Key safety measures at Fukushima Daiichi Nuclear Power Station

Reference materials

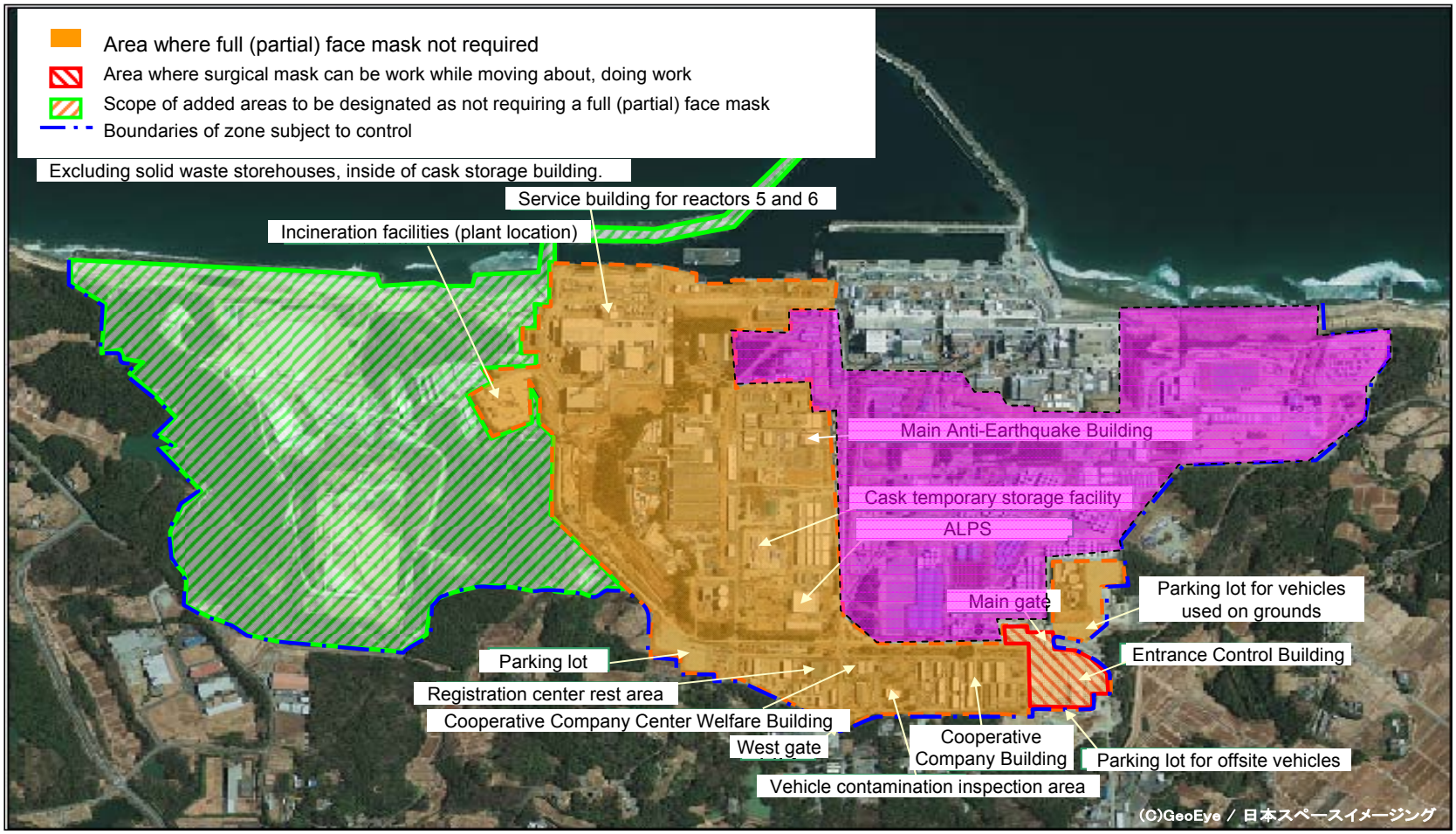
November 8, 2013

Tokyo Electric Power Co., Inc.

Reference 1: Improvements in working conditions

Reference 1-1: Enlargement of non Requiring Full Face Mask area

- Sequentially designate areas where it may be possible to forego full face masks, after confirming concentration of radioactive materials in the air and soil (orange-tinted area on illustration below)
- Debris storage area will be designated an area not requiring full face masks after Nov. 11. As a result, full face masks will not be required on more than 2/3 of the premises. (green-tinted area on illustration below)
- Plan to expand area in which full face masks will not be required by implementing facing countermeasures on the surface of the ground around the tanks (pink-tinted area on illustration below)



Areas where full face masks will not be required

Reference 1-2: Debris removal at sea side

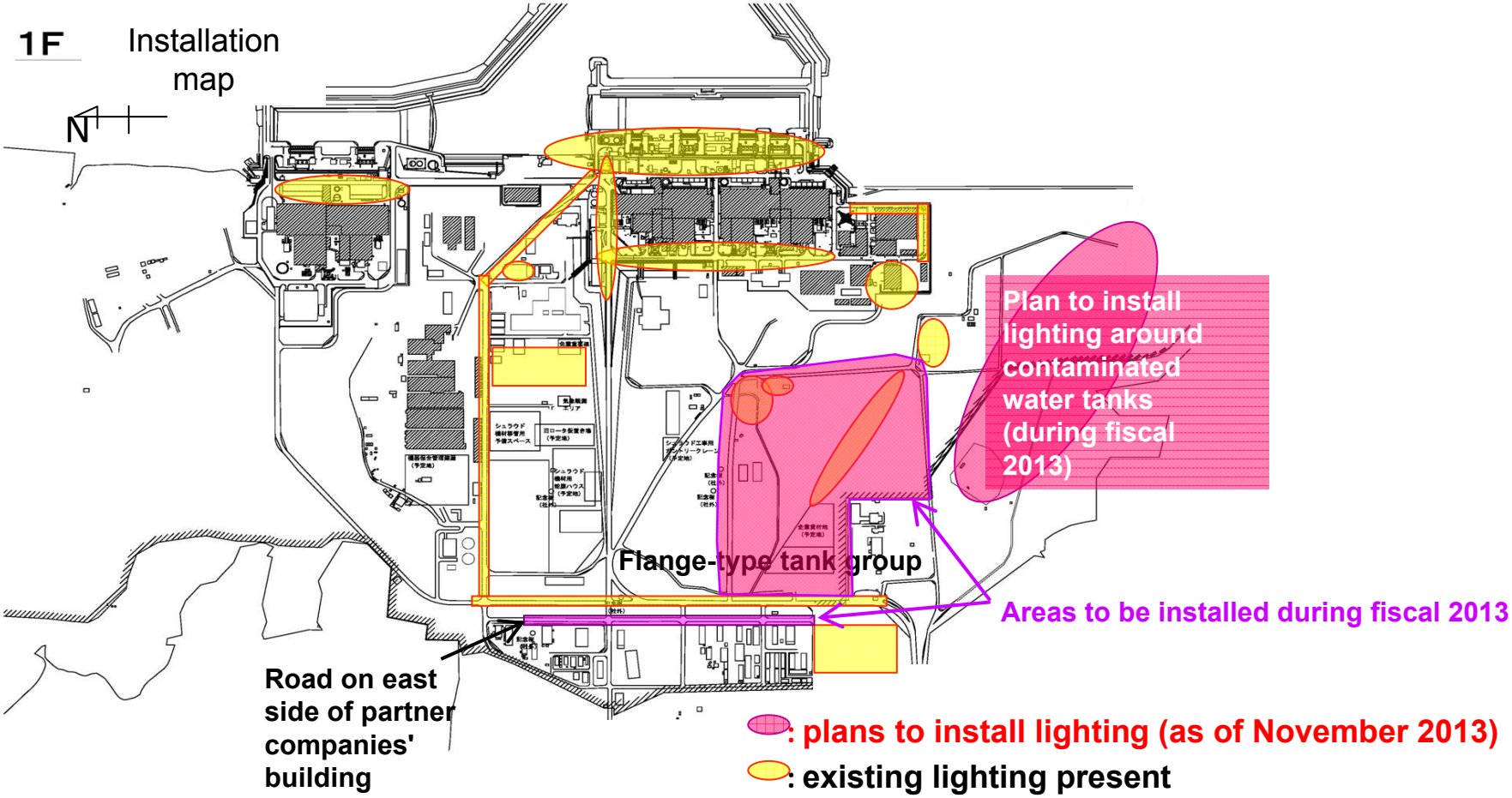
- Begin removal of vehicles in November.

