Fukushima Dai-ichi NPS Defueling Status

May 2013

Hitachi-GE Nuclear Energy, Ltd

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1. Overview of Fukushima Daiichi (1F) Events

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Earthquake (M9.1: the 4th powerful earthquake on record)

- ➢Scram for earthquake ⇒ Reactor function loss by high temperature
- ➢Loss of power ⇒ D/G operation
- ➢Isolation of reactor ⇒ Reactor cooling by emergency condenser

Tsunami (The height: Approx. 11~15m)

- ➢Emergency D/G loss ⇒ Station blackout
- ➢DC power-supply loss ⇒ Loss of cooling function in condenser
  Loss of monitoring function
- ➢Sea water pump loss ⇒ Loss of cooling function of heat sink

Loss of core cooling function

- ➢Hydrogen generation by fuel exposure ⇒ Explosion of building
- ➢Damage of RPV by melt-through
- ➢PCV leakage due to the delay of water injection, etc. ⇒ Radiological release

Station blackout, DC power-supply blackout, cooling function loss due to the huge tsunami caused the core meltdown, hydrogen explosion, radiological release.

1. Overview of Fukushima Daiichi (1F) Events

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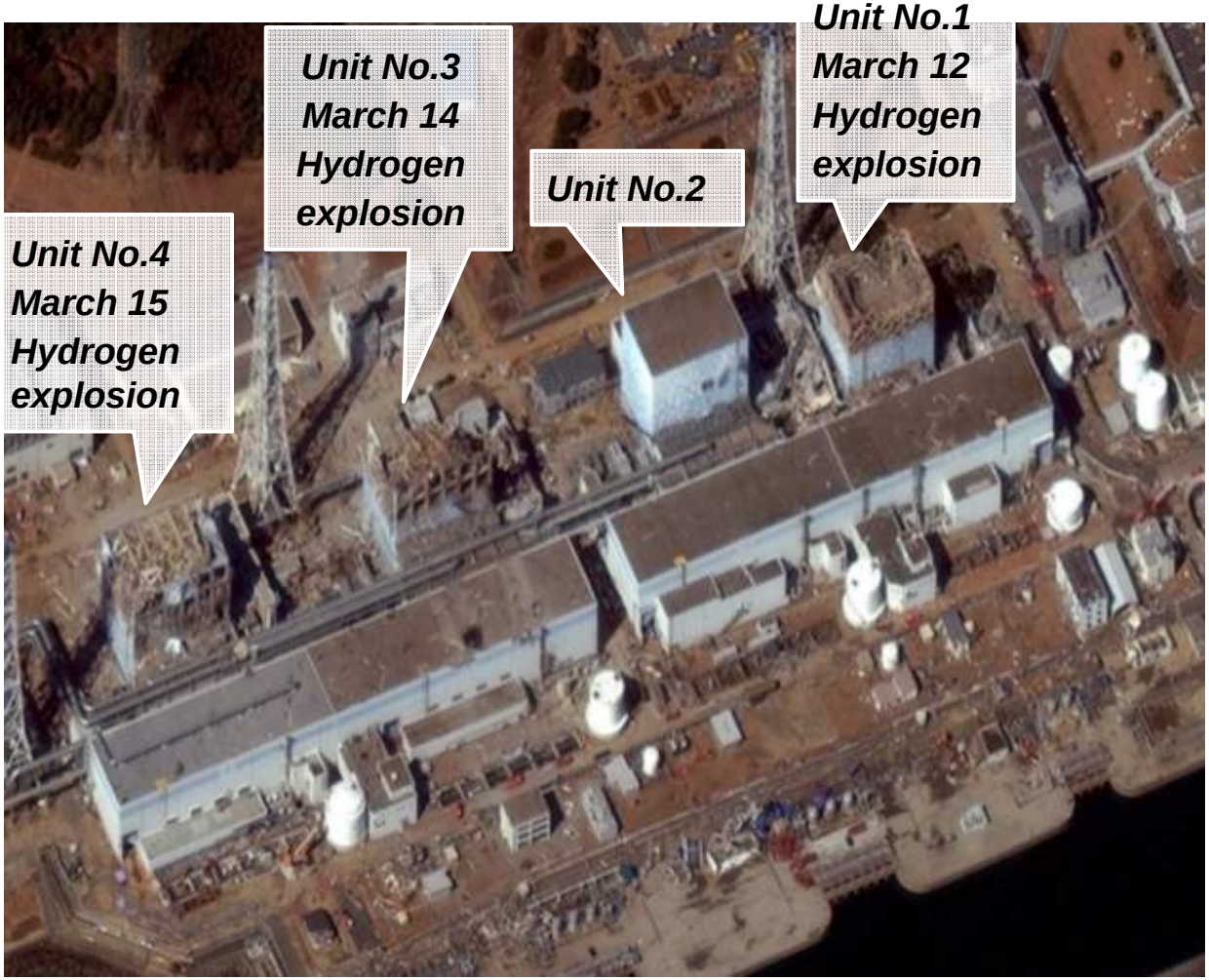

Satellite image of Fukushima Daiichi NPP (March 18, 2011)

Unit No.3 & 4

Reactor building of Unit No.4

1. Overview of Fukushima Daiichi (1F) Events

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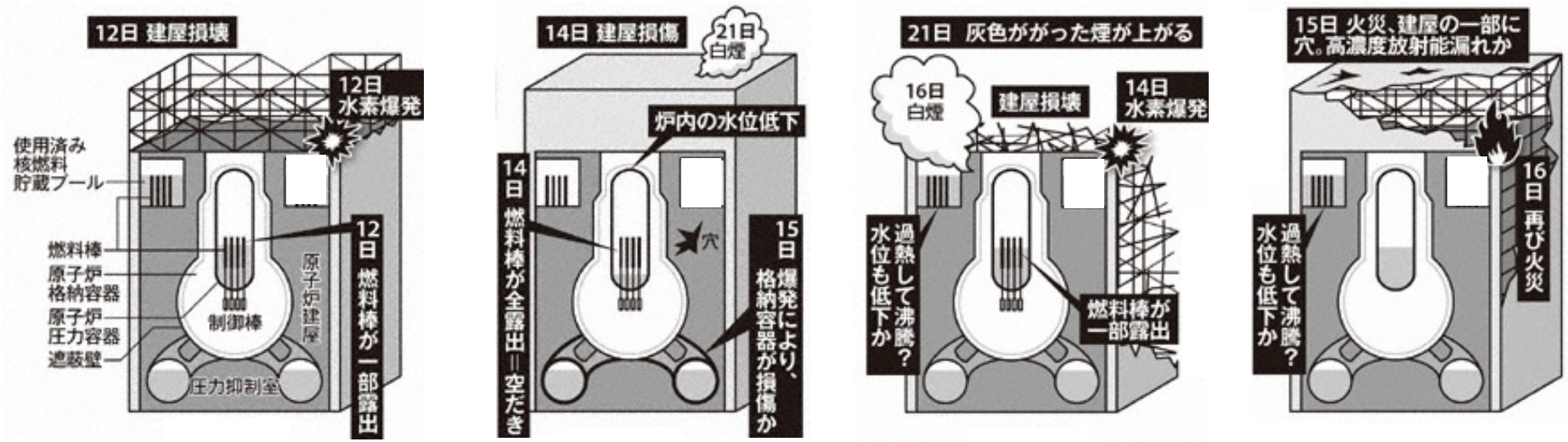

