The integrity evaluation of the reactor building at unit4 in the Fukushima Daiichi nuclear power station

May 2012

Government and TEPCO’s Mid-to Long Term Countermeasure Meeting Management Council

Outline

- The situation of the reactor building (R/B) at unit 4 in the Fukushima Daiichi nuclear power station
  - ✓The situation of the R/B at unit4 in the Fukushima Daiichi nuclear power station
  - ✓What has caused the hydrogen explosion of the R/B at unit4?
  - ✓The majority of the fuel in the pool is sound
  - ✓Confirmed that there is no leakage and no damage around the spent fuel pool
- Structural integrity evaluation for reactor building and spent fuel pool
  - ✓Confirmed the seismic resistance against aftershocks
  - ✓Reinforced the bottom of the spent fuel pool
  - ✓Confirmed that the building has not tilted
  - ✓Regularly check the reactor building and spent fuel pool
  - ✓Ensure the safety of spent fuel pool by preventing corrosion and monitoring leakage
  - ✓Vice minister Nakatsuka made a visitation
- Action toward spent fuel removal
  - ✓Remove rubble on and around the reactor building
  - ✓Begun to construct the cover for Unit 4 spent fuel pool
  - ✓Going to steadily remove spent fuels
- Reference
  - ✓Unit4 spent fuel pool water level at the time of the accident

The situation of the reactor building at unit 4

- The top of the unit 4 R/B was damaged by the hydrogen explosion、BUT we confirmed that
  - the building, including the spent fuel pool, has a sufficient margin of seismic resistance even if an earthquake equivalent to the Tohoku-Pacific Ocean Earthquake (JMA Seismic Intensity Scale 6+) occurs in the area.
  - the building has not tilted

【The fuel situation at unit 4】

- No fuel in the reactor pressure vessel
  *periodical inspection at the Tohoku-Pacific Ocean Earthquake
- 1535 fuels in the Spent fuel pool
  *include 204 fresh-fuels

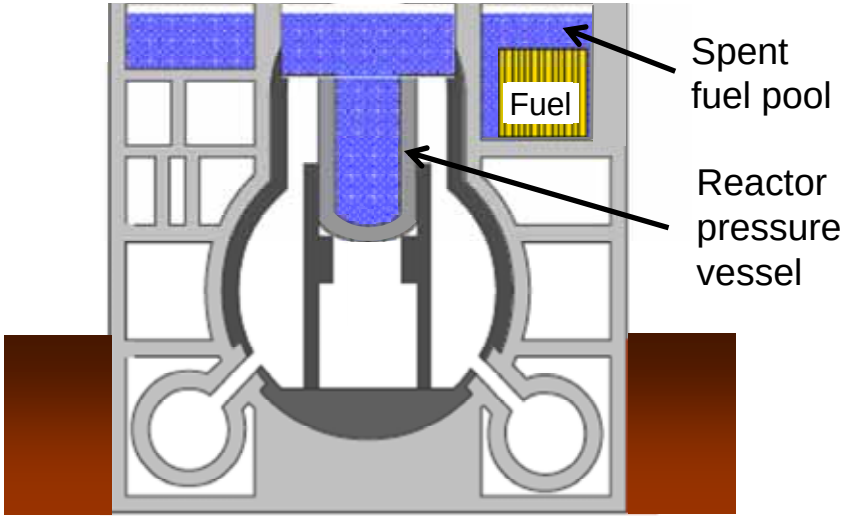
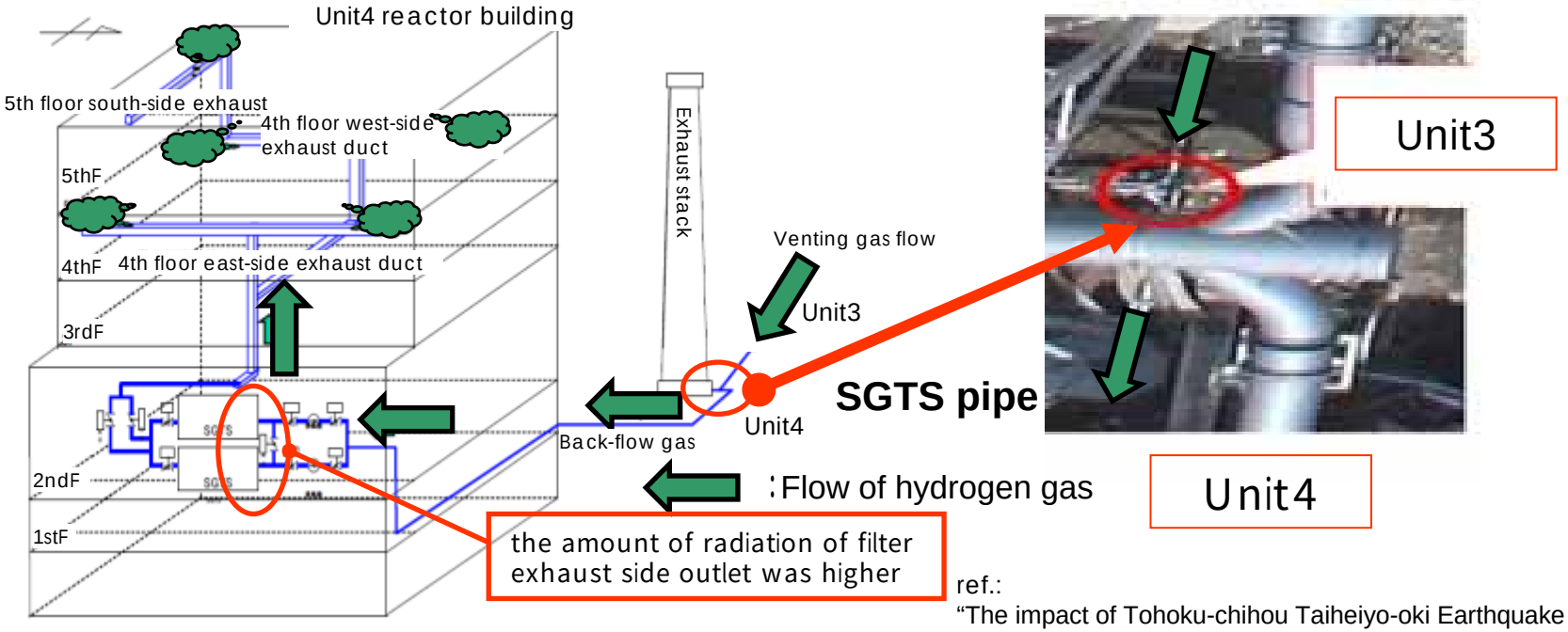


Image of the Unit 4 R/B

※ JMA : Japan Meteorological Agency

What has caused the hydrogen explosion of the R/B at unit4

- It is considered that the venting inflow, which comprised hydrogen gas originated from unit3, might have flowed into unit4 through SGTS piping and exhaust ducts, resulting in a hydrogen explosion.
- This was caused by the fact that the valves of unit4 SGTS were open though unit3 and unit4 a common exhaust stack.