(photograph date: November 7, 2013)

(photograph date: November 7, 2013)

Reference 1-3: Reinforcement in lighting at the site

- Restoration and installation of lighting to satisfy needs on-site (already done: yellow-tinted areas)
- Plans to sequentially implement augment patrols and similar measures in contaminated water tank areas starting in October 2013. (pink-tinted area on illustration below)



Lighting restoration and installation plans

Reference 1-4: Constructing of Fukushima Daiichi new administration office building

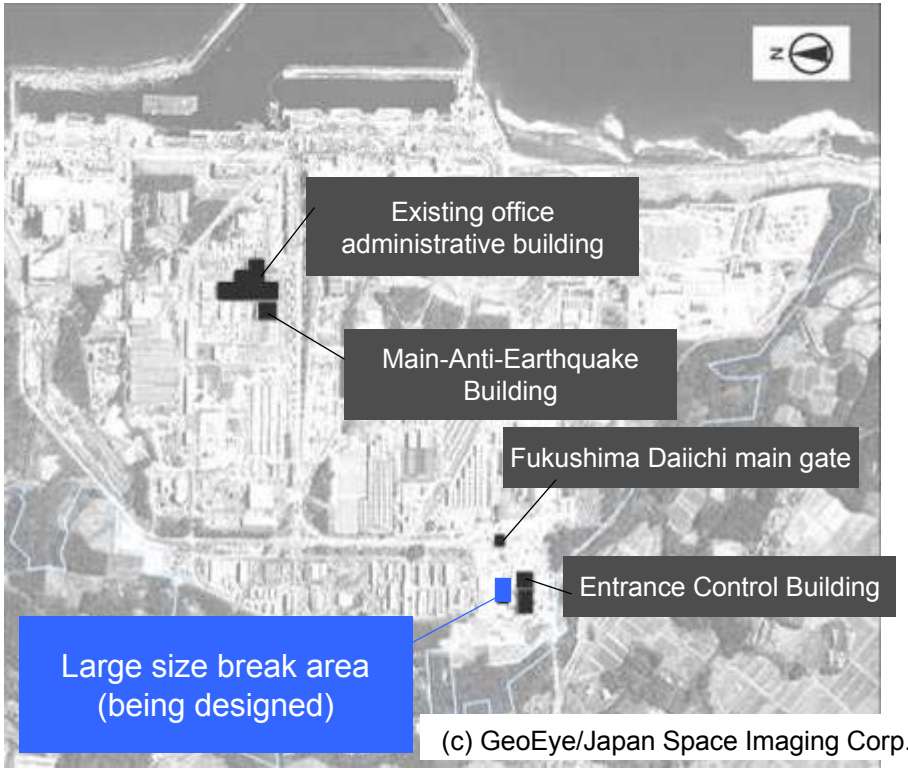
Illustration of building interior

*Studying vicinity of Entrance Control Building as candidate site for construction of both temporary and main office administrative buildings

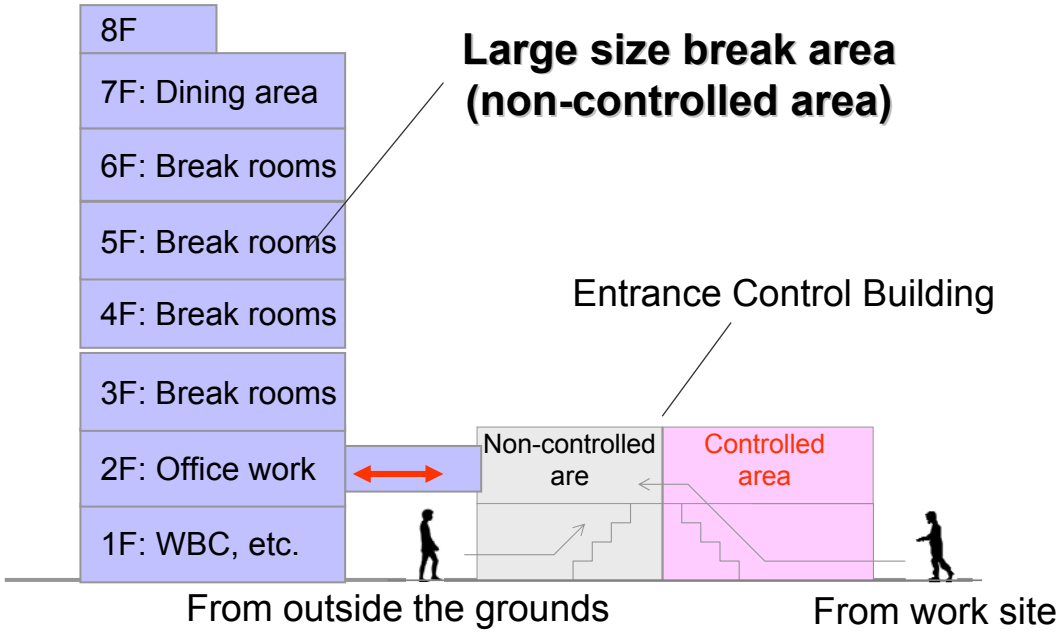
Progress outline

Building name	2013	2014		2015
	second half	first half	second half	
Temporary office administrative building	1st phase of construction		2nd phase of construction	
Main office administrative building				

Reference 1-5: Large size break area



Site layout plan



Lateral view of building

Progress outline

Item	2013	2014	
	second half	first half	second half
Design	■		
Construction		■	

Reference 1-6: Meal Supply Center

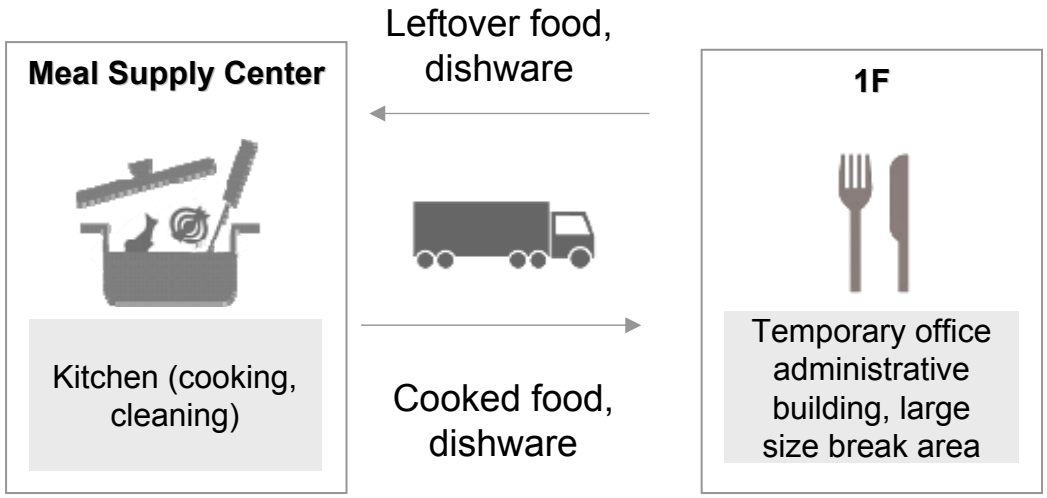


Illustration of method for supplying meal

Photographic representation (cookroom)

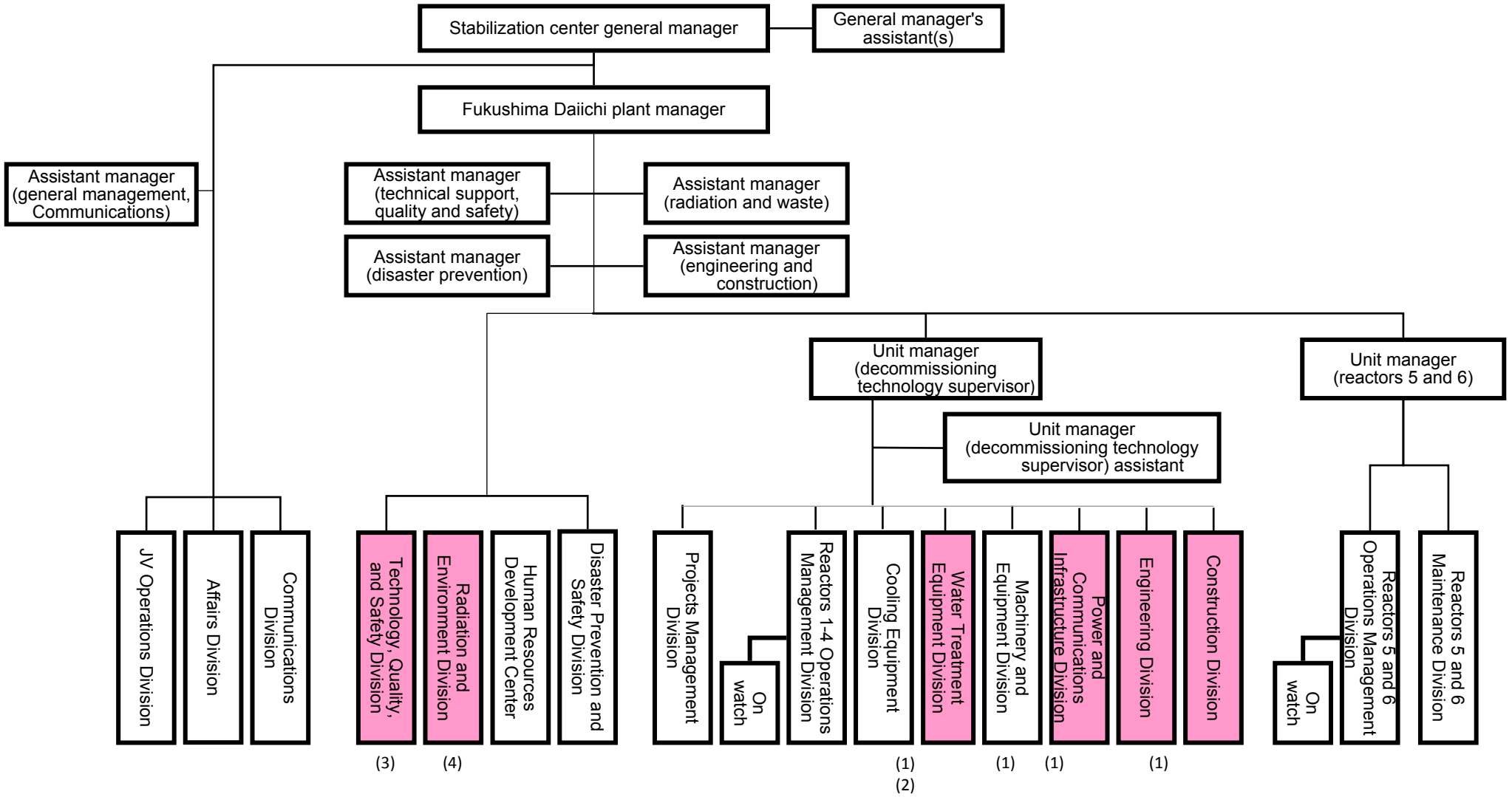
Progress outline

	2013	2014	
Progress	second half	first half	second half
Planning	Site selection, basic plan		
Design and construction		Design and construction	