	Unit 1	Unit 2	Unit 3	Unit 4
Status in earthquake	In operation	In operation	In operation	In regular inspection
Events after earthquake	-Automatic shutoff -Incomplete cooling -Fuel rod exposure -Building damaged by hydrogen explosion	-Automatic shutoff -Incomplete cooling -Fuel rod exposure -Explosion near pressure control room	-Automatic shutoff -Incomplete cooling -Fuel rod exposure -Building damaged by hydrogen explosion	-Building damaged by hydrogen explosion - Fire breakout

2. Roadmap towards restoration

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	Step 1	Step 2	Mid. & Long term challenges
Target	Decrease of radiation dose	Management of release, control of radiation dose	
Period	3 months	3-6 months (After Step1 achievement)	3 years ~
Reactor cooling	Water injection for cooling → Water circulation for cooling Nitrogen injection		Continuous cold shut down
SFP cooling	Water injection for cooling Water circulation for cooling		Challenges of defueling
Storage, treatment, reuse of contaminated water	Installment of equipments for storage and treatment Decontamination/Salinity treatment for reuse		Installment of permanent water treatment system
Suppression of radioactive material in air and soil	Dispersal of antiscattering agent /Removal of debris Covering for R/B		Installment of container for R/B

2． Roadmap towards restoration

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Present	*Within 2 years*	*Within 10 years*	*After 30-40 years*
Step 1,2	1st Phase	2nd Phase	3rd Phase
-Stable condition -Quasi-Cold shut down	Period to start SFP Defueling	Period to the start of fuel debris Removal	Period to the end of decommissioning
	- Commence to start the unit 4 SFP defueling in 2 years	- Complete the SFP defueling - Complete the preparation for the fuel debris removal -decontamination of building - repair the PCV - fill water in the PCV	-Complete the fuel debris removal in 20-25 years - Complete the decommissioning in 30-40 years

- ◆ Japanese government request to hurry up the implementation;
  - ✓ Unit 4 SFP fuel defueling to be started at Nov. 2013
  - ✓ Core debris removal to be hurried up from the original schedule of 2012FY
- ◆ Updated road map to be released at June 2013

3.SFP Defueling status (1/3)　April 2013

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- ✓ ***Unit 4 SFP Defueling*** to start from the Nov. 2013 and to be finished within one year.
- ✓ ***Unit 3 SFP Defueling*** to start by the end of 2014.(Target)

  (as of the mid-long term milestone. But, it is about a half of a year behind for the schedule due to rubble removal works by remote operation.)
- ✓ ***Unit 1 SFP Defueling*** to be completed within middle and long term phase 2 period with unit 3 and 4 experience and rubble survey on the operation floor.

  Reactor building ceiling, FHM, Over head crane may not drop into the SFP.
- ✓ ***Unit 2 Defueling*** to be completed within the middle and long term phase 2 period with the reactor building and the existing equipments survey and radiation dose rate survey.
- ✓ Unit 1 to 4 Defueling to completed until 2021 and SFP fuels storage, site dry storage or reprocessing policy to settled within the middle and long term phase 2 period, around 2017.

3.SFP Defueling status (2/3)　April 2013

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- ✓ A total of 3,108 fuel assemblies (of which 2,724 are spent fuel assemblies) are stored in the SFPs of unit 1, 2, 3 and 4.
- ✓ Result of investigation to date indicates that ceiling and walls around the SFP were severely damaged, the FHM and Overhead crane were not operative due to hydrogen explosions, and rubble dropped into the pools (Units 1, 3 and 4).
- ✓ Sea water injections for cooling of the pool were performed.(Units 2, 3, 4)
- ✓ The nuclide analysis of SFP water shows that most of fuel assemblies are undamaged.

Stored Fuel Bundles in SFPs

	capacity	spent fuel (a)	new fuel (b)	(a)+(b)	Sea water injection	Remarks
Unit 1	900	292 (70)	100	392	no	Large rubble drop
Unit 2	1240	587 (7)	28	615	done	
Unit 3	1220	514 (4)	52	566	done	Large rubble drop
Unit 4	1590	1331 (3)	204	1535	done	All most intact fuels
total		2724 (84)	384	3108		

Remarks: ( ) damaged fuel number before the earthquake

Extract from METI report on Mar.17,2012

3.SFP Defueling status (3/3) April 2013

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- ✓ The fuel assemblies will be packed in the transport cask, and moved to and stored in the Common Pool of the Fukushima Daiichi plant.
  - -Transfer cask: NFT 22B for unit 4 SFP stored fuel
  - -New design cask for Unit 3 or other SFP damaged fuel.

- ✓ To make a space for the SFP fuel storage, the existing fuel assemblies stored in the Common Pool are loaded into dry cask and moved to the temporary storage facility on the plant premises for the time being.

- ✓ The fuel integrity during long term storage will be evaluated as an influence of seawater injection by observation of the oxide film thickness of the rods, the PIE for unit 3, 4 SFP fuel bundles.