Flow path of the PCV venting gas flow from Unit3 to Unit4

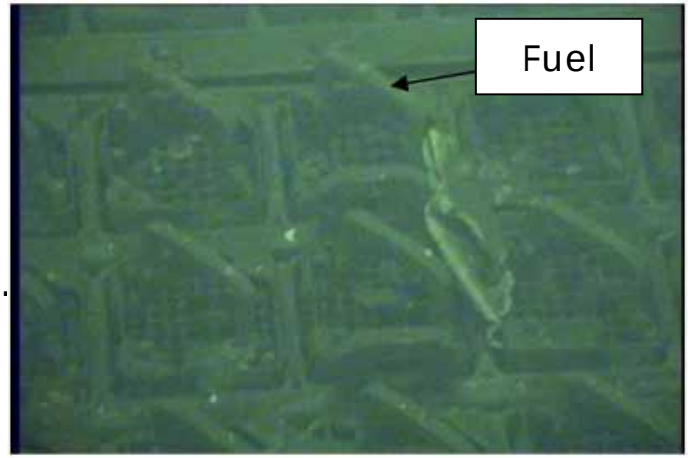
ref.:
"The impact of Tohoku-chihou Taiheiyo-oki Earthquake to Nuclear Reactor facilities at Fukushima Daiichi Nuclear Power Station" TEPCO (Sep. 9, 2011, amendment Sep.28, 2011)

※ According to TEPCO's investigation results, the amount of radiation in SGTS filter exhaust side outlet (downstream side) was a few orders higher than the amount of radiation on the upstream side filter. It is therefore unlikely that the explosion was caused by the gas generated in unit4.

The majority of the fuel in the pool is sound

The situation in the spent fuel pool

- ✓So far the situation in the pool was filmed by TEPCO several times.
  （Apr. 29, 2011, May 7, 2011, Feb. 9, 2012）
- ✓Also, the investigation of the rubble distribution conditions inside the spent fuel pool was performed.(Mar. 15-21, 2012)
- ✓The results showed that no abnormalities of fuel racks were recognized.



The extent of contamination in the spent fuel pool

- ✓The results of a nuclide analysis of the spent fuel pool water showed that Cs concentration was smaller than those of Units 1-3 by more than two orders of magnitude.（It is estimated that detected nuclide is mainly entered from the reactor cores of other units.）

Unit4 spent fuel pool and skimmer surge tank water※ nuclide analysis results

Detected nuclide	Half-life	Concentration（Bq/cm^3） Unit4 spent fuel pool water				
		Apr. 12, 2011 sampling	Apr.28, 2011 sampling	May 7, 2011 sampling	Aug. 20, 2011 sampling	（ref.）Mar. 4, 2011 sampling
Cs134	Approx. 2 years	88	49	56	44	Detection limit or less
Cs137	Approx. 30 years	93	55	67	61	0.13
I131	Approx. 8 days	220	27	16	Detection limit or less	Detection limit or less

※Apr. 12 – May. 7, 2011：Spent fuel pool water was collected by using a concrete pump vehicle.
Aug. 20, 2011：Skimmer surge tank water over-flowed from spent fuel pool was collected and analyzed.

ref.：The 5th hearing of academic expert's opinions regarding technical knowledge of the accident at the Fukushima Daiichi Nuclear Power Station.

Confirmed that there is no leakage and no damage around the spent fuel pool

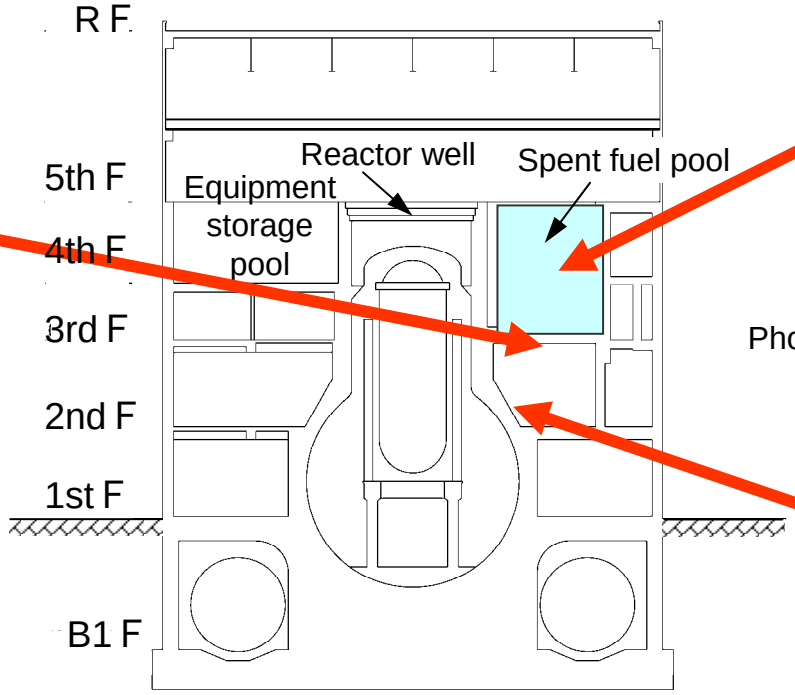
■The situation of the spent fuel pool

Water injection status into the spent fuel pool was confirmed by the camera attached to the tip of the concrete pump vehicle. And also, it was confirmed that there is no leakage of the 2nd floor, which is underneath the spent fuel pool.

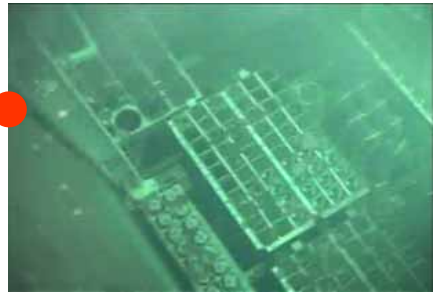
■The situation of the wall around the spent fuel pool（shell wall）

As the results of the visual inspection inside R/B, it was confirmed that there was no damage to the shell wall on the 1st and 2nd floor. As for the 3rd floor, the shell wall was enough thick (1855mm). Hence it was also evaluated that there was no damage.