Photographic representation (dock shelter)

2. Enforcement of Management and System to Secure Safety and Quality

Reference 2: Increase in number of personnel required for contaminated water and tank



Note: ▯ . . . division targeted for personnel augmentation

(1) . . . new and replacement tanks, (2) . . . tank patrols, (3) . . . safety and quality control, (4) . . . radiation and environment analysis and evaluation

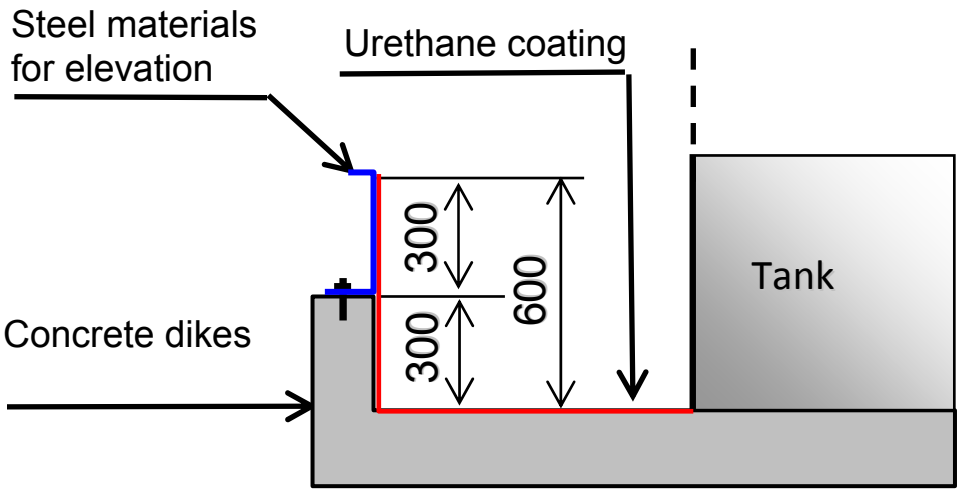
Reference 4: Precautionary measures of rainwater

Reference 4-1: Prevention of overflowing (Elevation of existing dikes)

- **Elevation of existing dikes by using steel plates (stopgap dike)**
  - •Elevation of dikes in H4 north, where contamination levels are highest; area B, where foundations are tilted; and at those locations in H1 east where crowns on dikes are low (high level contamination)
  - •Plan to complete elevations in all other areas within the year (plans for app. 30 cm-high elevations)
- **Further elevation of dikes using concrete, etc (improvement in credibility)**
  - •Being designed in detail

Dikes with steel plating installed (H4 north)

Figure showing conditions for steel-plate elevations



Reference 4-2: Control of rainwater inflow (installation of gutters on tank roofs, etc.)

- **Installing gutters clamps down on influx of rainwater by approx. 60%**

  *Temporary gutters installed (Oct. 24, 2013) at points where high level contamination was found (parts of H4 north and east)

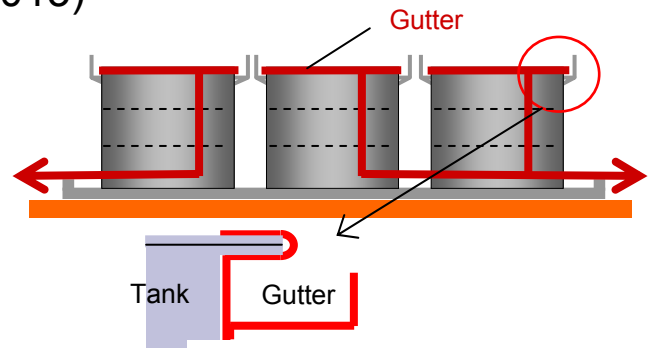
  *Areas (H4 north and east, H3, H2 south, B south) with high level contamination (goal of by end of December 2013)

  *Plan to install in sequence in other areas (goal of by end of fiscal 2013)

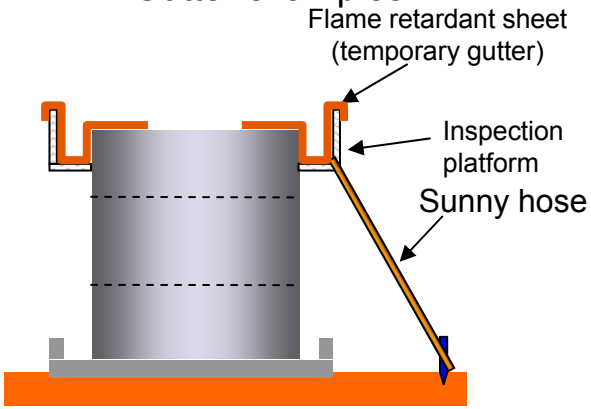
Tank inspection platform

Full view of tank

Situation with temporary gutters installed on tanks in area H4



Gutter examples



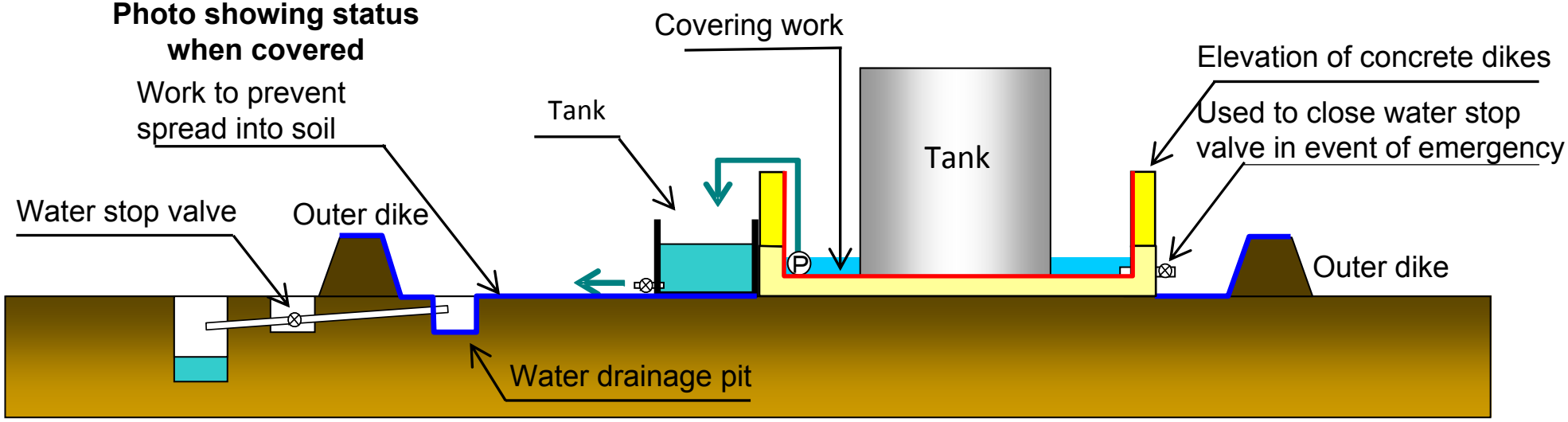
Temporary gutter

Reference 4-3: Prevention of contamination from spreeding into the soil (facing on surface of ground around tanks)

●Covering concrete surfaces inside the dikes, facing for surface of ground inside soil-fill dikes (goal of end of current fiscal year)

Photo showing status when covered

* Cover concrete surfaces inside the dikes and improve waterproofing
* Prevent rainwater from spreading into the soil between soil-fill and concrete dikes, apply facing using concrete (process currently under study)



Reference 4-4: Prevention of water inflow into drainage channel (convert drainage channel into closed conduits)

●Prepare for chance of runoff from soil-fill style dikes by converting drainage channel B into closed conduits (FY2013)

*Cover approx. 1,300 m of drainage channel B, which could receive influxes from tanks and other contaminated water storage facilities