4. Unit 4 New Fuel Inspection

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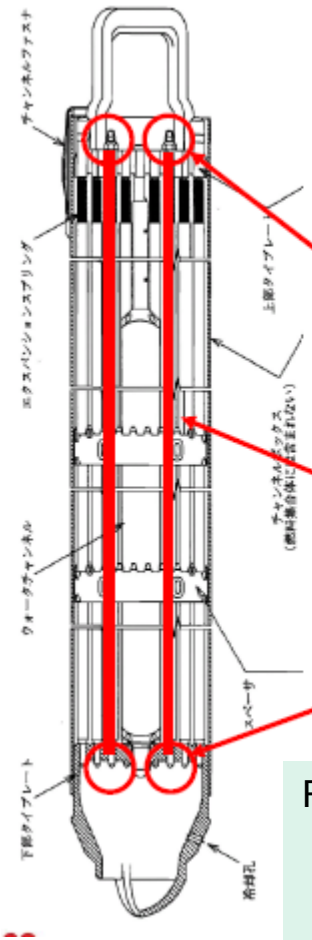

◆ Purpose of investigation

- From knowledge of seawater corrosion data, it could be assumed that no significant corrosion will occur.
- An investigation for seawater corrosion, and check of lifting possibility will be performed

- Cladding/lock nut connection
  Dissimilar metal combination
- Connecting rod
- Fuel rod connecting into lower tie plate
  Dissimilar metal welding part

Remarks ;

- Upper and lower tie plate are connected with eight connecting rods.
- Other fuel rods are set on the lower tie plate and are not connected on the upper/lower tie plate.

4. Unit 4 New Fuel Inspection

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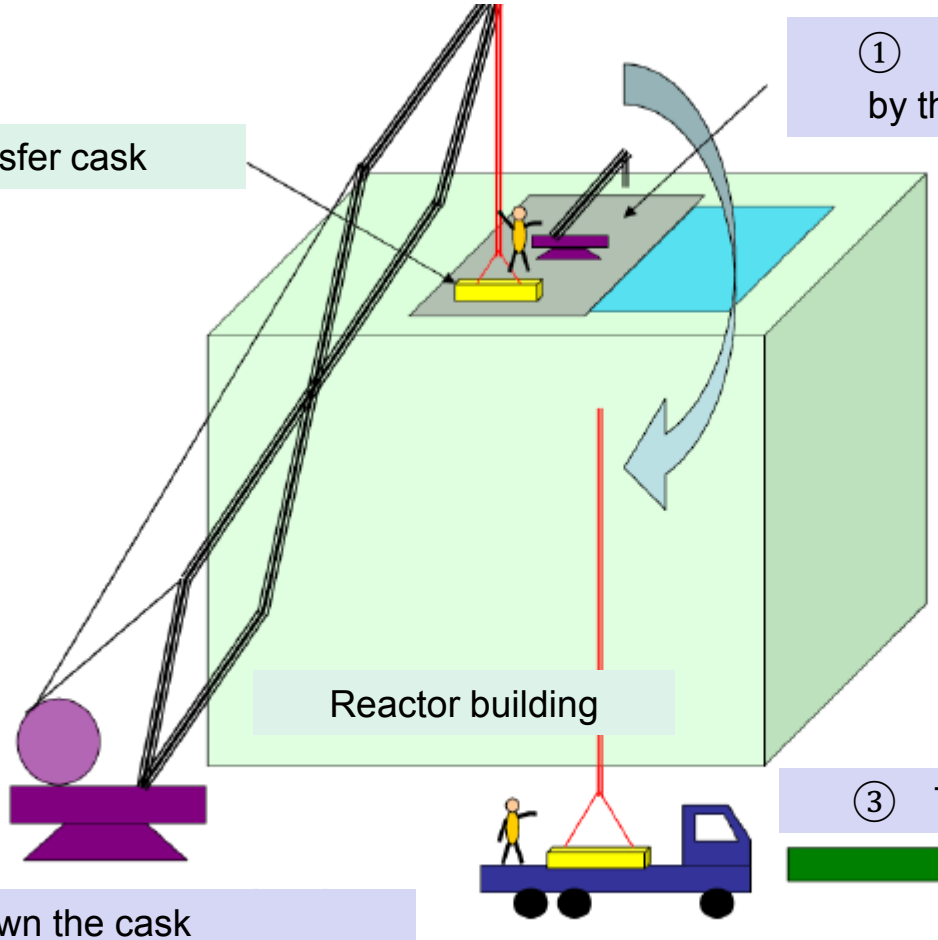

① Lift up the new fuel from SFP by the jib-crane

② Lift down the cask on the ground by the crawler crane

③ Transfer to the common pool

4.Unit-4 New Fuel inspection

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Object: inspect two new fuels, STEP Ⅲ, integrity after the earthquake