Photo① View from lower floor (Before concrete placement)



Sectional view of Reactor building



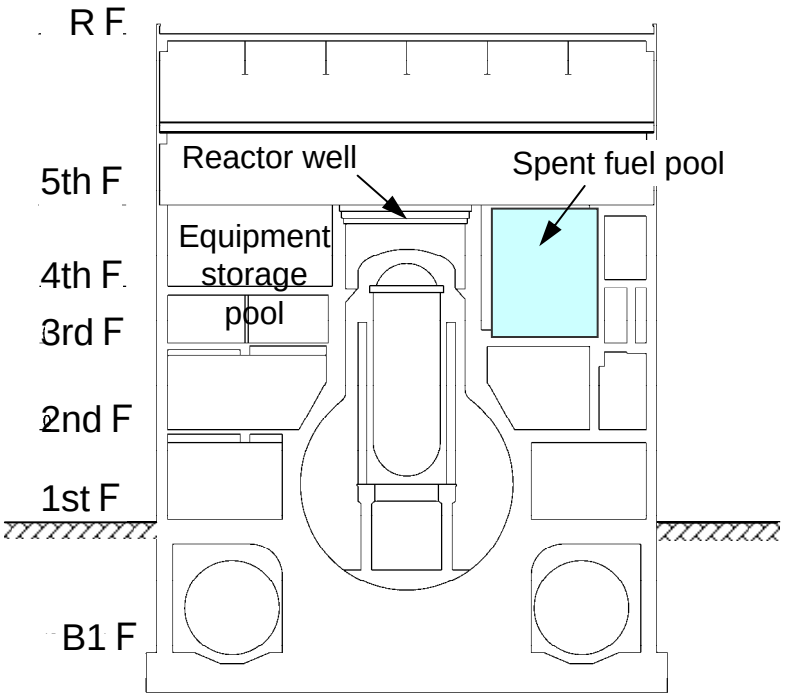
Photo② Situation in the spent fuel pool

Photo③ Situation of the 2nd floor shell wall

※ Photo①May 21, 2011
Photo②Apr. 28, 2011
Photo③May 20, 2011

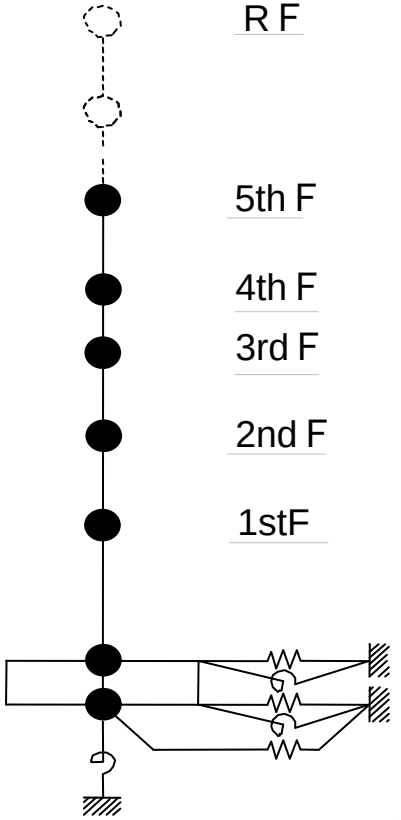
Confirmed the seismic resistance against aftershocks①

- Using lumped mass model reflecting the damage state of the reactor building after the hydrogen explosion, we conducted an evaluation of the reactor building against the future big earthquake (JMA Seismic Intensity Scale 6+) equivalent to the Tohoku-Pacific Ocean Earthquake and confirmed that the reactor building has a sufficient margin of seismic resistance. （※1）



Sectional view of Reactor building

Modeling

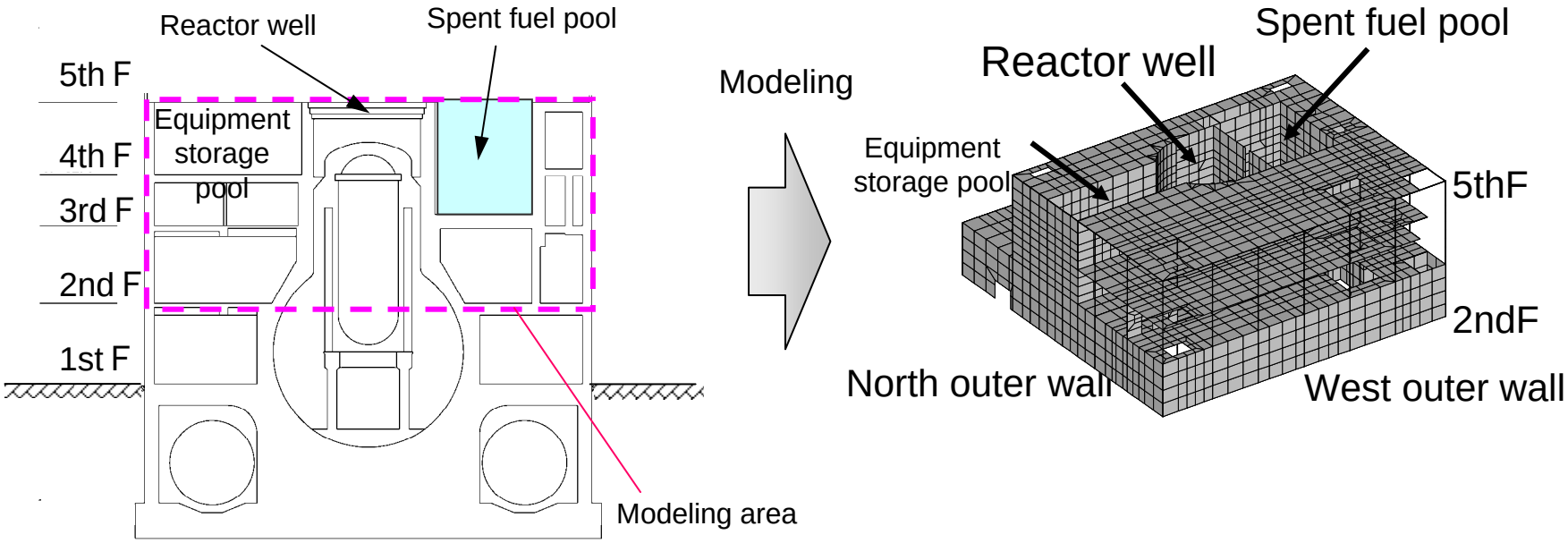


Finite element analysis (horizontal direction)

※1；"Submission of Reports concerning the study of the current seismic resistance and reinforcement of reactor buildings at Fukushima Daiichi Nuclear Power Station (1)" TEPCO（May 28, 2011）