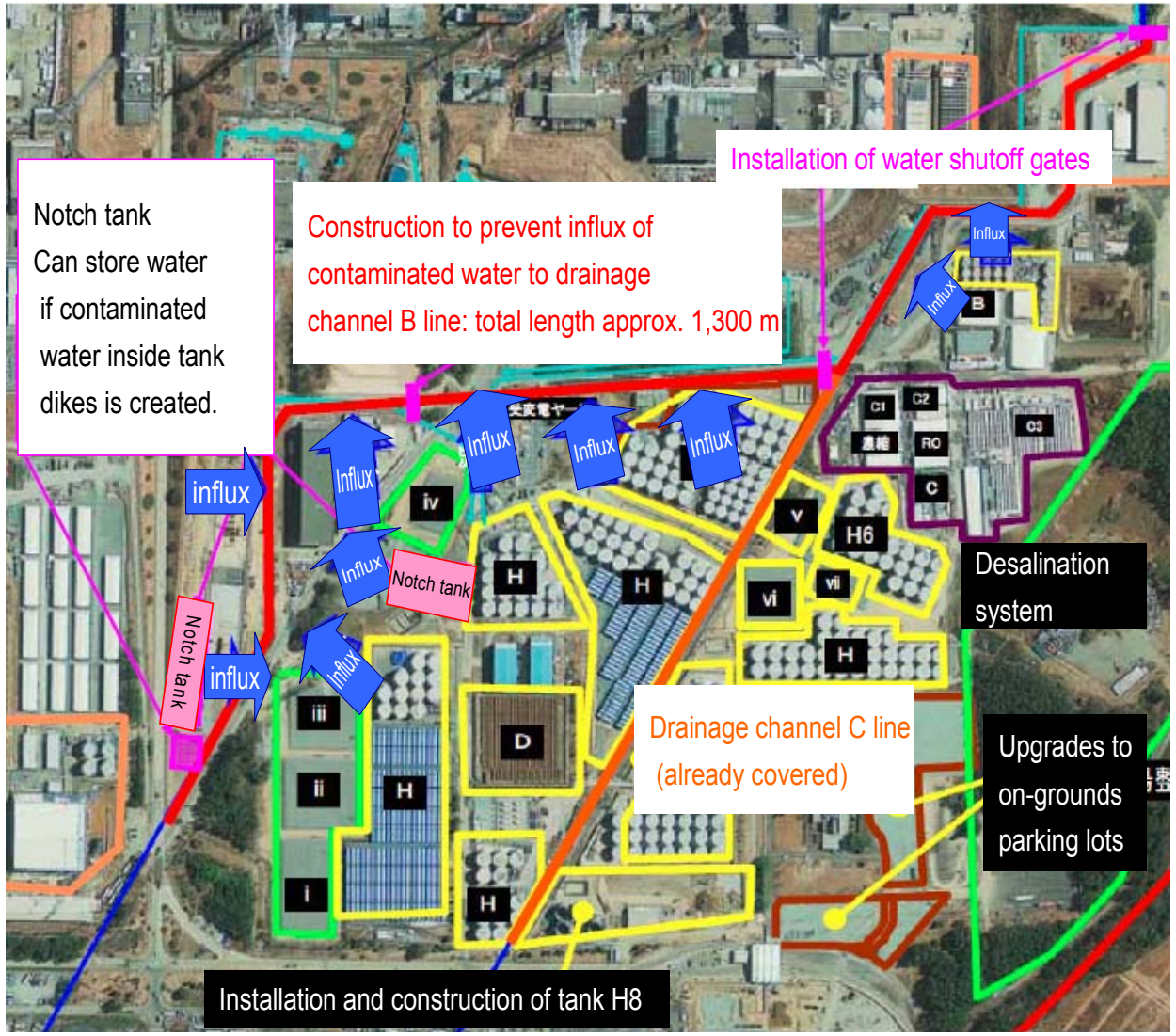
*Plans for conversion to closed conduit by such methods as placing covers on drainage channels

*Install water shut-off gates at 3 places along drainage channel that can be closed in the event of contaminated influx into the channel

Situation with drainage channel C covered

Prior to switch to closed conduits

After switch to closed conduits



Reference 4-5: Increase in capacity of temporary receiving tank of accumulated water

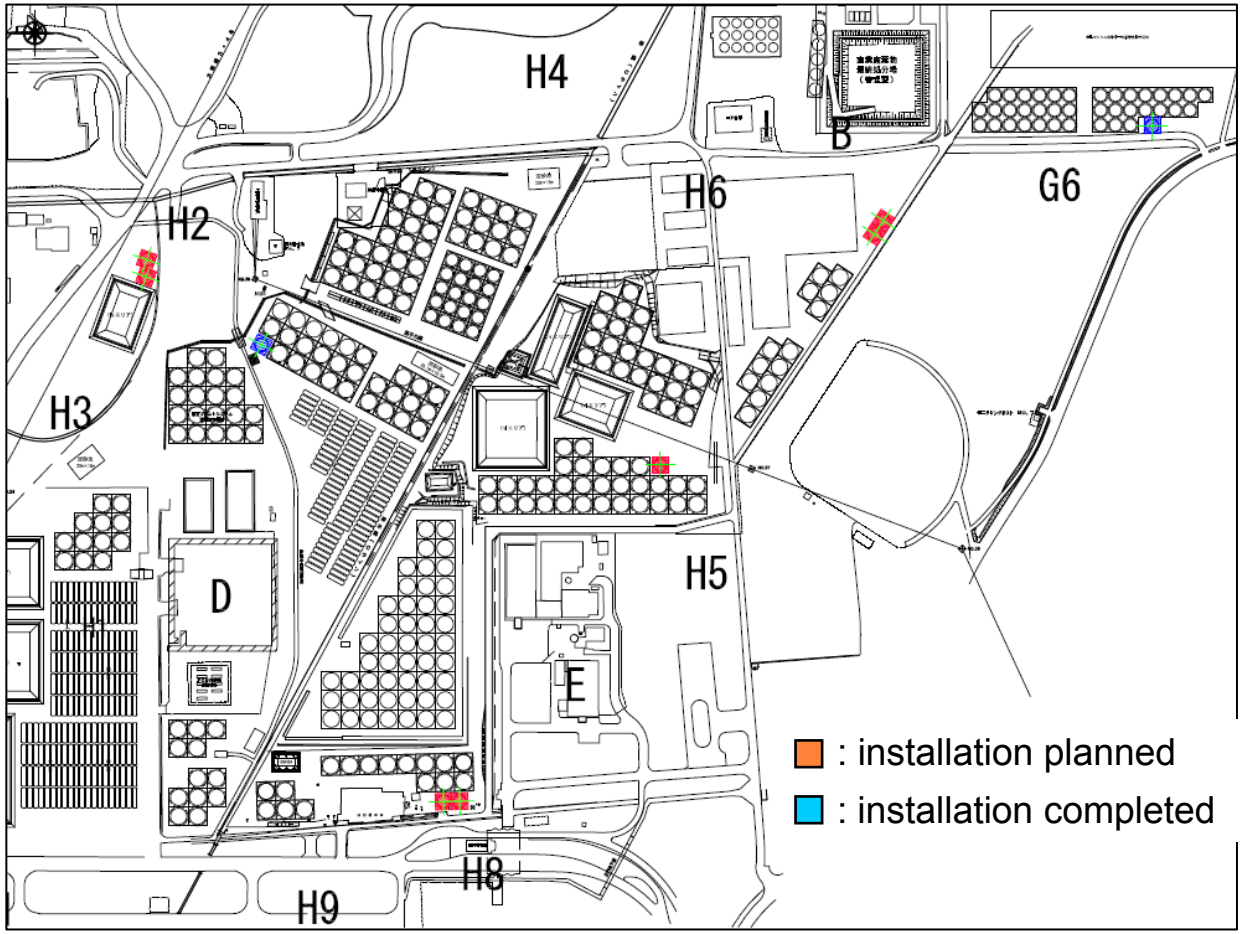
- **Work to increase in capacity of temporary rainwater receiving tanks in order to properly manage discharges of accumulated water**

•Installation of rainwater receiving tanks

✓Install rainwater receiving tanks neighboring areas H2 and G6 (two 500 m^3 tanks)

✓Furthermore, plans to install rainwater receiving tanks near the 4,000 m^3 notch tank cluster and areas C, H5, and H8 (seven 500 m^3 tanks) [FY2013]

✓Together with increasing in capacity of the aforementioned rainwater receiving tanks, further augmentations of drainage system (pumps and hoses) [FY2013]



Locations for installation of rainwater receiving tanks (planned)