Date: July 2012 Fuel lift up from 1F-4 SFP

Aug. 2012 Inspection at 1F Common pool

Inspection at common pool

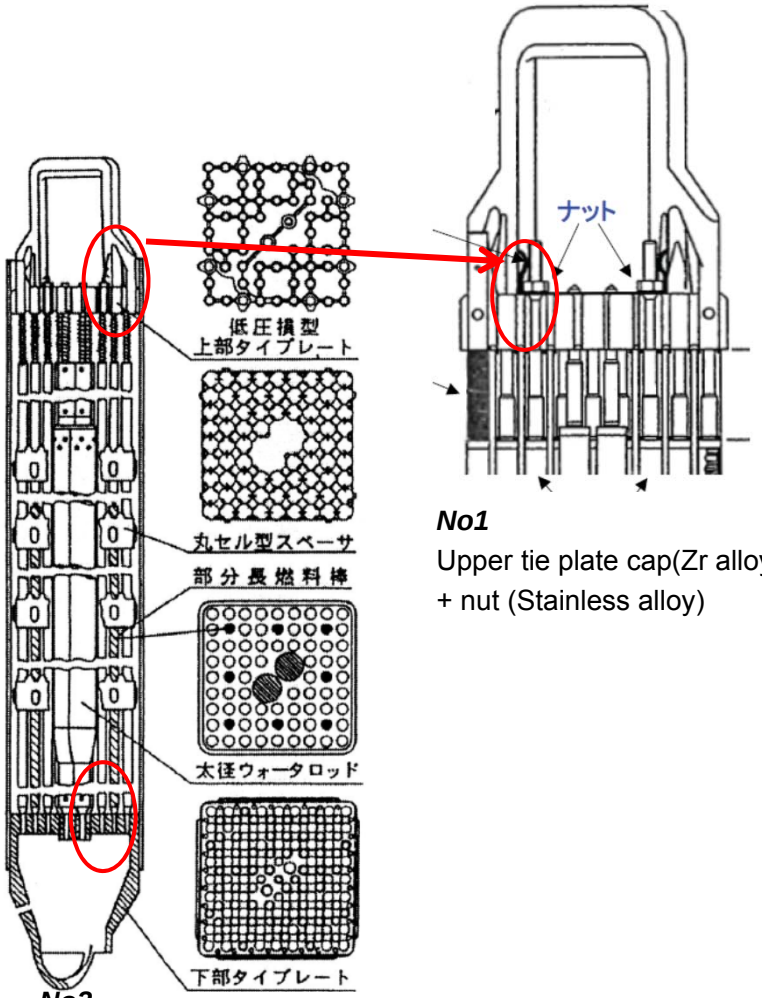
Rubble inside fuel assembly

Small particles inside fuel assembly

Inside fuel assembly

- No deformation of any fuel part
- No damage for lift up of fuel
- Rubble and particles inside fuel
- Iron based chemical compound on rod

5.Seawater corrosion test



No1
Upper tie plate cap(Zr alloy)
+ nut (Stainless alloy)

No2
Lower tie plate cap(Zr alloy)
+ tie plate (Stainless alloy)

◆ ***Object***

to verify the fuel integrity with condition of seawater Injection during SFP stored fuels lifting from the rack and transfer to the common pool.

◆ ***Test piece***

- ✓ Upper tie plate cap(Zr alloy)+ nut (Stainless alloy)
- ✓ Lower tie plate cap（Zr alloy) + tie plate(Stainless alloy)

◆ ***Potential corrosion due to sea water***

- ✓ Crevice corrosion
- ✓ Dissimilar metal contact corrosion

◆ ***Test condition***

- ✓ Chloride concentration 400-6000ppm
- ✓ temperature 40-90℃
- ✓ pH 8.2, 11.2
- ✓ oxide film effect to be surveyed

5.Seawater corrosion test

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Corrosion test condition

- ✓ Immersion time: 2000h
- ✓ Chloride content:6000→ 2500ppm
- ✓ Temperature 90℃

Conclusion;

No significant corrosion, which would affect fuel lifting was observed.

A type fuel test: upper tie plate + nut

Before test

After test

A type fuel test: lower tie plate + cap

Before test

After test

6.Unit 4 SFP Defueling -schedule-

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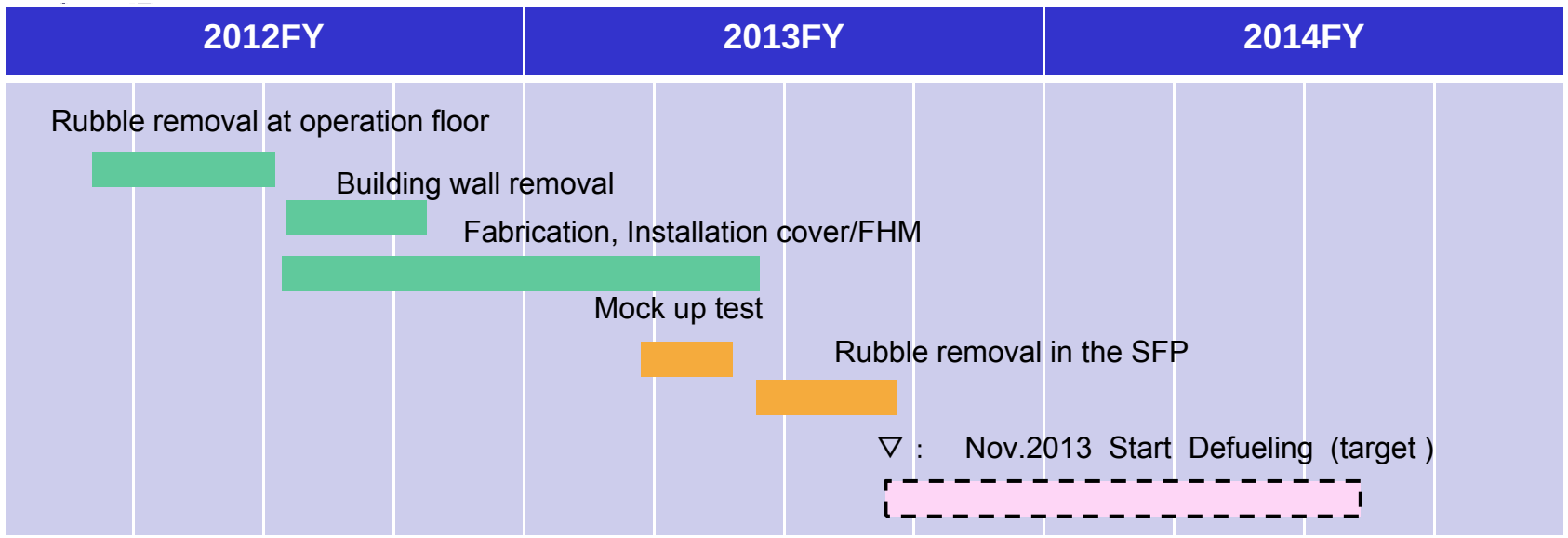
Unit 4 SFP Defueling schedule

- Schedule
  - Rubble removal of upper part of Reactor building: Sep. 2011 to 2012 Summer
  - Installation of Fuel transfer cover/ crane: Apr. 2012 to 2013 Summer
  - Defueling start: Nov. 2013 (target)
- Operation
  - Manual operation at operation floor with considerations to lower dose rate



