Investigation of Operating Floor after making an opening in the Outer West Wall of the Unit 2 Reactor Building

July 26, 2018

TEPCO

Tokyo Electric Power Company Holdings, Inc.

1. Investigation of the operating floor after making an opening in the west wall

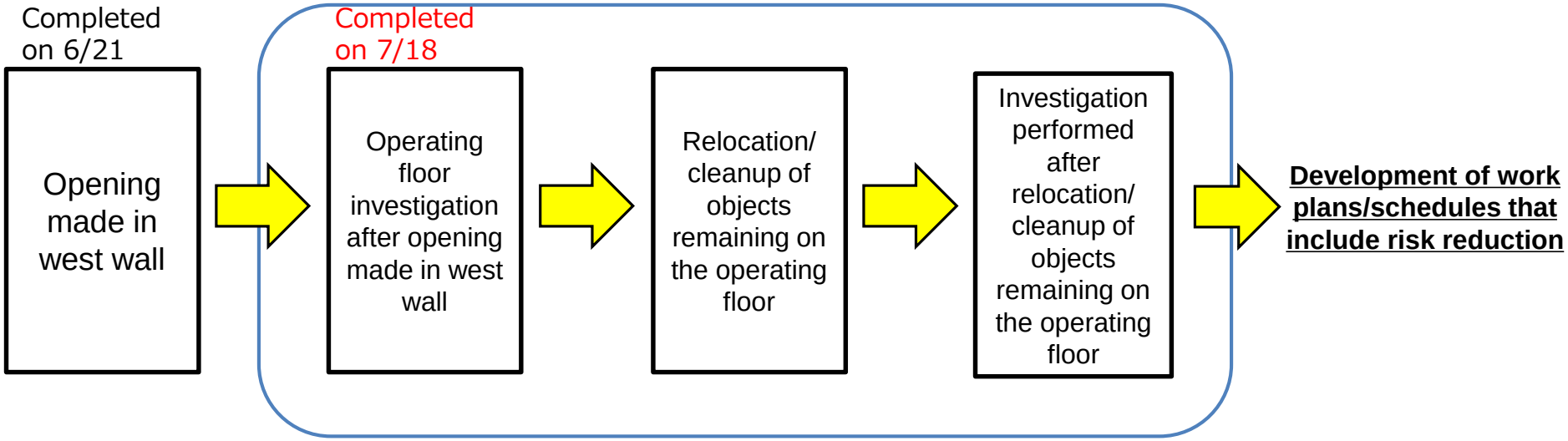
- In order to remove fuel from the Unit 2 spent fuel pool, the top of the reactor building must first be dismantled. However, prior to dismantling we plan to implement an investigation of the operating floor (5th floor) to measure dose rates and dust concentrations in order to thoroughly implement measures to prevent the dispersion of radioactive substances.

- Work to make an opening in the outer west wall of the Unit 2 reactor building was completed on June 21.

- On July 2 we began using remotely operated robots to measure dose rates and dust concentrations, and survey contamination conditions within areas where it is possible to use these robots without moving any of the objects that remain on the operating floor. This investigation was completed on July 18.

- Going forward, we shall clean up the operating floor and remove any obstacles that currently hinder an investigation of the entire floor.

Operating Floor Investigation



2. Investigation of operating floor after opening made in west wall

【Investigation Objectives】

- Ascertain the condition of objects remaining on the operating floor and measure dose rates around the opening made in the west wall in order to ensure that “Relocation/cleanup of objects remaining on the operating floor” and “Investigation performed after relocation/cleanup of objects remaining on the operating floor” go smoothly.
- The primary tasks performed during the investigation were as follows:
  - Air dose measurements, surface dose measurements, surface contamination density measurements (smear tests), measurement of the concentration of radioactive substances in the air (dust measurements), investigation of the condition of remaining objects using cameras