Confirmed the seismic resistance against aftershocks②

- Additionally, we conducted a detailed evaluation with lumped mass model considering the building damage or conditions of the pool water at high temperatures and confirmed that the spent fuel pool has a sufficient margin of seismic resistance（※1）



Sectional view of Reactor building

Finite element analysis

※1；”Submission of Reports concerning the study of the current seismic resistance and reinforcement of reactor buildings at Fukushima Daiichi Nuclear Power Station (1)” TEPCO（May 28, 2011）

Confirmed the seismic resistance against aftershocks③

- Nuclear and Industrial Safety Agency(NISA) ordered TEPCO to report the following matters pursuant to Section 67.1 of Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors. (Apr. 13, 2011)
  - ✓ Results of the earthquake-proof safety evaluations using the possible earthquakes in the future
  - ✓ Results of the studies of countermeasures such as antiseismic reinforcement work

  NISA reviewed TEPCO's report and compiled their own report regarding their review result. (May 28, 2011)
- NISA's evaluation result was reported to Nuclear Safety Commission on May 30, 2011, the commission presented the opinion that TEPCO's analysis included necessary consideration such as the damage state of the building.
- At the time of the evaluation, the opinions of experts, belong to Advisory Committee on Energy and Natural Resources / Seismic and Structural Design Subcommittee / Nuclear and Industrial Safety Subcommittee, were obtained. Also, NISA held the hearing of academic experts, and confirmed the adequacy of TEPCO's report. （※1）
- In addition, Japan Nuclear Energy Safety Organization evaluated the seismic resistance of unit3 and unit4 reactor building, in order to assess the appropriateness of TEPCO's evaluation. （※2）

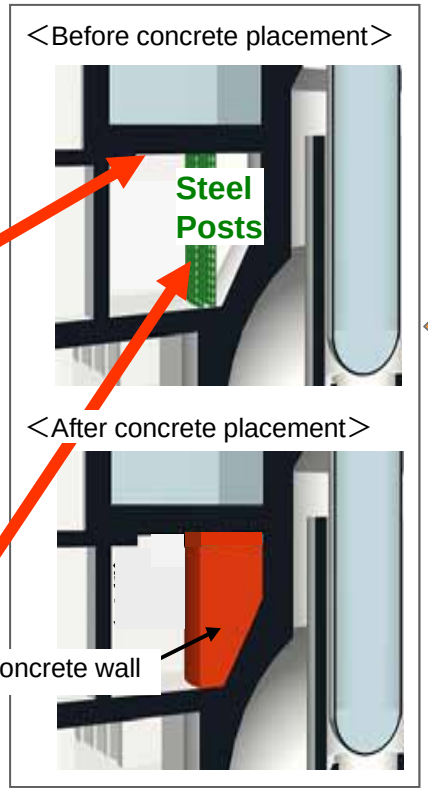
※1；Nuclear and Industrial Safety Agency (Feb. 16, 2012),"The interim report on the evaluation of the earthquake and tsunami at Nuclear Power Stations in consideration of the knowledge about the Great East Japan Earthquake, and on the influence and evaluation for the reactor buildings and structures at Fukushima Daiichi Nuclear Power Station and Fukushima Daini Nuclear Power Station"

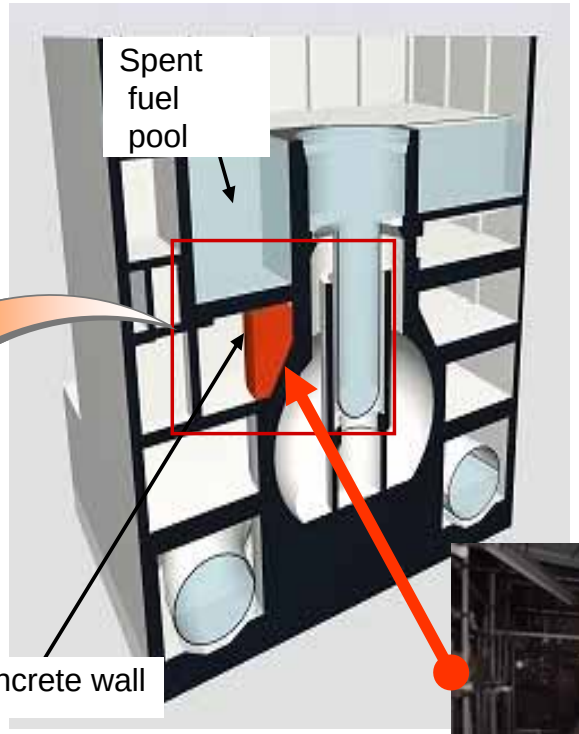
※2；Japan Nuclear Energy Safety Organization (Oct. 28, 2011), "Outline of the study regarding current seismic safety of unit3 and unit4 reactor building at Fukushima Daiichi Nuclear Power Station"

Reinforced the bottom of the spent fuel pool

- We installed a support structure at the bottom of the spent fuel pool. This increased the seismic safety margin by an extra 20 %.

Photo① View from lower floor
(Before concrete placement)





Photo② Steel posts installed condition
(Before concrete placement)

※Concrete placement (red) after posts installation (green)

Photo③ Surface of the 2nd floor shell wall
(Before concrete placement)

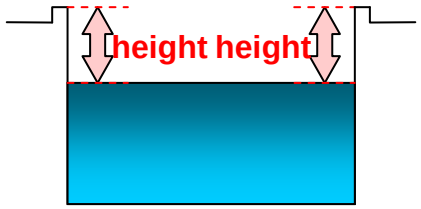
※ Photo① May 21, 2011 Photo② June 15, 2011 Photo③ May 20,2011

※ Completed reinforcement on July 30, 2011

Confirmed that the building has not tilted①

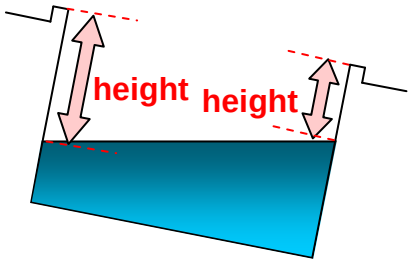
- We measured the distance between the water surface of the spent fuel pool and the floor surface of the building, and confirmed that the building has not tilted