6.Unit 4 SFP Defueling -rubble removal-

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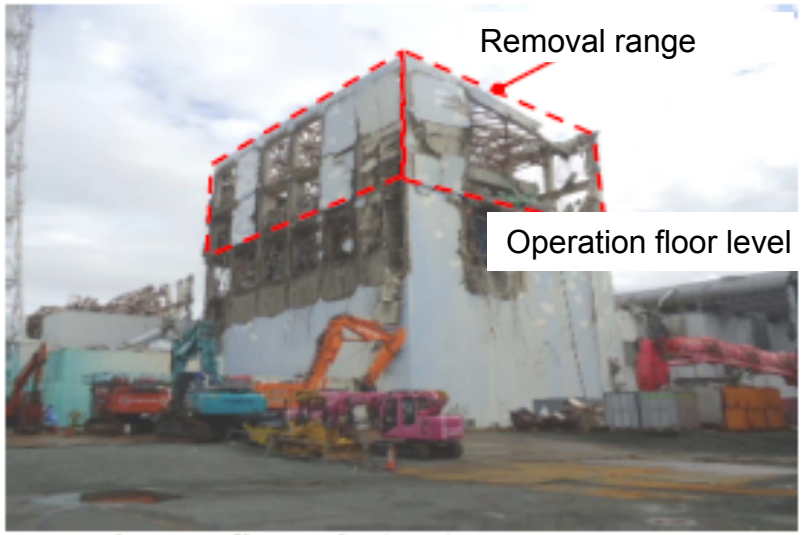
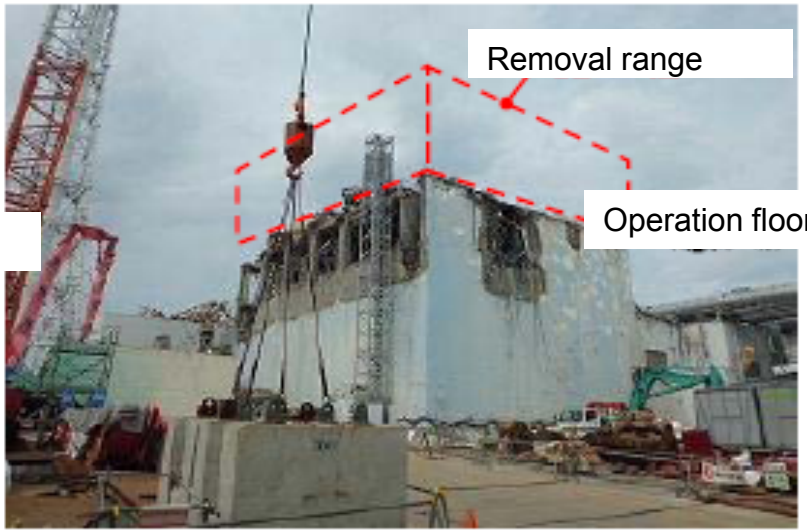
Unit 4 Reactor building rubble removal

Rubble removal of reactor building started from Sep., 2011
and completed by 2012 autumn.



Before rubble removal
Sep., 2011



After rubble removal
July, 2012

5.Unit 4 SFP Defueling -Fuel transfer cover-

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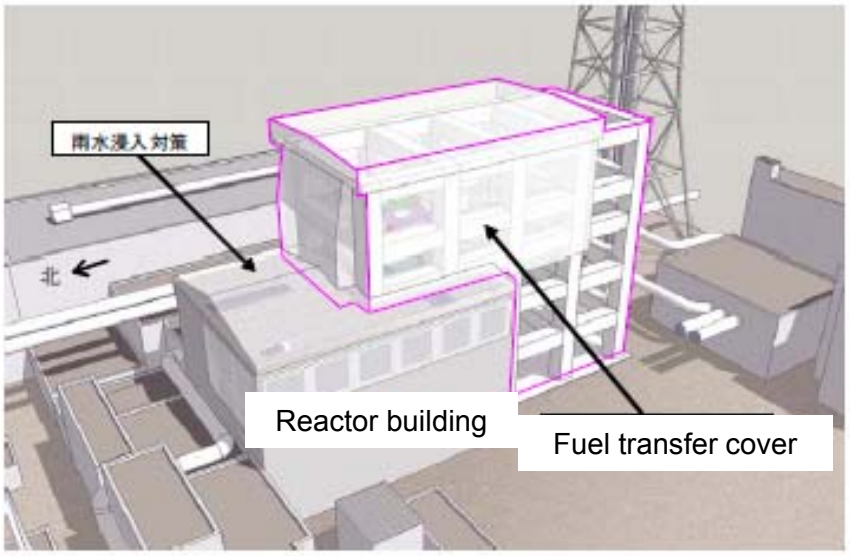
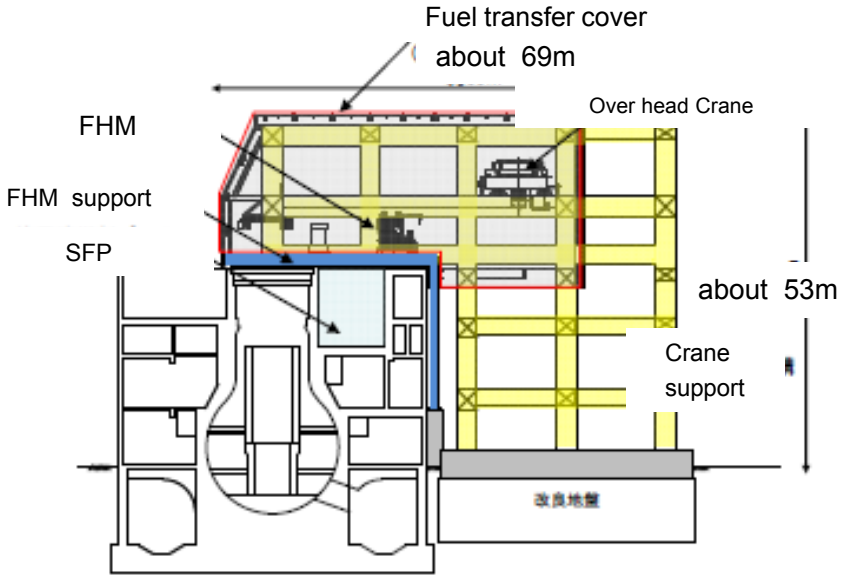
◆Object of Fuel transfer cover;

to support FHM, Crane, to maintain environment during defueling, and to prevent from release, or spread radioactive materials

◆Site implementation started from Apr. 2012 and to be finished in July 2013 .





Concept of Fuel transfer cover

6.Unit 4 SFP Defueling -Fuel transfer cover-

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- Fuel transfer cover outside the Reactor building finished on Apr.10, 2013.
- Furthermore, the cover on the 5th floor of the Reactor building will be installed.