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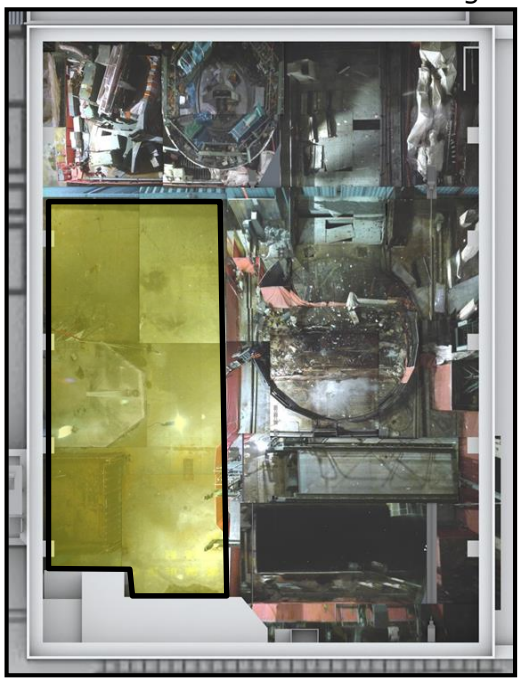
Scope of this investigation



Remotely operated unmanned robots used for this investigation

※Have been used in the past to perform investigations/work inside the R/B

Kobra

Main use
- Investigation tasks

Packbot

Main use
- Monitor Kobra operations
- Assist with tasks

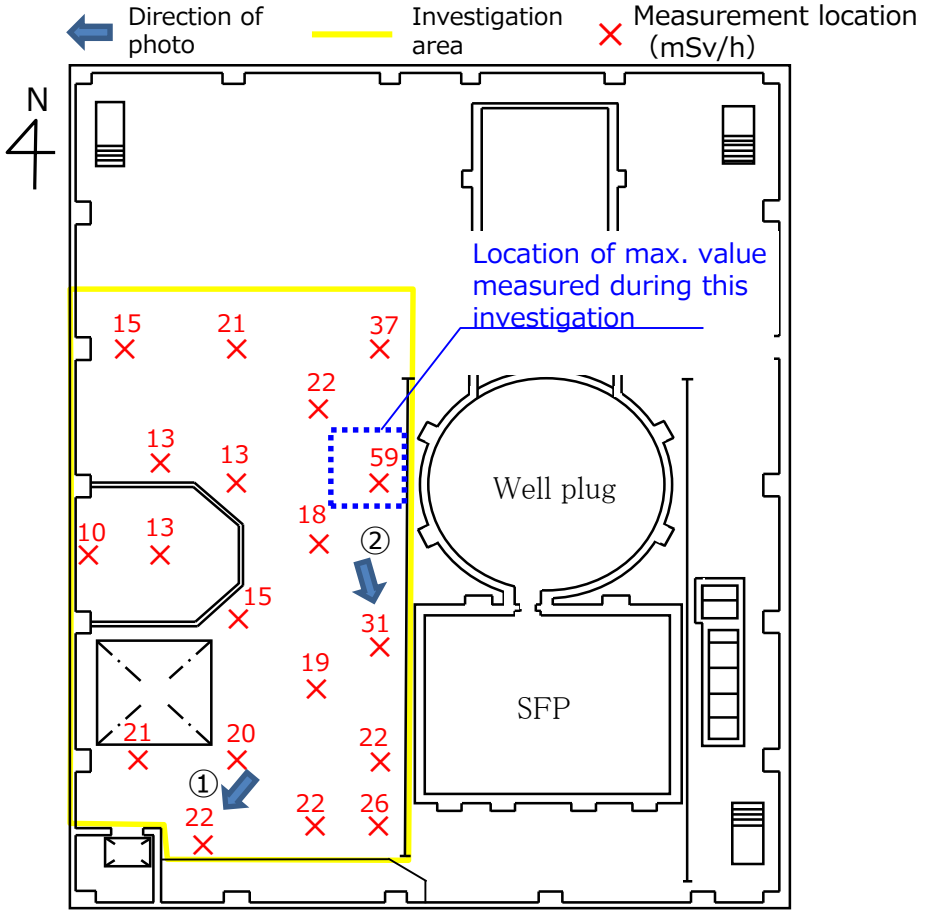
3. Results of operating floor investigation after opening made in west wall （1） Air dose rates

■ Air dose rate measurement results: γ ray dose rate※ measured at a height of approx. 1.5m from the floor

Dose rates near the well plug are high and get lower as you move away from the well plug, so it is assumed that the radiation source is the well plug. (It was confirmed during the FY2012 investigation as well that dose rates above the well plug were 880mSv/ h and dropped as you moved away from the well plug.)