1） not tilted

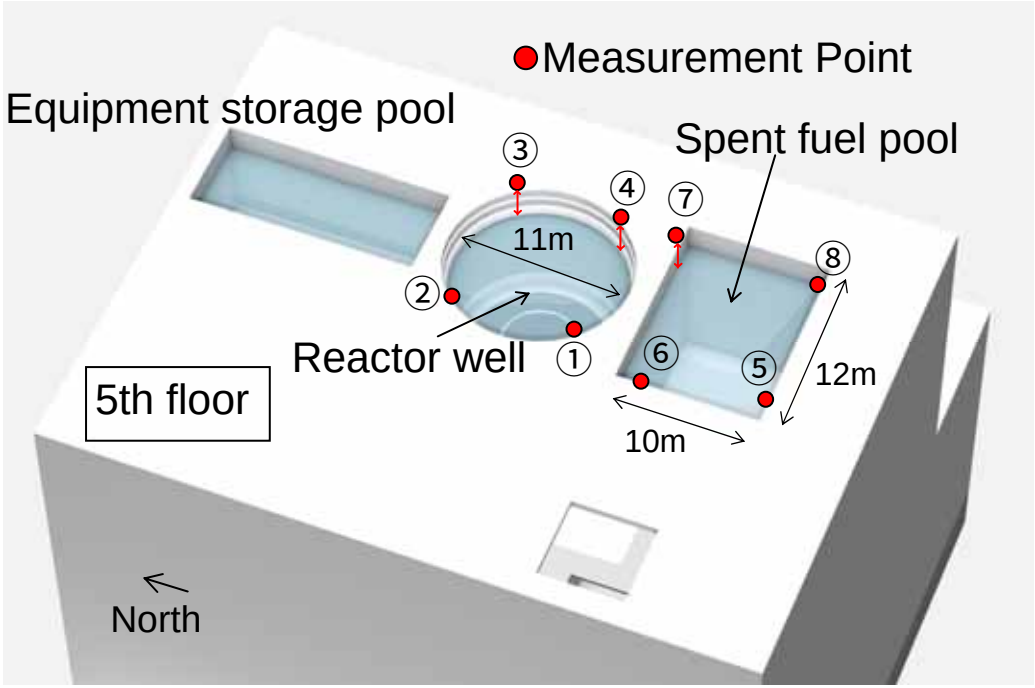


Almost same

2） tilted



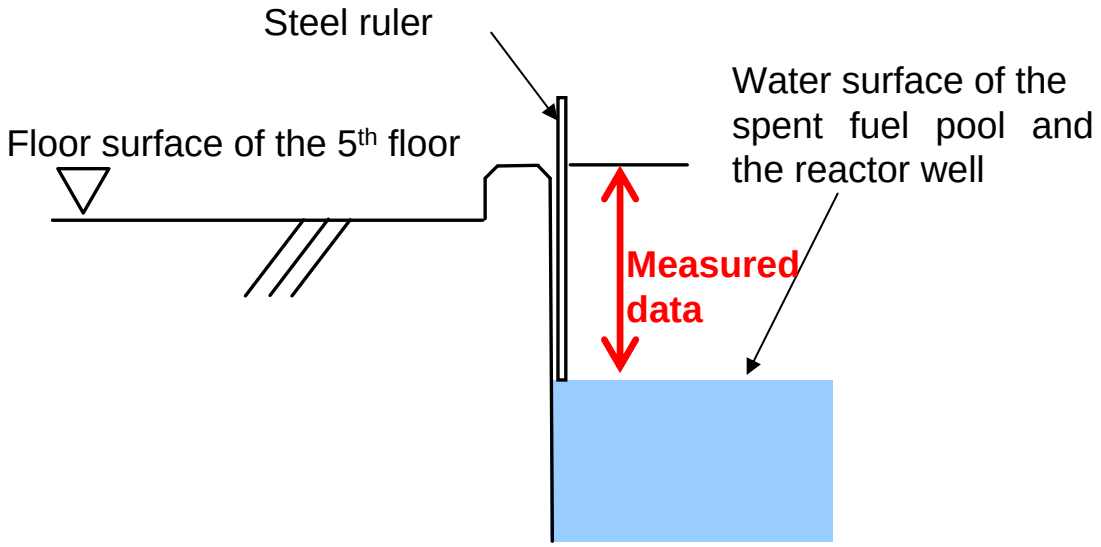
Not same



Measurement Point（on the 5th floor）

Confirmed that the building has not tilted②

- We conducted the measurements twice on February 7 and April 12, 2012 and the measured data at the 4 corners were almost the same. Thus, we confirmed that the floor surface of the 5th floor, water surfaces of the spent fuel pool and the reactor well were parallel.



Measurement Method

※The measured data includes measurement errors

Measurement results

Unit [mm]

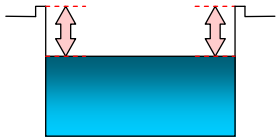
Reactor well	Measurement date	
	Feb.7, 2012	Apr. 12, 2012
①	462	476
②	463	475
③	462	475
④	464	475

Spent fuel pool	Measurement date
	Apr. 12, 2012
⑤	468
⑥	468
⑦	468
⑧	468

※Only reactor well was measured on Feb. 7
※Water level changes depending on the operation of cooling system

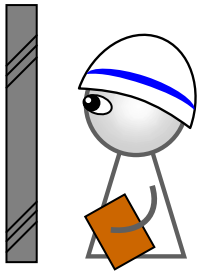
Regularly check the reactor building and spent fuel pool

- We have already conducted visual inspections to ensure there is no damage that could lead to the collapse of the reactor building
- We will regularly check cracks on the concrete floors and walls including those of spent fuel pool. As necessary, we will repair them.



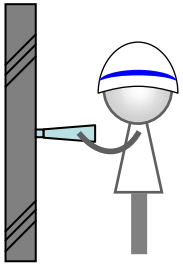
①Checking the building's inclination

We will ongoingly check the building's inclination



②Visual inspection

We will regularly check cracks on the concrete floor and wall, and measure their progression regularly to confirm the damage level and conduct repairs as necessary.



③Concrete strength check

We will regularly conduct a non-destructive inspection to confirm concrete strength, and the seismic resistance.

Ensure the safety of spent fuel pool by corrosion prevention and leakage prevention monitoring

■Corrosion suppression by water quality improvement

✓In addition to the installation of a circulating cooling system to the spent fuel pool, hydrazine injection (since May 9, 2011) and a desalting facility installation (since Aug. 20, 2011) have been put into practice. The water quality of the spent fuel pool will be ongoingly improved by these continuous efforts as corrosion prevention.

Date	temperature（℃）	pH	Chloride concentration(ppm)
2011/5/7	approx. 80	7.2	approx. 2,500
2012/1/30	approx. 30	10.0	approx. 250

■Leakage prevention monitoring at the spent fuel pool

✓In order to detect leakage from the spent fuel pool rapidly, ①Pool water level monitoring by a temporary water level indicator（Remote monitoring from the seismic isolated building by the gauge set up in the pool)、② Water level monitoring in the skimmer surge tank, into which the water from the spent fuel pool flows continuously, are being performed.

