② Safety measures prepared by the construction supervisor in the TEPCO's primarily responsible group had not been fully examined. <Inadequate conduction of a pre-work safety evaluation> Despite their recognition that this work was to be carried out near important facilities and equipment and had characteristics called 3 Hs*, the members of the TEPCO's primarily responsible group did not conduct a pre-work safety evaluation because they had considered that stopping the RO-3 system would be sufficient to eliminate risks of affecting the important facilities and equipment (the nearby pressure-resistant hoses in this case) around the work area.	

Example of marking for removal identification

* The term "3 Hs" indicates 3 Japanese words "hajimete (for the first time)", "henka (change)", and "hisashiburi (after a long interval)".

Cause analysis results on and measures against occurrence of body contamination

	Cause analysis results	Measures
Direct causes	<Inadequacy of contamination prevention measures> ① When contaminated water leaked from the cam lock, Work Team Leader B and Workers C and D did not immediately leave the site. ② Work Team Leader B and Workers C, D, E, and F conducted work to stop water wearing inadequate gears. <Inadequate undressing manner> The workers undressed while contaminated water attached on the outer surfaces of their anoraks had not been wiped off.	TEPCO requests the cooperative companies to follow the following requirements (a) and (b) at meetings regularly held and participated by TEPCO and cooperative companies, and informs TEPCO employees of these instructions via the intra-company network: (a) In case of a leakage incident, a worker must first leave the location of leakage for the purpose of preventing himself from being contaminated, when there is a risk of being contaminated because of his light gears worn before the leakage. Further, when carrying out restoration work such as stopping water, a worker must start carrying out the work after wearing adequate protective gears. (b) In a case where a worker takes off an anorak on which contaminated water has been attached, a radiation management specialist must instruct another worker such as a radiation management assistant about the adequate undressing manner including wiping off the contaminated water.
Indirect causes	<Inadequacy of contamination prevention measures> When contaminated water leaked, Cooperative Company A conducted the work to stop water because they thought that the first priority was to mitigate the leakage. <Inadequate undressing manner> ① A worker who helped the undressing had not been instructed to wipe off contaminated water and therefore did not wipe off contaminated water when helping Work Team Leader B and Workers C, D, E, and F take off their anoraks. ② A radiation management specialist was being engaged in helping some of the workers take off their shoes as contaminated water had entered into the shoes. Thinking that the worker who helped the undressing would wipe off contaminated water from the anoraks, the radiation management specialist did not instruct any worker to wipe off the contaminated water attached on the outer surfaces of the anoraks.	

Cause analysis results on and measures against delay of reporting leakage to the restoration team leader