5: Causes and Measures of the Leak from the Tank

Reference 5-1 (1): Root causes investigation regarding leaks from tanks

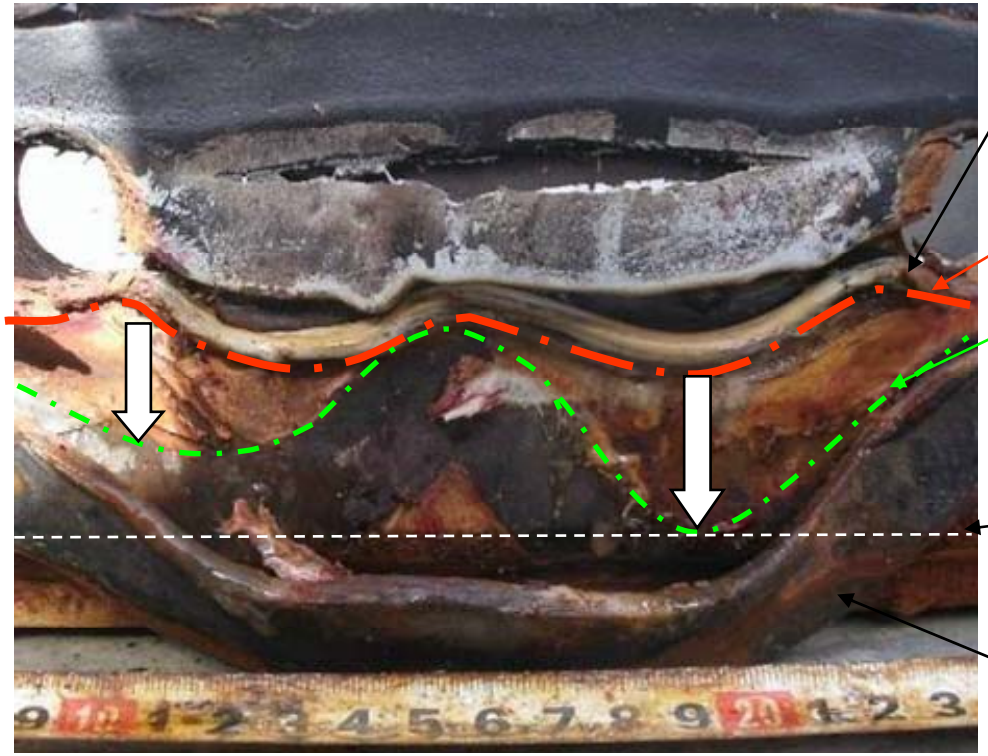
- Given that packing gradually drops and detaches from the flange bottom due to the effects of thermal expansion and contraction in flanges, water pressure, and similar reasons, hypothesis is that leaks result through gaps in bolts and so forth.
- Other causes are not phenomena that were confirmed solely in those sections where leaks have been confirmed. While they are not direct causes, they could conceivably be factors that promote gaps in packing.
- Results of interviews with individuals involved confirmed no problems with process of installing tanks and items that conceivably were causes.

Hypothesized cause		Items to check	Results of checks	Assessment
Materials	Leaks due to bottom ends of flanges having been open owing to bends in flanges	* measure flange opening * measure packing thickness	Openings toward bottom ends of flanges were confirmed at leak locations, but they were insignificant.	△
Construction	Leaks due to tanks having been constructed without packing at bottom of flanges	* Visual observation of joint areas on flanges	Based on condition of putty possibility exists that slight swelling occurred in the packing (bottom side) when bolts were fastened, but presumption is that packing is level for the most part.	△
	Leaks due to bolts having been loosely fastened and packing pressed out by water pressure	* Construction procedure	Bolts tightened with impact wrench at 950N・m. Checked by retightening by hand each lower and side plate assembly (four layers).	×
	Leaks due to bottom end of flanges opening attendant on height differences in concrete foundations	* Height differences of concrete foundations	Situation not such that a height difference of 1 to 3 cm between a location with a leak compared to surrounding areas is a striking gap.	×
Operations	Leaks due to packing being pressed out attendant on drop in fastening power of bolts	* Check bolt torque	Torque is dropping on the whole, but situation not such that bolt torque alone at spots with leaks is dropping to striking degree.	△
	Leaks due to packing being pressed out attendant on tank water pressure along with thermal expansion and contraction of flanges	* Visual observation of joint areas on flanges	Check if packing is missing from flange bottoms, based on packing traces at flange joint areas.	○
	Leaks because drop in pressure of flange surface arising attendant on packing gaining plasticity	* Packing thickness * Confirmation of packing flexibility	Using packing found on site, work underway to check plastic state of packing, including analyses.	–

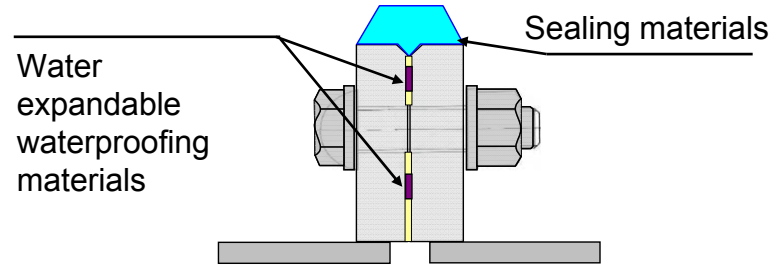
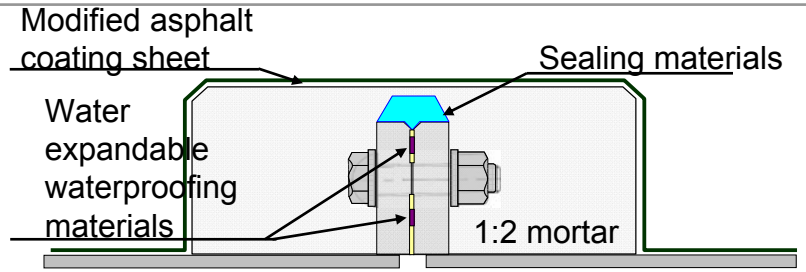
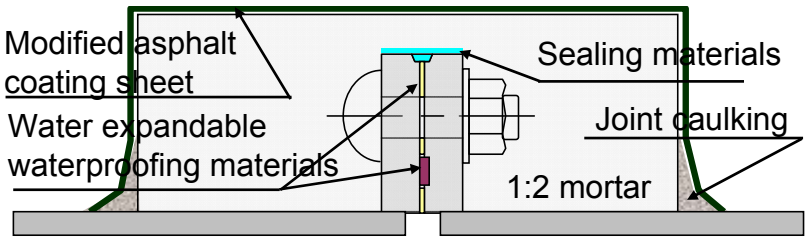
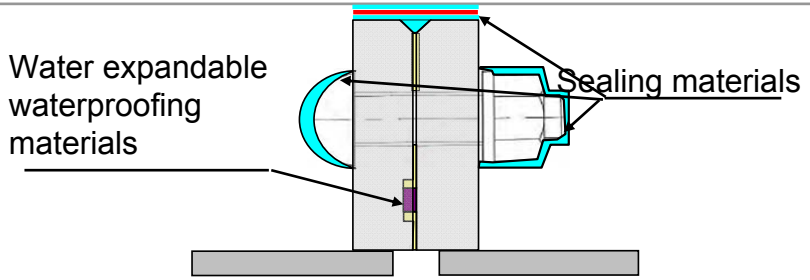
○: Conceivably a direct cause; △: Conceivably an indirect cause; ×: Not a cause

Reference 5-1 (2): Root causes investigation regarding leaks from tanks

- Based on how much putty remains in the joint areas of the flanges where leaks occurred, presumption is that it is level for the most part.
- Presumption from traces on the upper parts of the last packing to go in (on bottom panel) is that, after bolts were fastened, packing gradually dropped and finally detached from bottom due to thermal expansion and contraction of flanges, tank water pressure, and similar effects, resulting in openings.

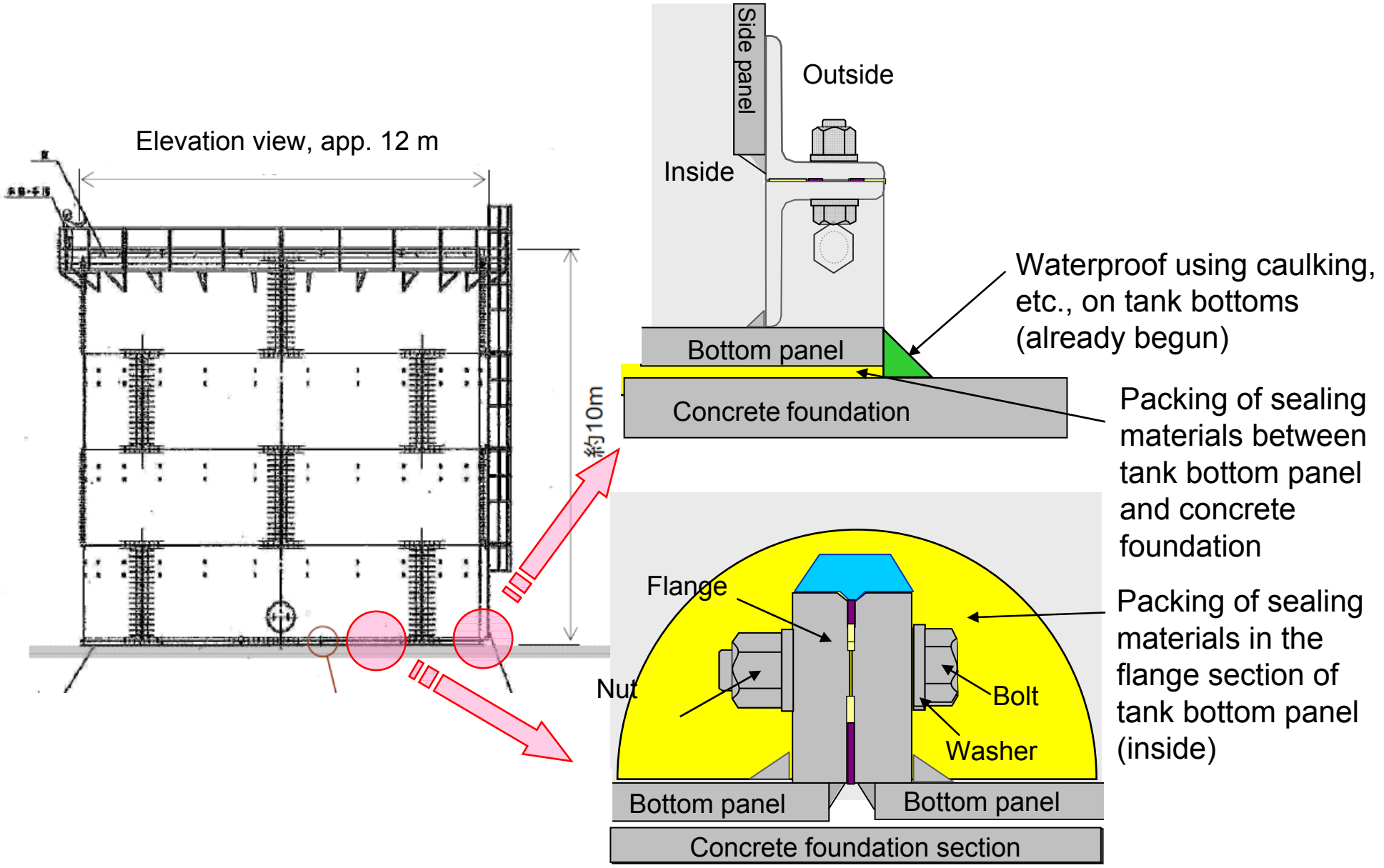


Reference 5-1 (3): Structure of coupler sections on bottom panels of flange-type tanks