① Measurements being taken with remotely operated unmanned robot (photographed by ceiling camera)

② Measurements being taken with remotely operated unmanned robot (photographed by other robot)

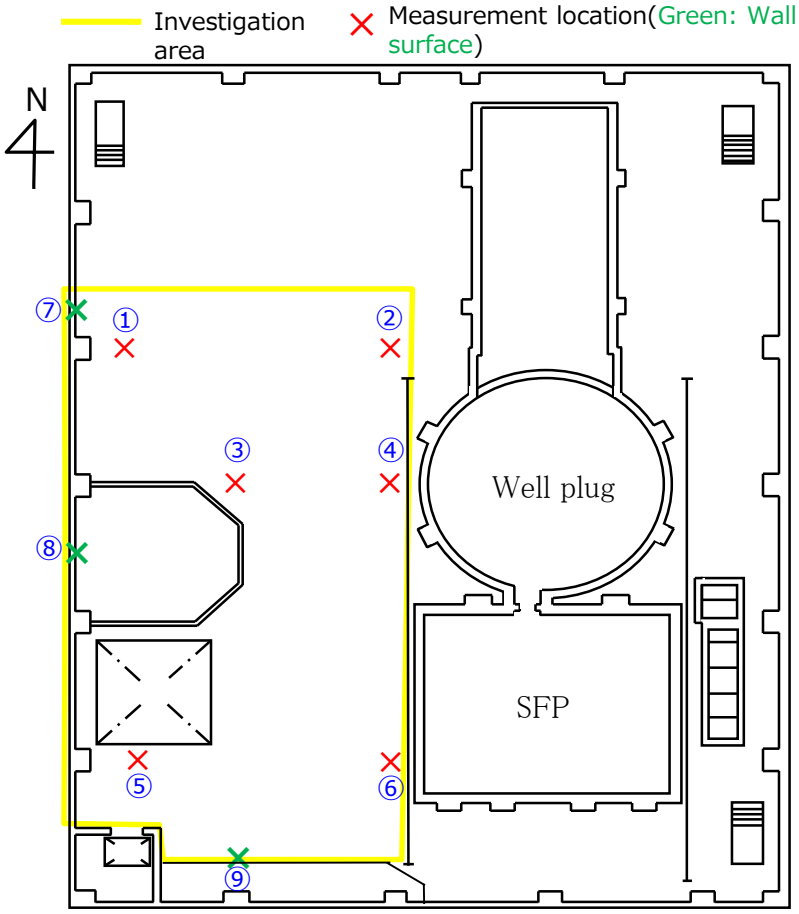


※: 1cm dose equivalent rate

3. Results of operating floor investigation after opening made in west wall （2）Surface contamination conditions

■ Measurement results for surface contamination density (smear tests) on the floors and walls

【Measurement location】



【Measurement results】

Sampling location	Surface contamination density (Bq/cm²)			
	Gamma ray emitting nuclide		Beta ray emitting nuclide	Alpha ray emitting nuclide
	Cs-134	Cs-137	Gross β	Gross α
① Floor	2.4×10^{3}	2.3×10^{4}	$> 2.6\times10^{2}$	5.2×10^{0}
② Floor	9.7×10^{2}	8.9×10^{3}	$> 2.6\times10^{2}$	4.0×10^{0}
③ Floor	1.1×10^{3}	1.0×10^{4}	$> 2.6\times10^{2}$	2.2×10^{0}
④ Floor	3.0×10^{3}	2.8×10^{4}	$> 2.6\times10^{2}$	8.8×10^{0}
⑤ Floor	7.7×10^{3}	7.2×10^{4}	$> 2.6\times10^{2}$	9.2×10^{0}
⑥ Floor	5.1×10^{3}	4.8×10^{4}	$> 2.6\times10^{2}$	6.6×10^{0}
⑦ Wall	2.9×10^{1}	2.4×10^{2}	2.3×10^{2}	$< 9.9\times10^{-2}$
⑧ Wall	6.5×10^{0}	5.8×10^{1}	6.8×10^{1}	$< 9.9\times10^{-2}$
⑨ Wall	2.7×10^{1}	2.3×10^{2}	8.6×10^{1}	$< 9.9\times10^{-2}$