Fuel transfer cover concept

Construction status as of Apr.10, 2013

Construction progress

6.Unit 4 SFP Defueling -Defueling flow-

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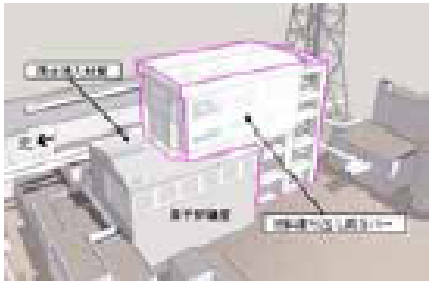
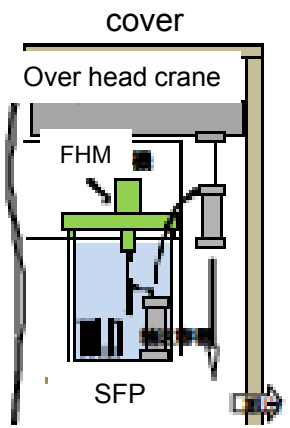
Unit 4 Defueling target:
Start :Nov,2013, Finish: within one year

Rubble removal of building
Complted:Dec.19,2012



Installation of Fuel transfer cover
to be completed in 2013 Summer



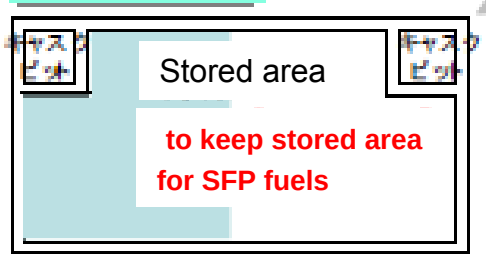
Defueling Start
Target: Nov,,201 3

Transfer existing fuel in the pool
to keep SFP fuel stored area

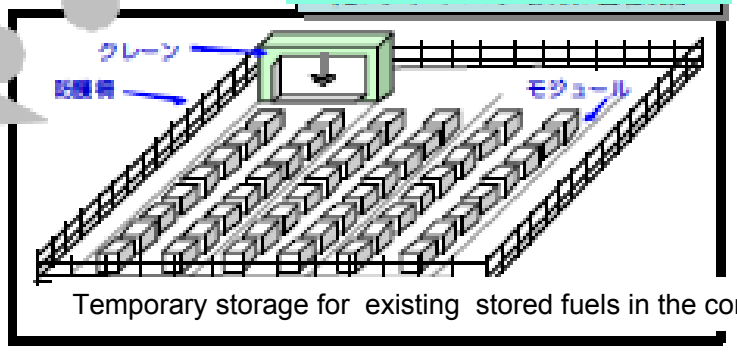
Common pool

Cask pit

Cask pit



Temporary Cask Storage



Temporary storage for existing stored fuels in the common pool

Construction started from Aug. 2012
and completed end of Mar. 2013

From TEPCO report of status of mid-long term Fukushima recovery plan as of 2013.03.28

6.Unit 4 SFP Defueling -Rubble survey-

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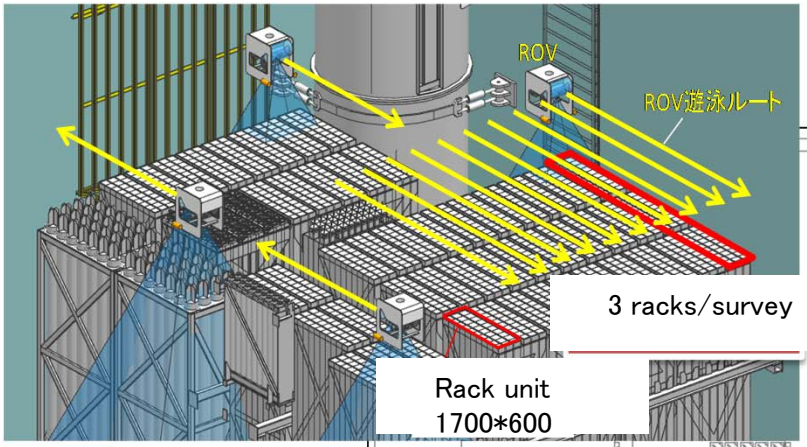
Result of rubble survey in SFP (Mar.19,20, 2012)