✓Until now, neither water leakage nor abnormal change in the pool water level has been found.

ref.：Mid-and-long-Term Roadmap towards the Decommissioning of Fukushima Daiichi Nuclear Power Units 1-4 Working Council the 3rd meeting

Vice minister Nakatsuka made a visitation

- Vice minister Nakatsuka and government officers made a visitation of unit 4 reactor building and confirmed the building structural integrity on April 23, 2012.

①Confirmation of the reactor well on the fifth floor of Nuclear Reactor Building Unit 4

②Confirmation of support structure installed at the bottom of the spent fuel pool on the second floor of Nuclear Reactor Building Unit 4

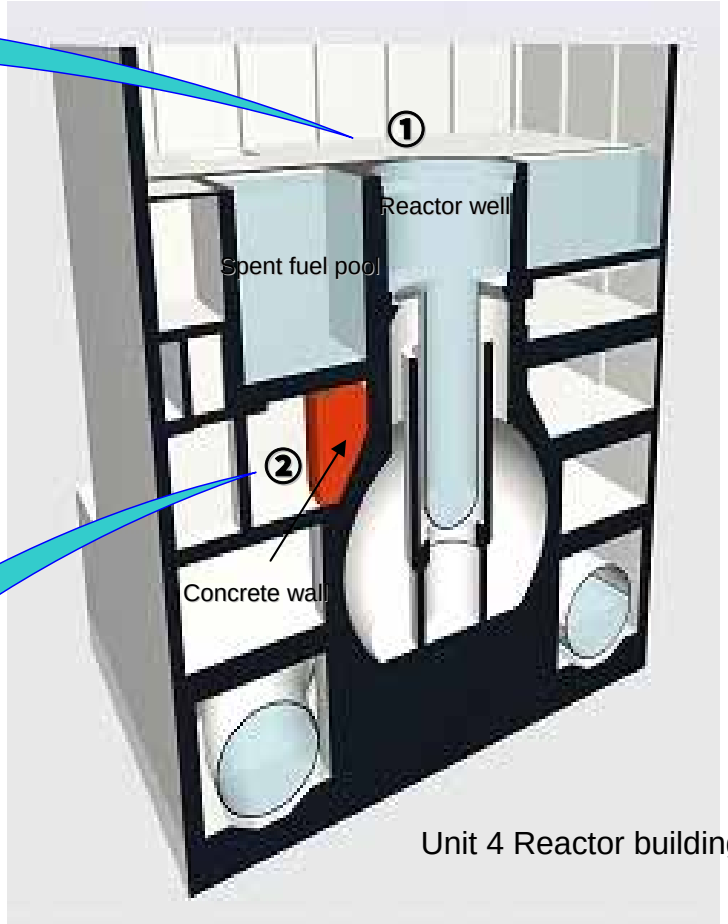
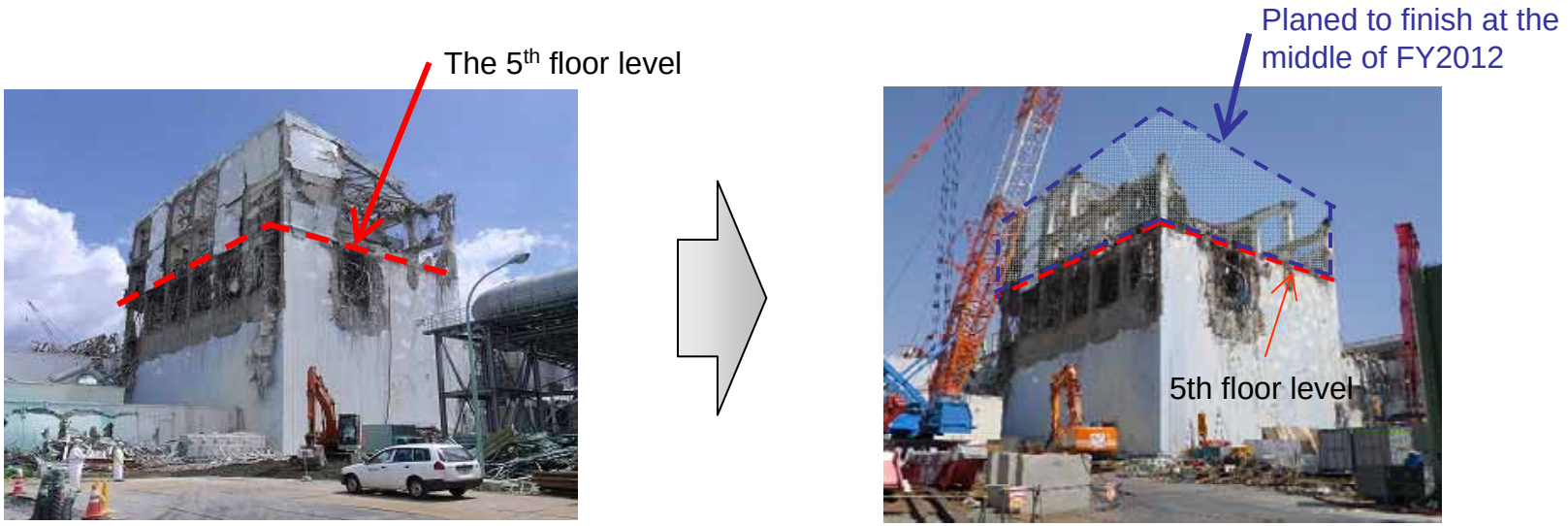


Photo location

Remove rubble on and around the reactor building

- Before removal of fuels in the spent fuel pool, we have begun to clear rubble on the top of reactor building since September 21, 2011.
- We plans to finish rubble removal at the middle of FY2012



Full view（South side）

Begun to construct the cover for Unit 4 spent fuel pool

- The cover for fuel removal will be constructed in order to support the fuel handling facility, to improve work environment of fuel removal , and to prevent scatter and diffusion of radioactive materials during the work
- Construction has begun on April 17, 2012.