Type	Cross-section view of bottom panels waterproofing structure	Construction example	No. of tanks
TYPE-1 ※			120
TYPE-1’			20
TYPE-2			37
TYPE-3 TYPE-4			59
TYPE-5			69

*Tanks where leakage was confirmed

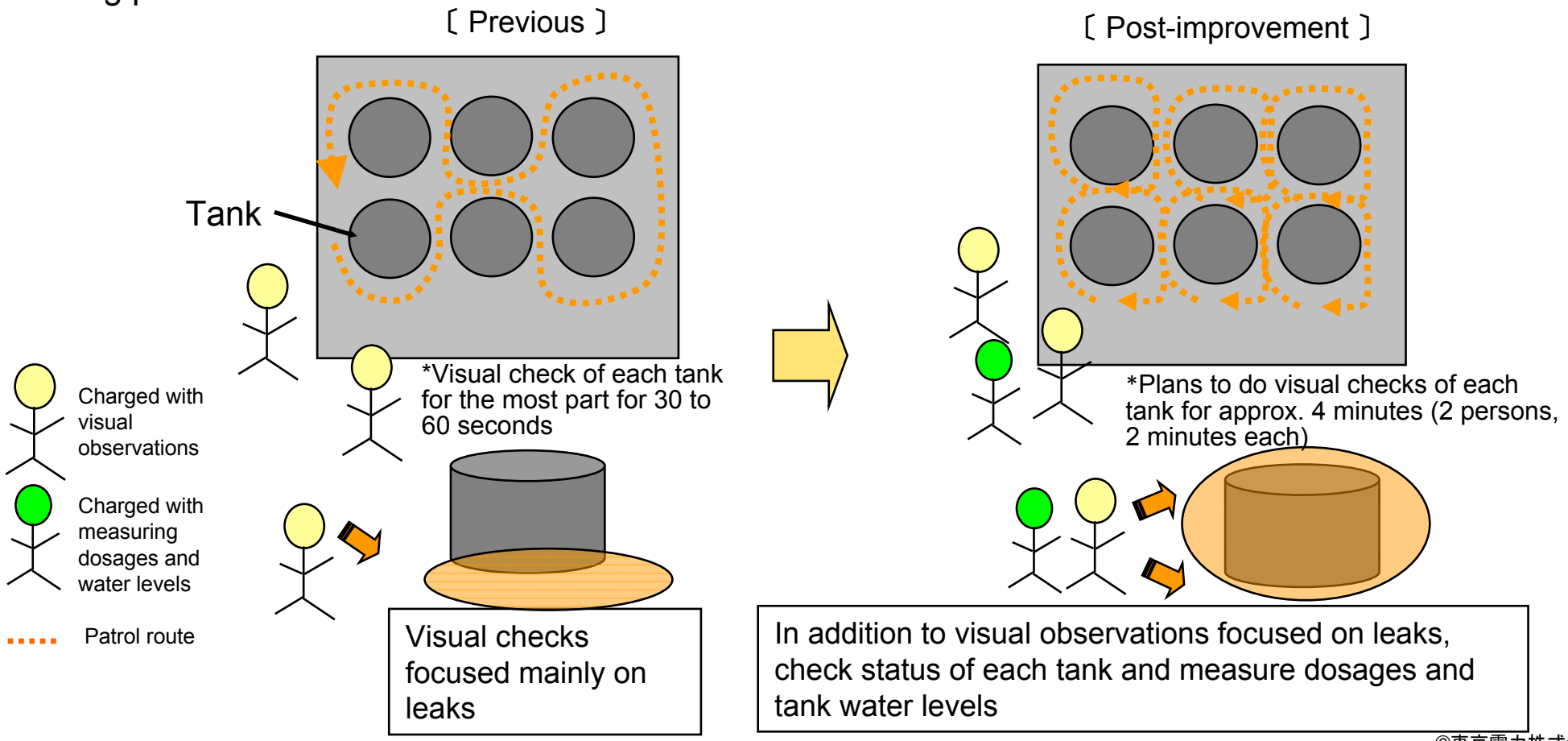
Reference 5-2: [Immediate measures] Water leakage prevention measures for the same type of tanks



Reference 5-3: [Management measures] Strengthening patrols

- Further augment early discovery of leaks and prevention of their expansion through improvements to patrol system and methods

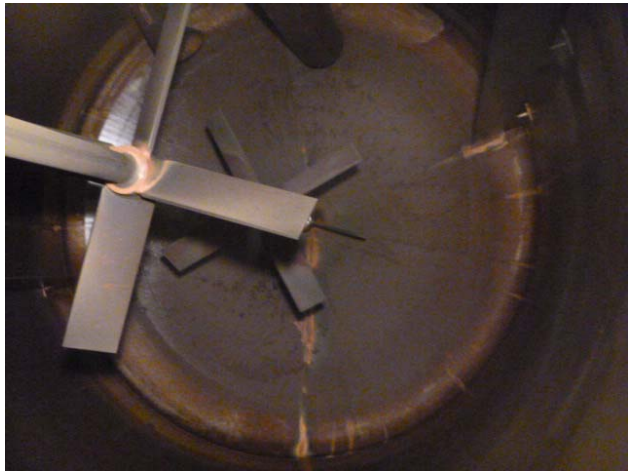
*Increase number of people needed for and frequency of patrols (4 times daily, total of 120 persons/day)
*Clarification of items to check on patrol (visual checks, measure dosages, measure water levels)
*Insure time to enable adequate check of situation of each tank
*Accumulate knowledge helpful for making judgments by reassessing documentation methods for when doing patrols



6. Storage plans/ Measures to manage contaminated water

Reference 6: Improving reliabilty of Multi-nuclide removal facilities (ALPS)

- Corrosion countermeasures for batch treatment tanks
  - ✓ Apply rubber lining to inner surfaces
  - ✓ Install gasket-type sacrifical anodes for flanges, which can develop corrosion in their gaps
- Measures to deal with batch treatment tanks with mislaid rubber lining
  - ✓ Bolster management to prevent contamination with foreign substances (employ checksheet for prevention of contamination by foreign substances)
  - ✓ Beef up final checks of inside (checks by TEPCO employees and construction supervisors/quality control officers from manufacturer)
- Given need to make steady progress with treating contaminated water, implement the following new initiatives
  - ✓ Reconfirm logic of controls
  - ✓ General inspection and reconfirmation with respect to factor analysis created at the planning stage (failure mode and effects analysis) from perspective of starting operations and most recent examples of noncompliance



Inspection of batch treatment tank 2A

Batch treatment tank 1C (after rubber lining attached)

Gasket-type sacrificial anode

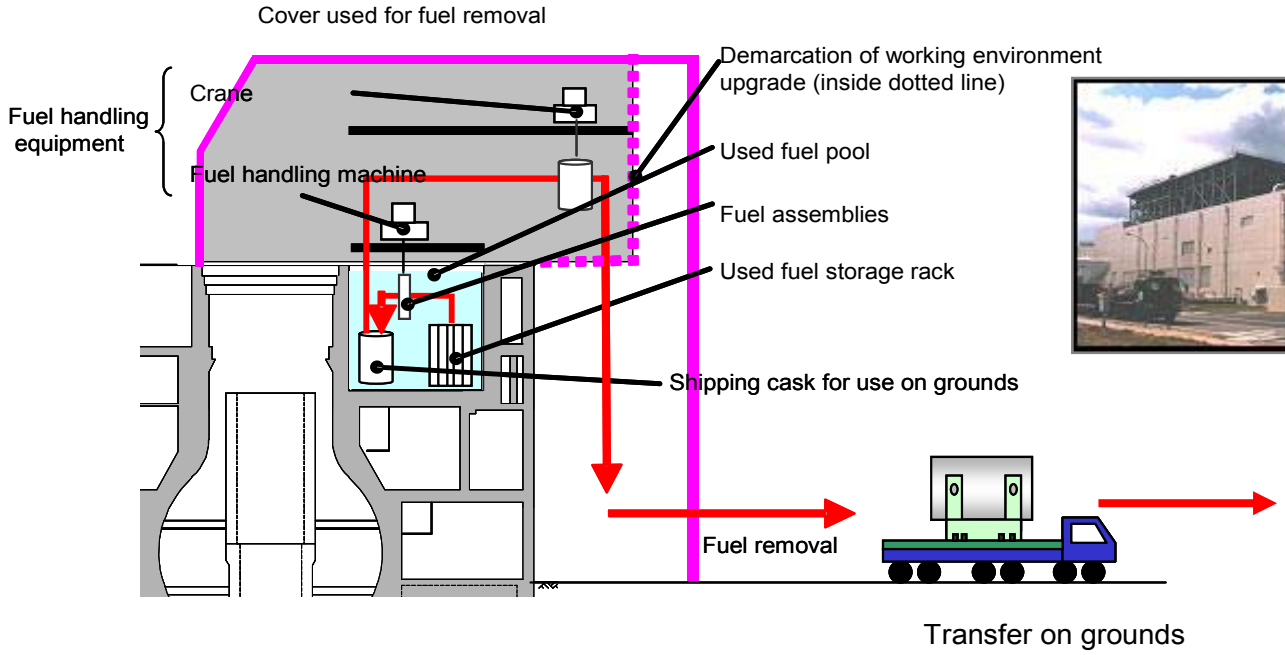
Reference 7: Fuel Removal from Unit 4 spent fuel pool