SFP survey by ROV

6.Unit 4 SFP Defueling -rubble removal-

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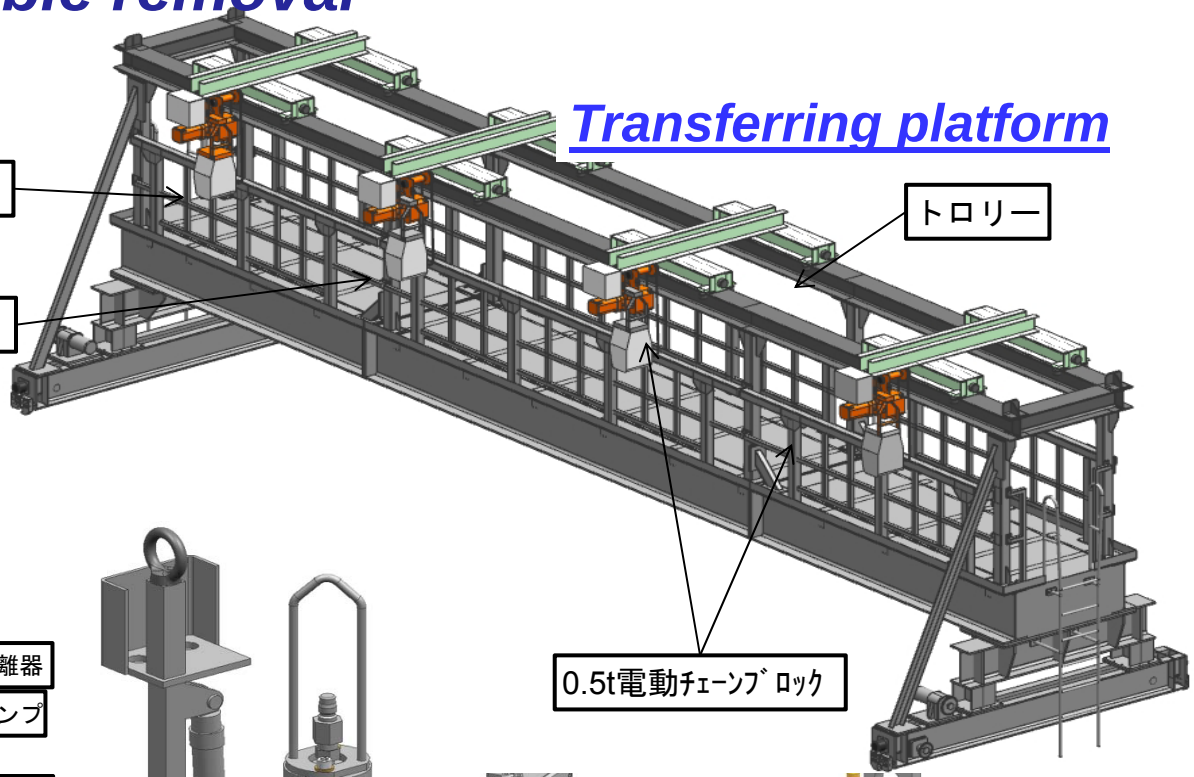
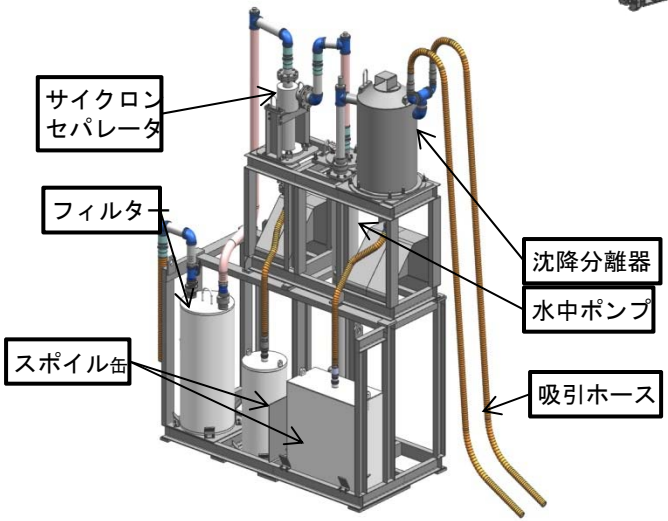
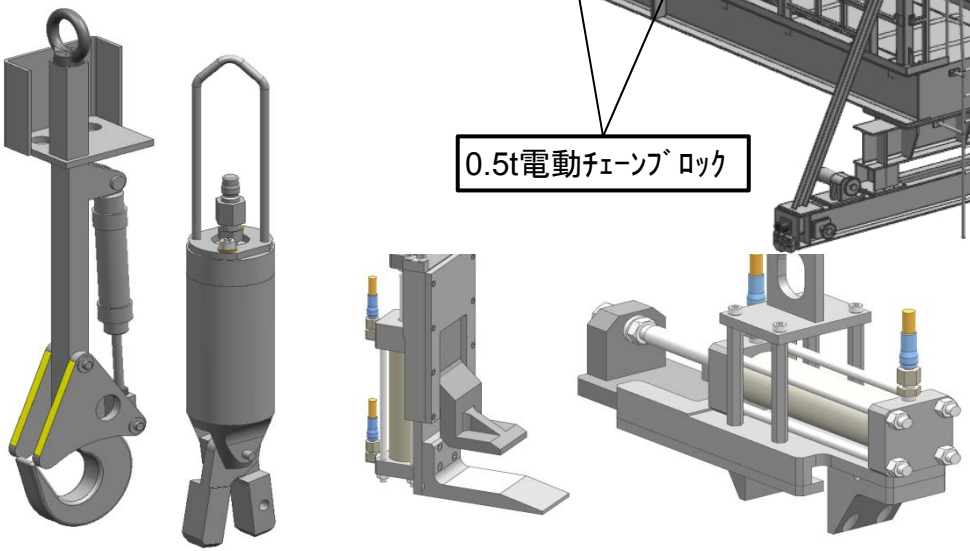
Equipments for rubble removal



Transferring platform



Equipment for rubble particle collection



Handling tools for rubble removal

7.Other Unit SFP Defueling -unit 3 SFP survey-

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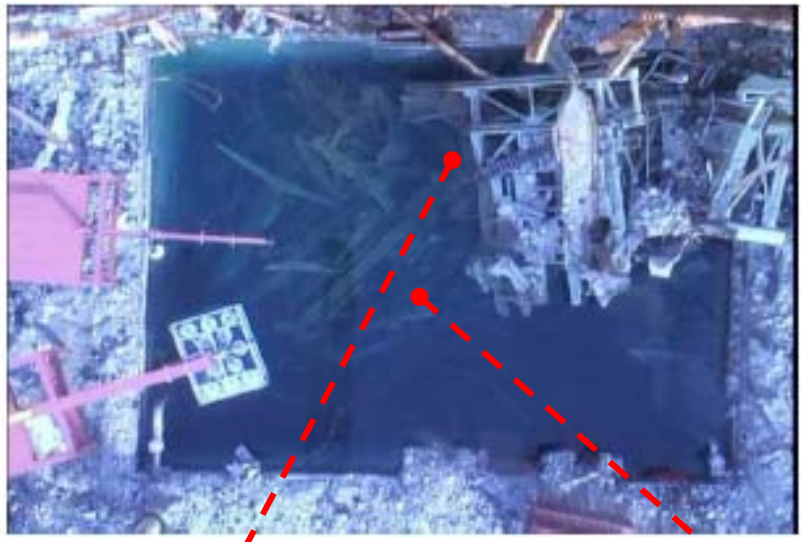
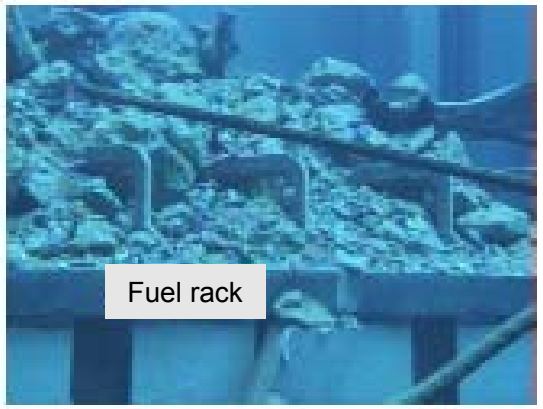


- Observation date:Feb.14, 2013
- FHM and Steel frame structure were observed.
- Fuel, rack, and pool damage was NOT observed.
- Further study for removal of rubble in SFP to be performed
- Defueling to be started at 2014 autumn.

But progress of as of today, it is around half of a year behind the schedule.