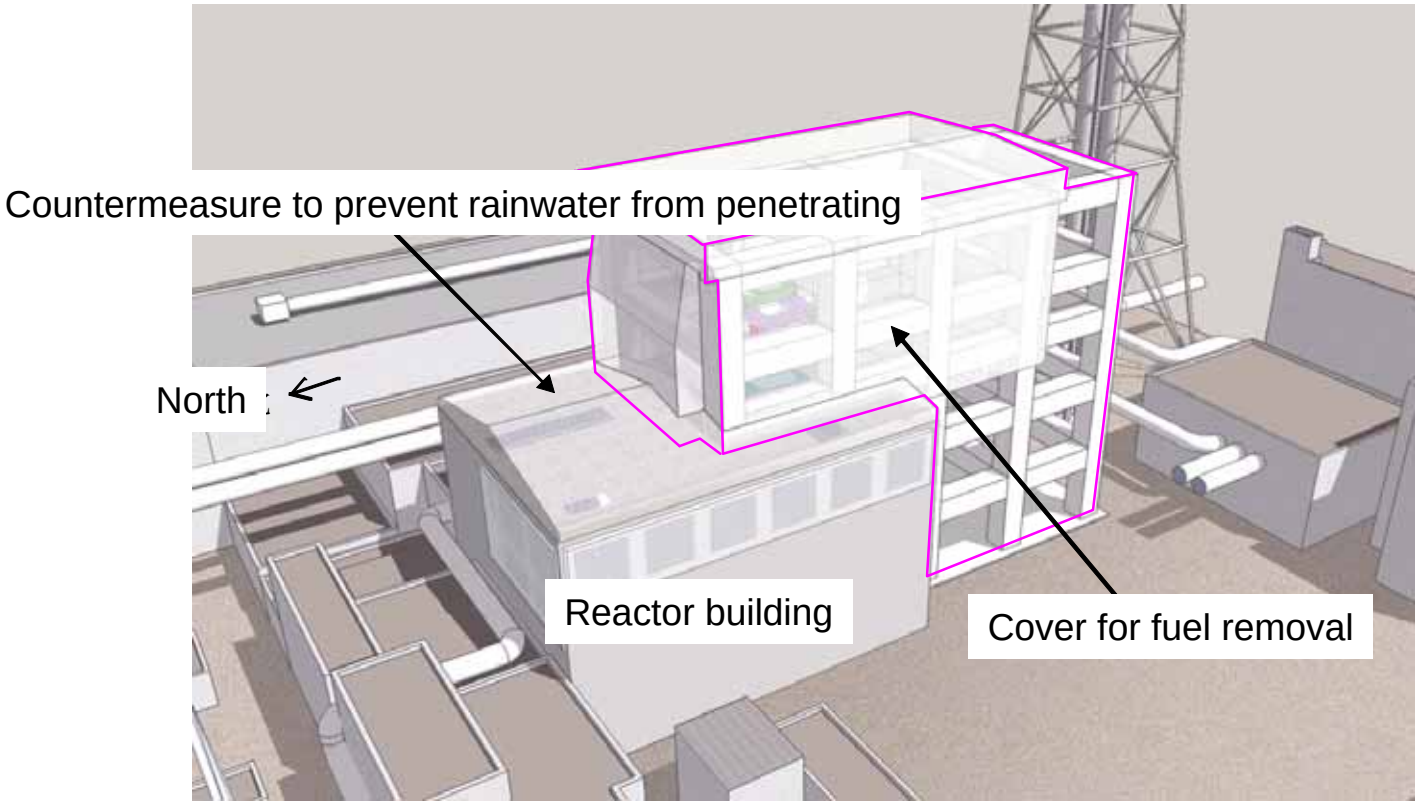


Image of the cover for fuel removal of Unit 4 in Fukushima Daiichi Nuclear Power Station
(This picture shows only a image of the general plan, therefore it can differ from the actual structure.)

Going to steadily remove spent fuels

- After construction of the cover for fuel removal, we will move inspected fuels to the common pool, using onsite casks, in order to more steadily cool them.
- Our target of beginning fuel removal is in 2013.