Reference 7 (1): Outline of process for removing fuel from spent fuel pool

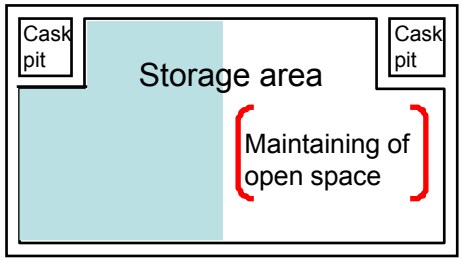
- **Transfer fuel from Unit 4 spent fuel pool (1,533 rods*) to common pool on the premises.**
- **Fuel removal to begin in November of this year, with goal of completing work by around end of 2014.**

(1) Using fuel handling equipment, transfer one at a time while immersed in water the fuel stored on fuel racks inside the spent fuel pool to casks used for shipping on grounds.
(2) Using crane, hoist the casks from the spent fuel pool.
(3) Clamp the lids of the casks at a floor level the height of the operating floor and decontaminate.
(4) Using crane, lower the casks to ground level and load onto a trailer truck.
(5) Using trailer, deliver the casks to the common pool.

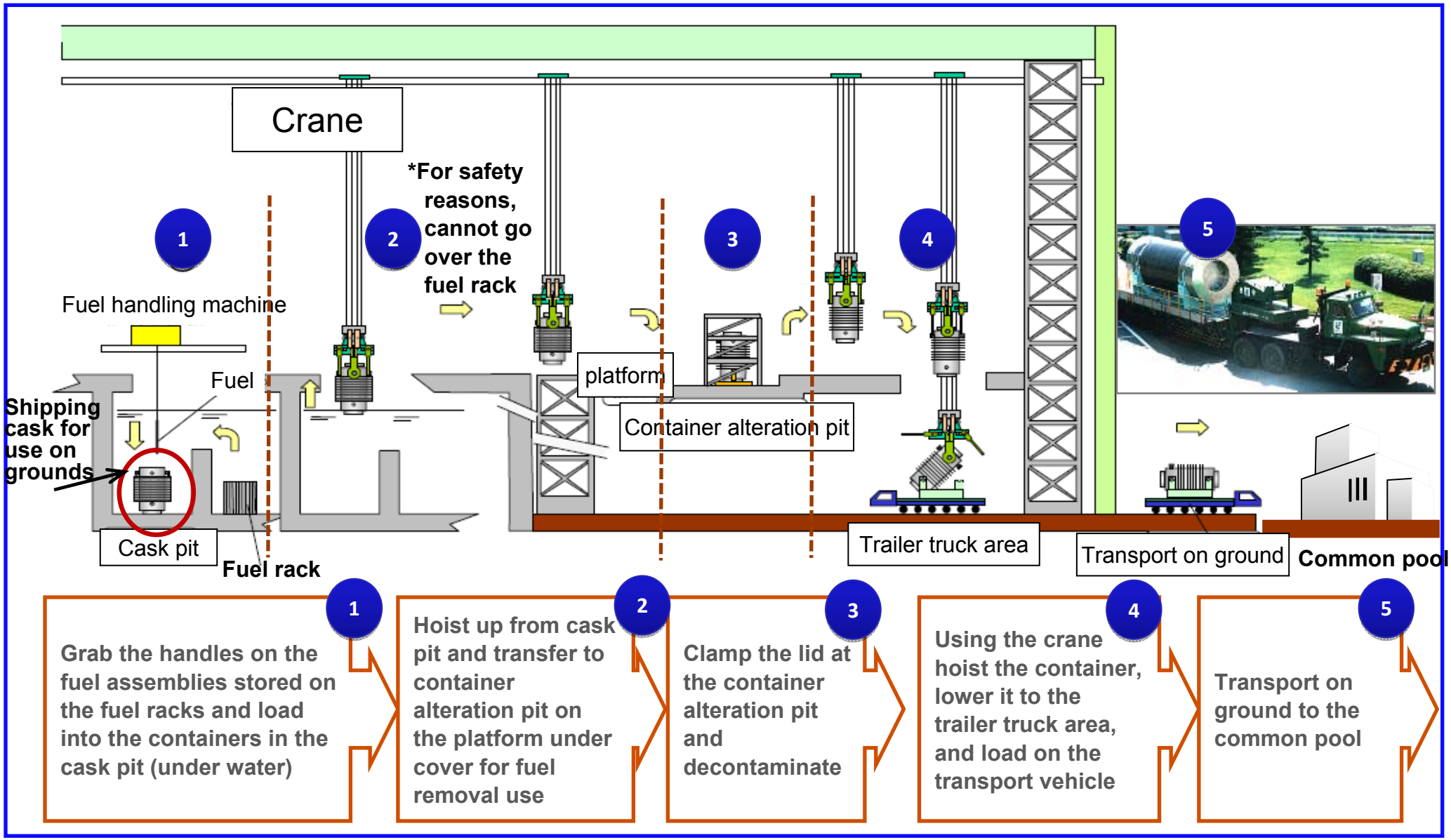
*Spent fuel: 1,331 rods; unirradiated fuel (new fuel): 202 rods



Common pool (on premises)



Reference 7 (2): Process for removing fuel from spent fuel pool



Reference 7-1 (1): Installation of facilities required for reliable fuel removal

● Status with installation underway

(1) Overall view of fuel handling equipment (photo taken from the north side of operating floor)

(photograph date: September 19, 2013)

(2) Status of installation of fuel handling equipment and crane (photo taken from north side of operating floor)

(photograph date: September 19, 2013)

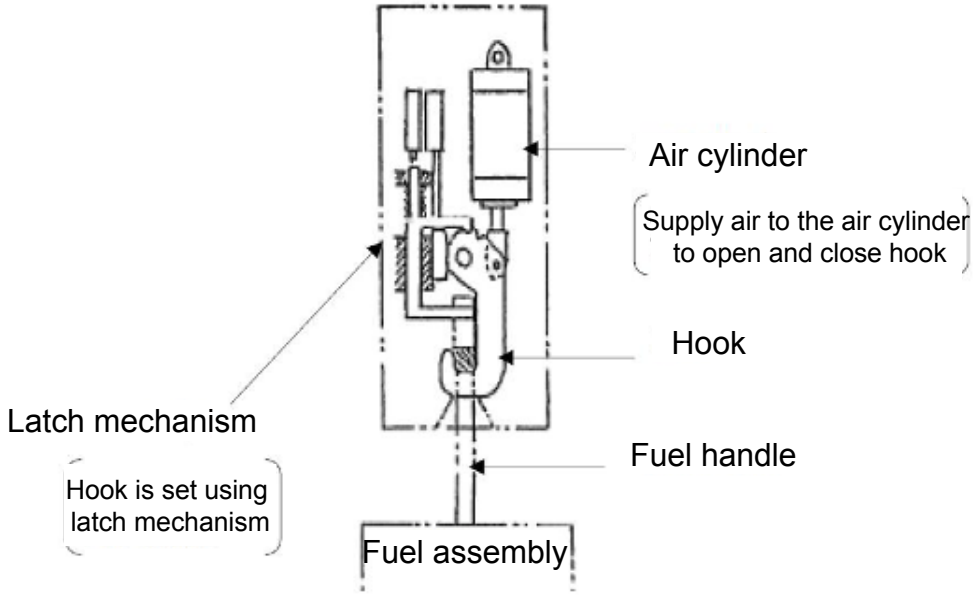
● Design and safety measures with redundancies

(1) Safety measures in the fuel handling equipment

Doubling of cables

Construction is such that even if power loss should by chance occur while working hooks for gripping fuel will not open

etc.