	Cause analysis results	Measures
Direct causes	<Inadequacy of the emergency reporting structure> ① In the course of the incident, when the wrong cam lock was taken off, Work Team Leader B and Workers C and D put a higher priority to restoration of the cam lock in order to mitigate the influence of the leakage, and therefore did not report the incident to the restoration team leader. ② Construction Chief A was not able to make direct contact with the restoration team leader because the leakage area was outside the PHS service areas. ③ The entrusted operator did not make direct contact with the restoration team leader although he knew that the leakage detector gave an alarm. ④ The person responsible for operation management did not make contact with the restoration team leader because he put a higher priority to initial response after finding water accumulated on the floor surface inside the temporary warehouse.	(1) TEPCO reinforms its employees, for example, via the intra-company network that, in case of an incident such as an accident or fire, the incident shall be immediately reported to the restoration team leader in accordance with "the organizational reporting structure in case of an accident, fire or personal accident". (2) At meetings regularly held and participated by TEPCO and cooperative companies, TEPCO requests the cooperative companies to follow the following requirements: (a) The cooperative companies must reinform their workers that the "contact information stipulated by the power station", which TEPCO requests the cooperative companies to comply with in the construction common specifications, corresponds to "the organizational reporting structure in case of an accident, fire or personal accident". (b) Based on "the organizational reporting structure in case of an accident, fire or personal accident", each cooperative company must prepare an organizational reporting structure for emergencies in which responsibilities of concerned people are clearly defined, and append the structure to the construction manual procedure. (c) Each cooperative company must secure communication means (such as PHS or cellular phones) enabling the organizational reporting structure for emergencies to be maintained all the time, and must designate, when a person whose responsibility is defined in the structure leaves the site, an alternative person in order to maintain the organizational reporting structure all the time. (3) TEPCO prepares a map containing information on the PHS and cellular-phone service areas, and informs its employees and the cooperative companies about the information in the map, for example, via the intra-company network.
Indirect causes	<Inadequacy of the organizational reporting structure for emergencies> ① Work Team Leader B and Workers C and D thought that Construction Chief A was responsible for reporting an emergency. ② While Construction Chief A was carrying a PHS cell, the leakage area was outside the PHS service areas. Therefore, he immediately asked Construction Chief B, who was outside the temporary warehouse carrying a cellular phone, to ask the person responsible for the construction to report the incident to the restoration team leader. Meanwhile, although the workers of Cooperative Company A had been informed of the organizational reporting structure for emergencies (any person who has found an emergency shall report it to the restoration team leader) but not thoroughly, so they put a higher priority to reporting the incident to their company structure. ③ Construction Chief A did not know that a PHS service area exists near the temporary warehouse. ④ TEPCO had informed its employees of the PHS service areas around the temporary warehouse, but had not fully informed cooperative companies of the areas. ⑤ TEPCO had informed the entrusted operator of "the organizational reporting structure in case of an accident, fire or personal accident" (any person who has found an emergency shall report it to the restoration team leader). However, this structure had been actually practiced differently in such a way that an emergency is reported to the restoration team leader through the person responsible for operation management. ⑥ The person responsible for operation management did not make contact with the restoration team leader because he put a higher priority to initial response such as confirmation of the site conditions, determination on how to stop the leakage, and shutoff of the waste liquid supply entrance valve, which was the supply source.	

Results of dose equivalent rate measurement on workers who had their bodies contaminated

Cooperative company worker	The most contaminated part	Actual dose results of the day (APD)		Skin dose equivalent rate from contamination (mSv)	Dose at work on the day (mSv)			Accumulated dose in FY 2013 (mSv)			5-year accumulated effective dose (mSv)
		Gamma dose (mSv)	Beta dose (mSv)		Effective dose	Dose equivalent rate (skin)	Dose equivalent rate (lens)	Effective dose	Dose equivalent rate (skin)	Dose equivalent rate (lens)	
Construction Chief A	Left heel	0.30	0.2	4.8	0.35	5.3	0.5	9.13	20.0	11.1	14.02
Work Team Leader B	Lower part of belly	0.15	1.2	1.1	0.18	2.5	1.4	10.81	25.1	22.8	49.35
Worker C	Back hip	0.15	0.7	0.5	0.16	1.4	0.9	2.55	3.8	3.3	3.51
Worker D	Sole of right foot	0.12	0.6	0.1	0.13	0.8	0.7	10.28	20.6	18.5	46.27
Worker E (for support*1)	Left thigh	0.42	0.7	0.8	0.44	1.9	1.1	4.83	8.5	5.5	8.45
Worker F (for support*1)	Sole of left foot	0.12	0.2	46.7*2	0.18	5.5	0.3	2.93	50.0	2.6	31.28
						Dose limits in the public notice (mSv)		50	500	150	100

*1: Workers who had been engaged in different work.

*2: Because the contamination level on a nail portion of the foot was 12,400cpm when this worker left the site on the day the incident occurred, Cooperative Company A conducted dose measurement until the contamination level came down to 7,500cpm, which is sufficiently low compared to the criteria (13,000cpm) for leaving the site. His skin dose equivalent rate from the contamination was measured at this stage. Note that the skin dose equivalent rates were measured according to the Regulation Concerning Prevention from Radiation Hazards due to Ionizing Radiation.

The 6 workers found to have their bodies contaminated were checked by Cooperative Company A for radiation exposure. As a result, it was confirmed that their yearly effective doses, 5-year accumulated doses and dose equivalent rates (lens of the eyes and skin) were all under the dose limits stipulated in Article 5 of “the public notice stipulating requirements for the operational safety and the protection of specified nuclear fuel material at the TEPCO's Fukushima Daiichi NPS nuclear reactor facilities”.