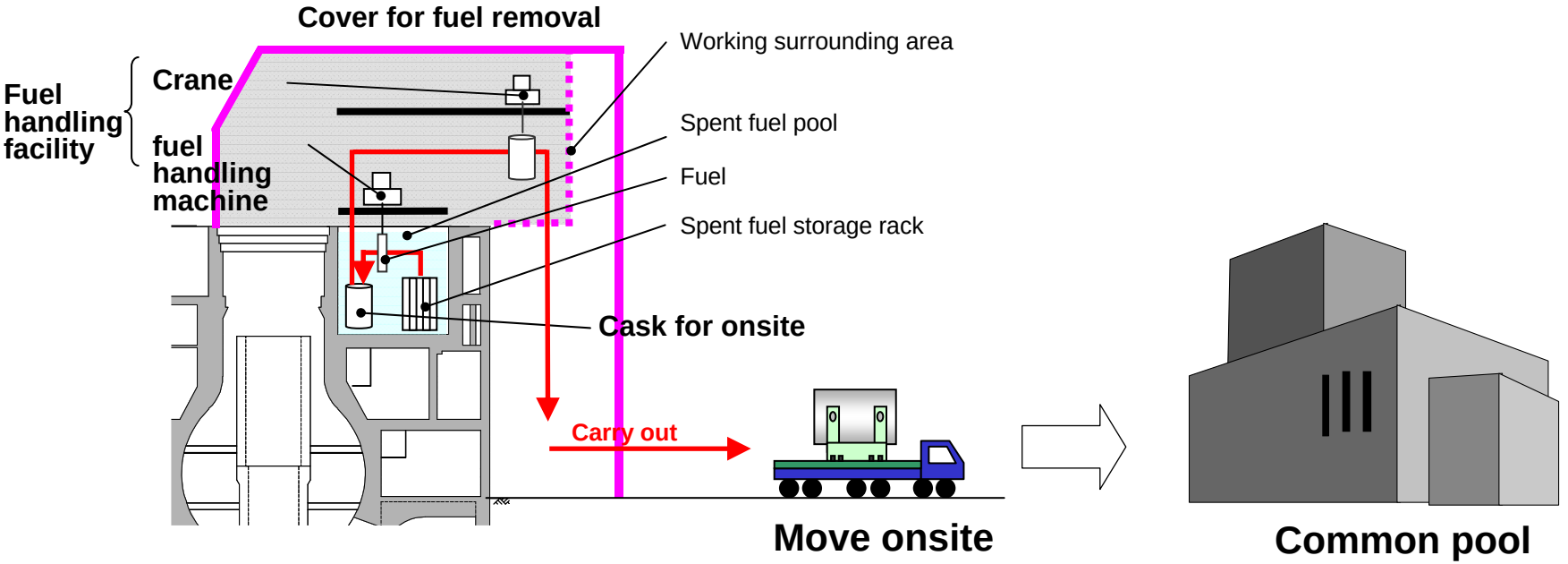
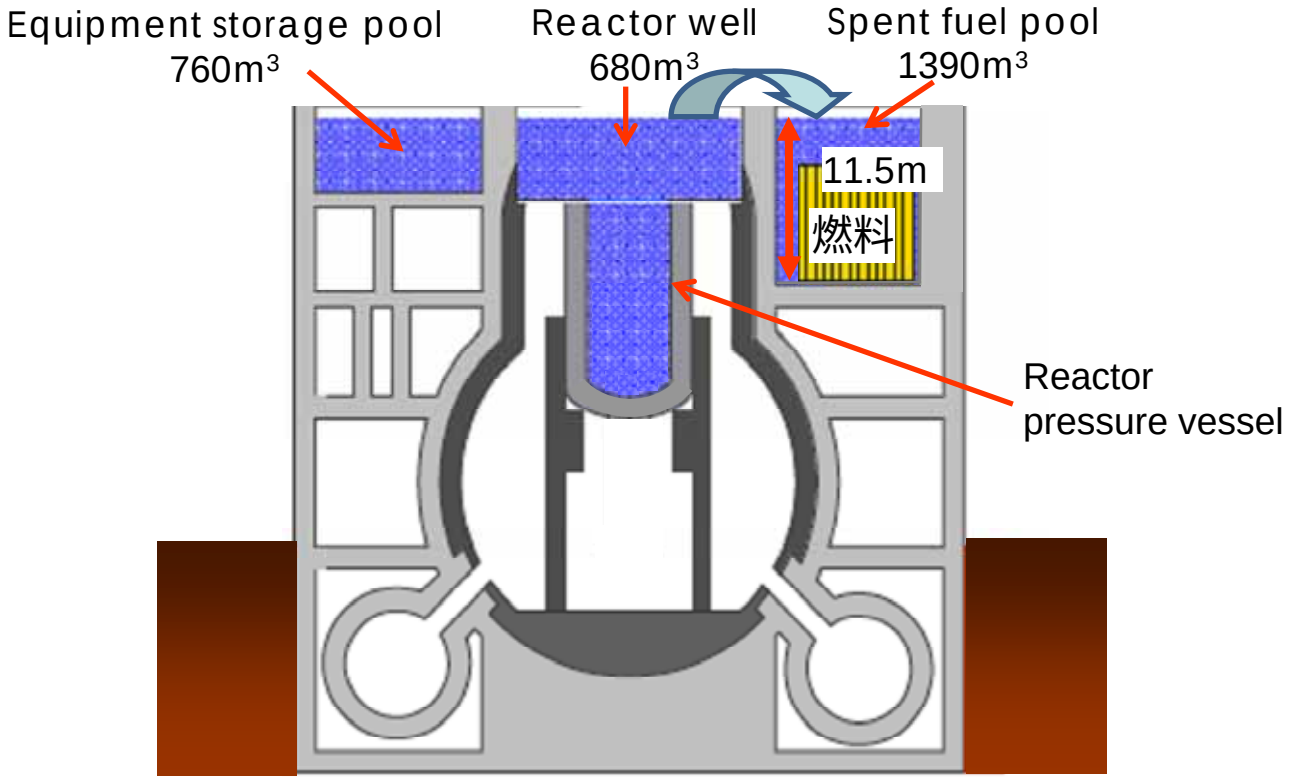


Image of fuel removal

construct cover for fuel removal and fuel handling facility (crane and fuel handling machine) and remove fuels from the spent fuel pool

Unit4 spent fuel pool water level at the time of the accident

- On and after Mar. 17, 2011, each unit including unit4 was supplied with water using a water-cannon vehicle, a fire engine, a concrete pump vehicle, etc..
- Since unit4 especially had been shutdown for outage, the reactor well water level was full. It is presumed that the reactor well water flowed into the spent fuel pool as a result of the lowered water level in the spent fuel pool, and that the fuel in the pool was not exposed and was not damaged according to the decay heat evaluation etc..



Related information and Links

- Submission of Reports about the study regarding current seismic resistance and reinforcement of reactor buildings at Fukushima Daiichi Nuclear Power Station (1) (May 28,2011)
  http://www.tepco.co.jp/en/press/corp-com/release/11052801-e.html
- Completion of installation of Supporting Structure under the Bottom of the Spent Fuel Pool in the Reactor Building at Fukushima Daiichi Nuclear Power Station Unit 4 (July 30.2011)
  http://www.tepco.co.jp/nu/fukushima-np/images/handouts_110730_02-j.pdf
- Removal of debris on top of the reactor buildings of Unit 3 and 4 of Fukushima Daiichi Nuclear Power Station (September 9, 2011)
  http://www.tepco.co.jp/en/nu/fukushima-np/images/handouts_110909_05-e.pdf
- Japan Nuclear Energy Safety Organization (Oct. 28, 2011), ”Outline of the study regarding current seismic safety of unit3 and unit4 reactor building at Fukushima Daiichi Nuclear Power Station”
  http://www.nisa.meti.go.jp/shingikai/800/25/003/3-3-4.pdf
- Mid-and-long-Term Roadmap towards the Decommissioning of Fukushima Daiichi Nuclear Power Units 1-4, TEPCO (December 21, 2011)
  http://www.tepco.co.jp/en/press/corp-com/release/11122107-e.html
- Nuclear and Industrial Safety Agency (Feb. 16, 2012),”The interim report on the evaluation of the earthquake and tsunami at Nuclear Power Stations in consideration of the knowledge about the Great East Japan Earthquake, and on the influence and evaluation for the reactor buildings and structures at Fukushima Daiichi Nuclear Power Station and Fukushima Daini Nuclear Power Station”
  http://www.meti.go.jp/press/2011/02/20120216003/20120216003.html
- Fukushima Daiichi Nuclear Power Station, Unit 4 Water Level Measurement for the Verification of Reactor Building Health （April 13, 2012）
  http://www.tepco.co.jp/en/press/corp-com/release/11122107-e.html
- General Plan and Start of Main Work of the Cover for Fuel Removal of Unit 4 in Fukushima Daiichi Nuclear Power Station April 16, 2012)
  http://www.tepco.co.jp/en/press/corp-com/release/2012/1201934_1870.html
- Visitation of Mr. Nakatsuka, Senior Vice Minister of Cabinet Office (April 23, 2012)
  http://www.tepco.co.jp/en/nu/fukushima-np/images/handouts_120423_06-e.pdf
- We affirm that the Reactor Building and Spent Fuel Pool of Unit 4 will not collapse in the event of an earthquake (April 26, 2012) http://www.tepco.co.jp/en/nu/fukushima-np/info/index-e.html