(2) Safety measures for when crane is used

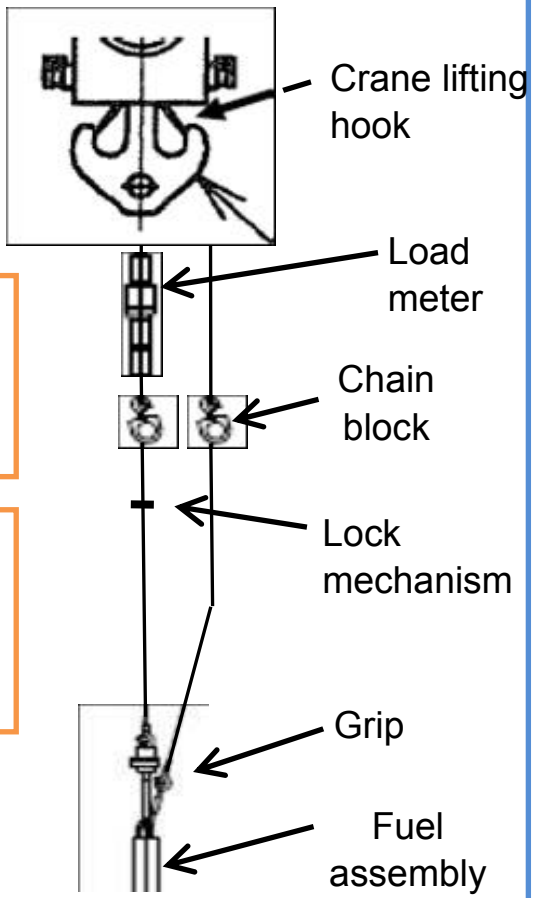
Anti-drop (double hook)

Load monitoring

Load limit that allows loads for working on fuel assemblies of up to 1 ton

Limits on maximum hoisting amounts (locking mechanism, Overexposure prevention)

etc.



Reference 7-2 (1): Sufficient preparation in advance

- **Conditions inside of pool after dropped debris has been removed**

(photograph date: November 5, 2013)

Reference 7-2 (2): Sufficient preparation in advance

- **Summary of pre-training 1**

*Education and training in handling fuel using fuel handling machinery (FHM)

(1) Skills called for handling fuel with the FHM

A "fuel exchange equipment contract operator" certification system had been set up to provide education and training in the necessary skills for handling fuel with previous FHM equipment. For the present fuel handling operations, however, in addition to the "fuel exchange equipment contract operator" certification, operators will also need to understand the following points

I. Difference in construction and work environment compared to previous FHMs

II. Emergency procedures should the cable catch (stick) during lifting

III. Other in-job risks and safety measures calling for consideration

IV. Emergency procedures in the event of anomalous event (earthquake, etc.)

(2) Education and training plan

For workers to acquire the skills called for when handling fuel as described above, the following education and training will take place.

- Education: Classroom learning using procedures manual regarding aforementioned points I through IV
- Training: Operational training using the actual FHM that has been installed
- Safety exercises: Confirmation of evacuation routes (insure two routes), carry out safety training involving taking those evacuation routes

(3) Implementation system

Workers who have received education and training described above will perform fuel handling

Number of workers to have finished training (as of November 4): 48

Reference 7-2 (3): Status of Work Safety Review from International Expert Group

Background

Ahead of the mid-November start to removing fuel from the spent fuel pool at Fukushima Daiichi Nuclear Power Station Unit 4, TEPCO asked the International Research Institute for Nuclear Decommissioning's International Expert Group to conduct a review as a third party into the status of TEPCO's preparations to handle the effects of debris, discrepancies in the working environment, and the latent risks in removing the fuel from the pool. TEPCO has also been working to make the fuel removal process safer and more reliable.

Results

September 25, 2013 . . . . Summary explanation
Starting October 22 . . . . . Sending of relevant materials (begin review based on TEPCO materials)
October 30 . . . . . Teleconference held
November 5 . . . . . Receive comments

○Review team members: International experts group - UK, France, Russia, Ukraine, US

Main comments

*Achieve a certain understanding regarding work safety.
*Should strive for work proficiency through use of mock-ups and training as a way to cope, for example, with channel boxes that are stuck in place by debris
*Should strive for work proficiency aiming to prioritize the removal of new fuel in the fuel removal process
*Should give thought to and reassess working environment safety to decide whether wearing full face masks is required

Status of Measures Undertaken

*Review is currently underway in response to the comments received

Future plans

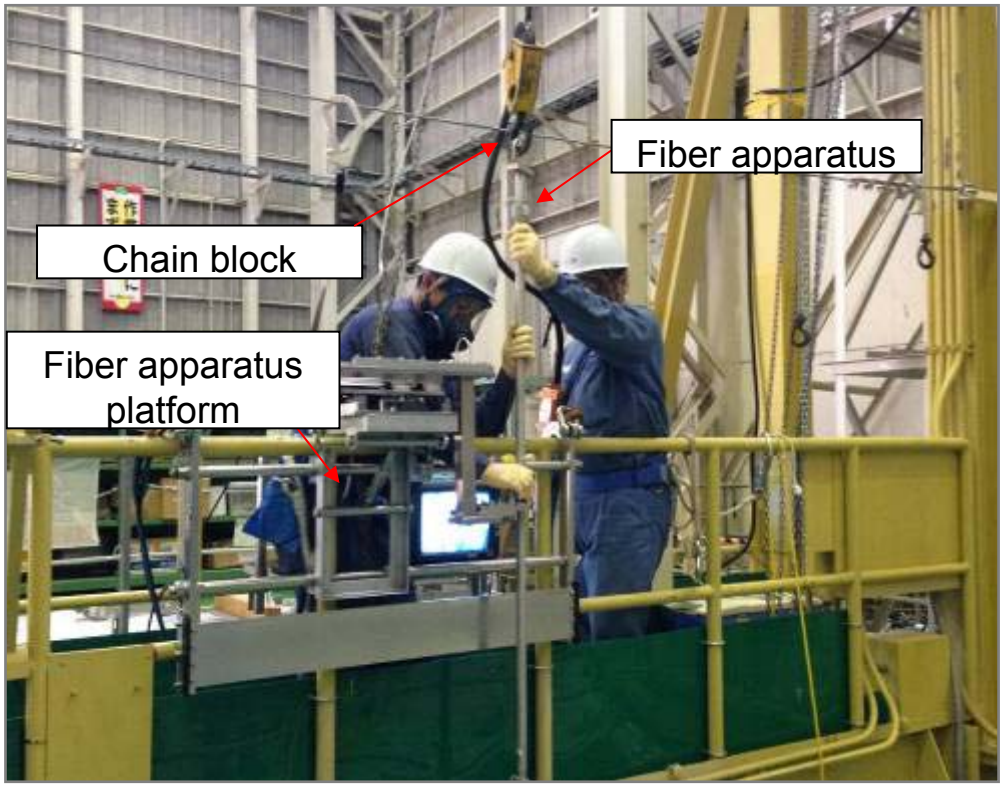
Site visit at Fukushima Daiichi Nuclear Power Station: November 14-15, 2013

Reference 7-2 (4): Sufficient preparation in advance

- **Summary of pre-training 2**

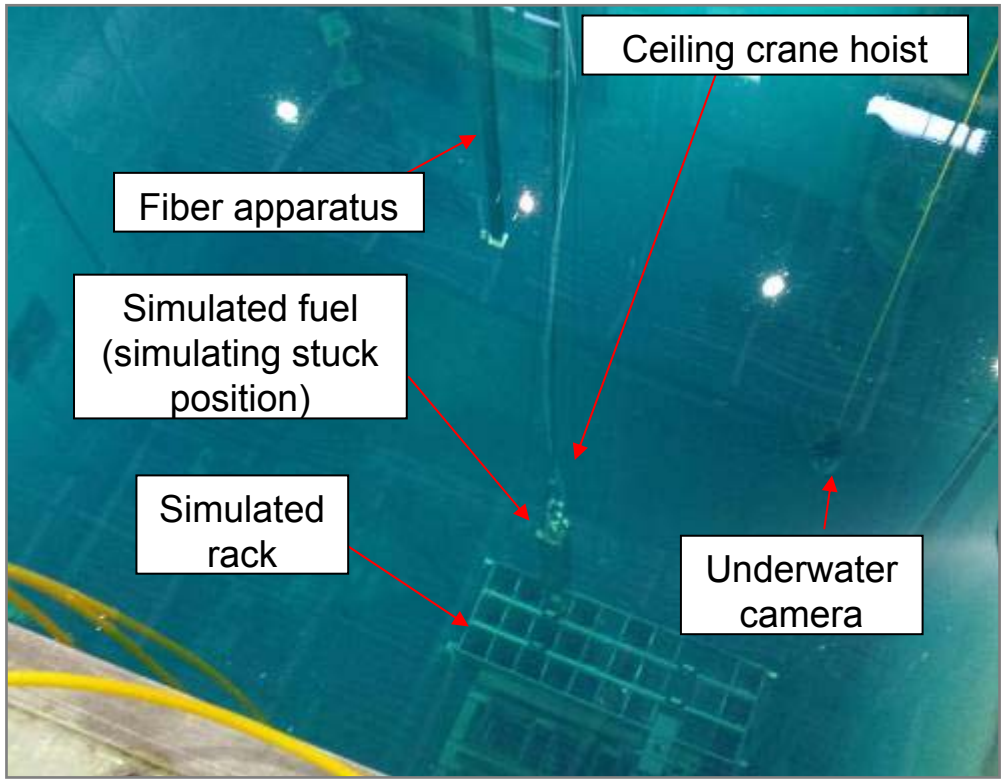
*Emergency procedures using simulated equipment for fuel getting caught up (stuck)

Drill conditions



Simulating on-site conditions with use of full face mask and rubber gloves

Simulated fuel (simulating stuck position), simulated rack



Reference 7-3: Upgraded reporting system (fuel removal from Fukushima Daiichi Unit 4)