FHM

Steel frames in the SFP



Rubble piled up atop fuel rack

7.Other Unit SFP Defueling
-unit 1 Operation floor survey-

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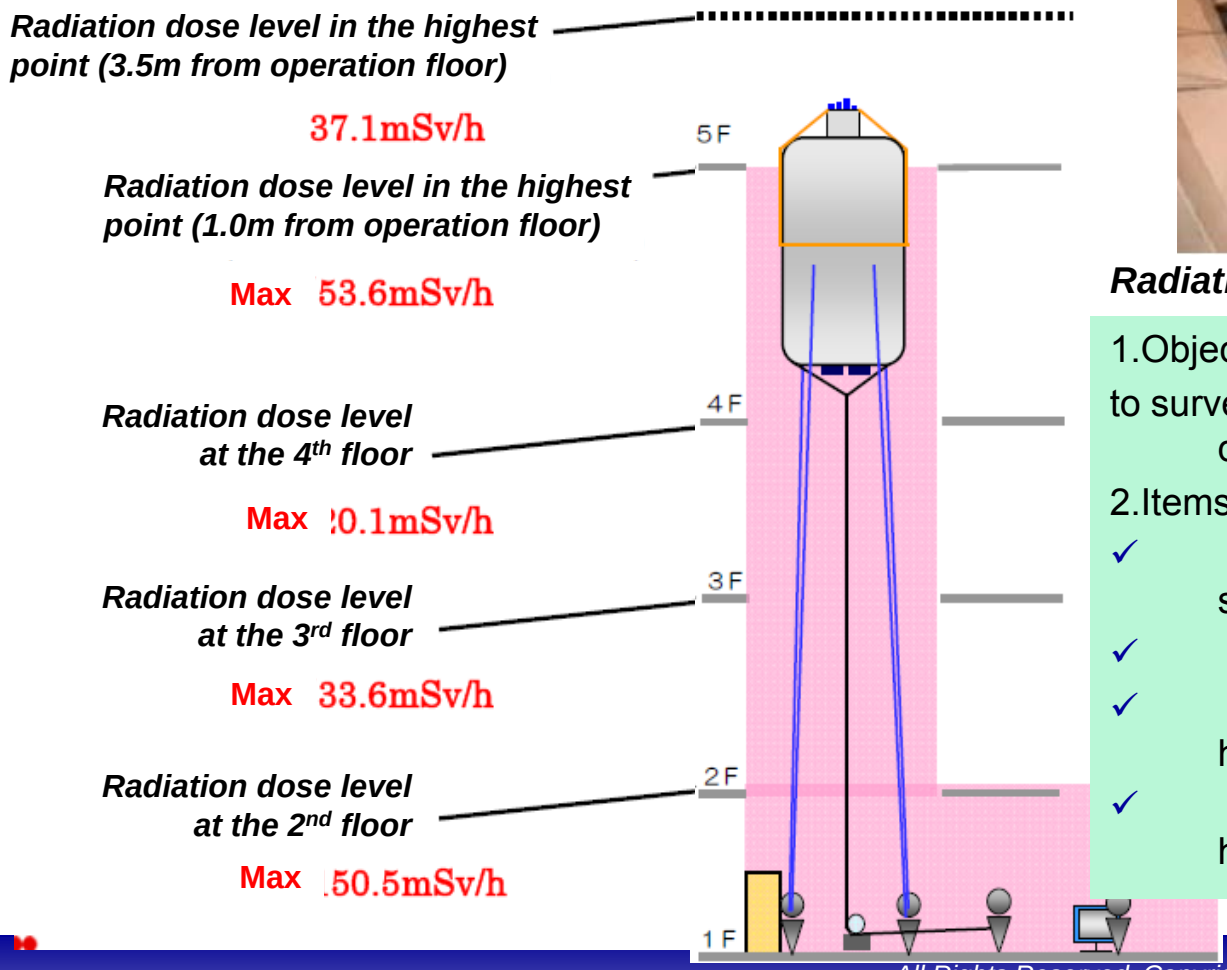
Operation floor survey of reactor building (Oct. 24, 2012)

Radiation dose level in each floor



Radiation dose monitoring by balloon

1.Object:

to survey the operation floor status for SFP defueling plan

2.Items;

- ✓ Ceiling, Overhead crane, FHM status,
- ✓ Rubble scattered status
- ✓ Access route check from equipment hatch
- ✓ Radiation dose rate near equipment hatch

7.Other Unit SFP Defueling
-unit 1 Operation floor survey-

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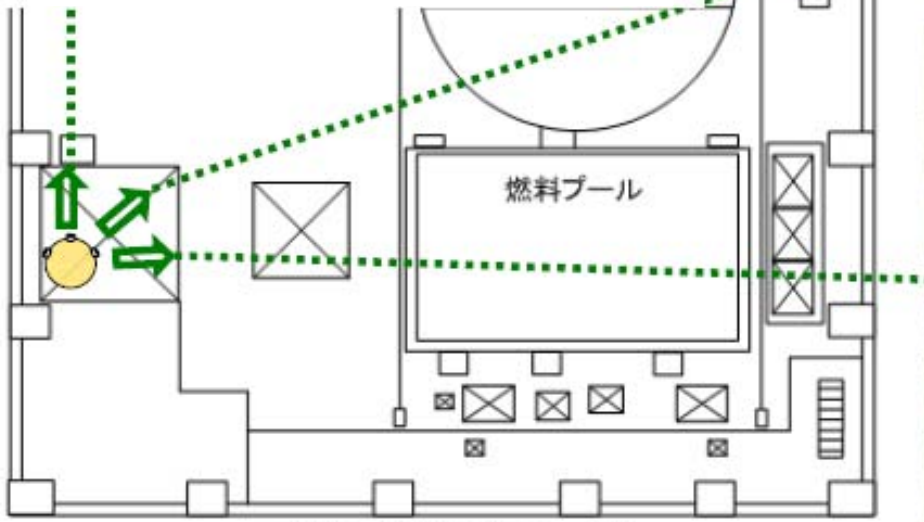
Operation floor survey of reactor building (October 24, 2012)

North direction from balloon

Northeast direction from balloon



Operation floor of reactor building in Unit 1

East direction from balloon

Conclusion

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1. Unit 4 SFP Defueling will be started from Nov. 2013 and be finished within a year.

2. Fukushima Restoration mid-long road map will enter into phase-2 stage, namely which consists of SFP Defueling and Preparation of removal of core debris.

3. Unit 1-4 SFP Defueling will be finished until 2020 FY(target).

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Thank you for your Attention

END

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