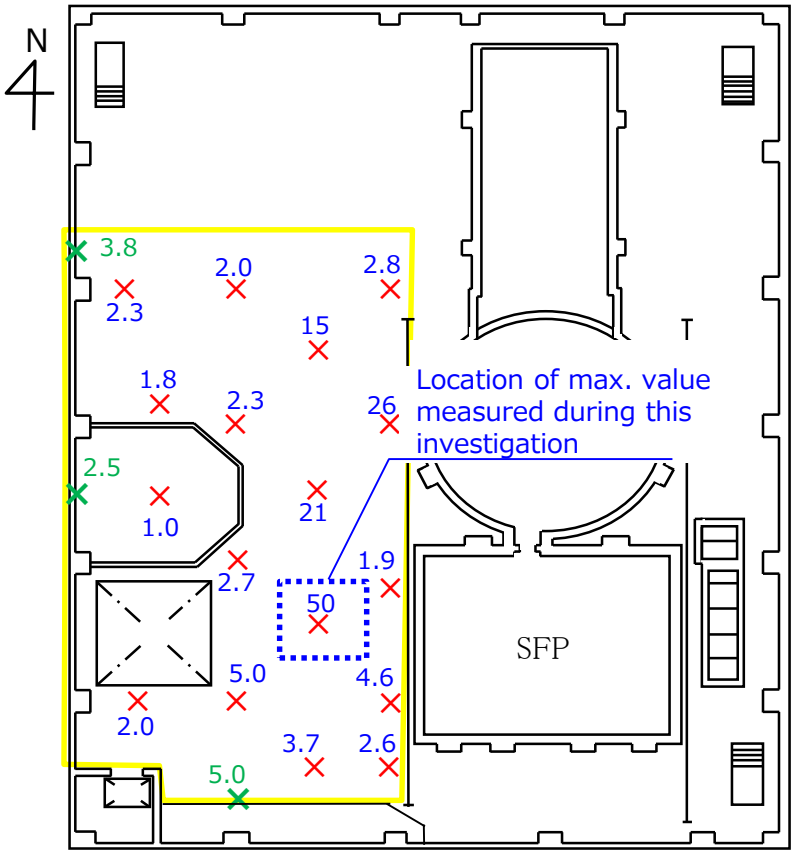
3. Results of operating floor investigation after opening made in west wall （2） Surface contamination conditions

■ Checking for Sr-90 using surface dose rates

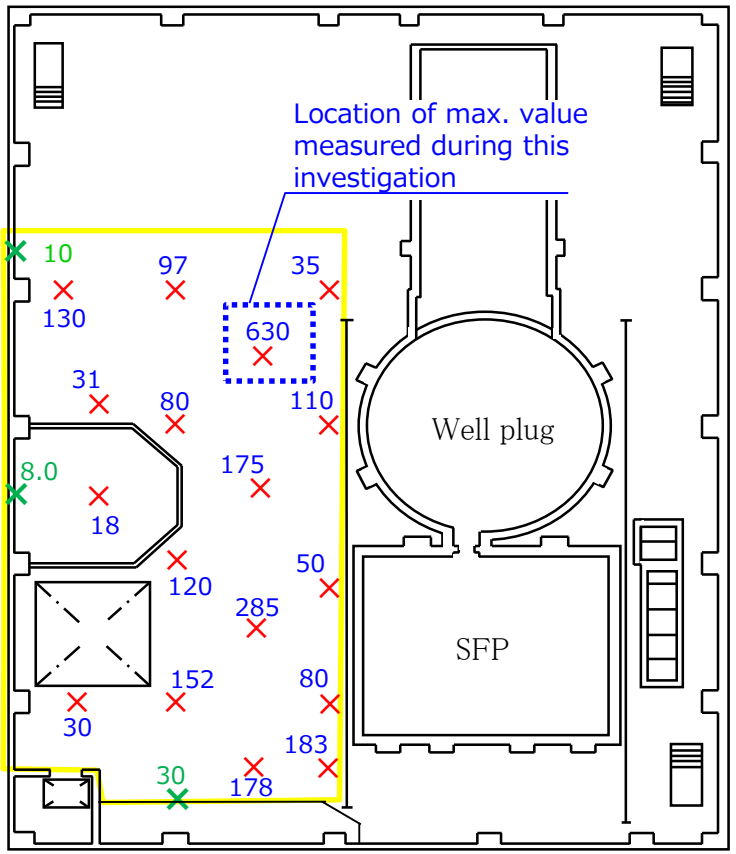
Since γ+β ray dose rate (dose contribution from γ ray emitting nuclides like Cs, and β ray emitting nuclides like Sr-90) is higher than the γ ray dose rate, it is assumed that highly energetic β nuclides, like Sr-90 are present on the surface

Investigation area　Measurement location(Green: Wall surface)　(mSv/h)　Measurement height: <1cm

【γ ray dose rate※1】



【γ+β ray dose rate※2】



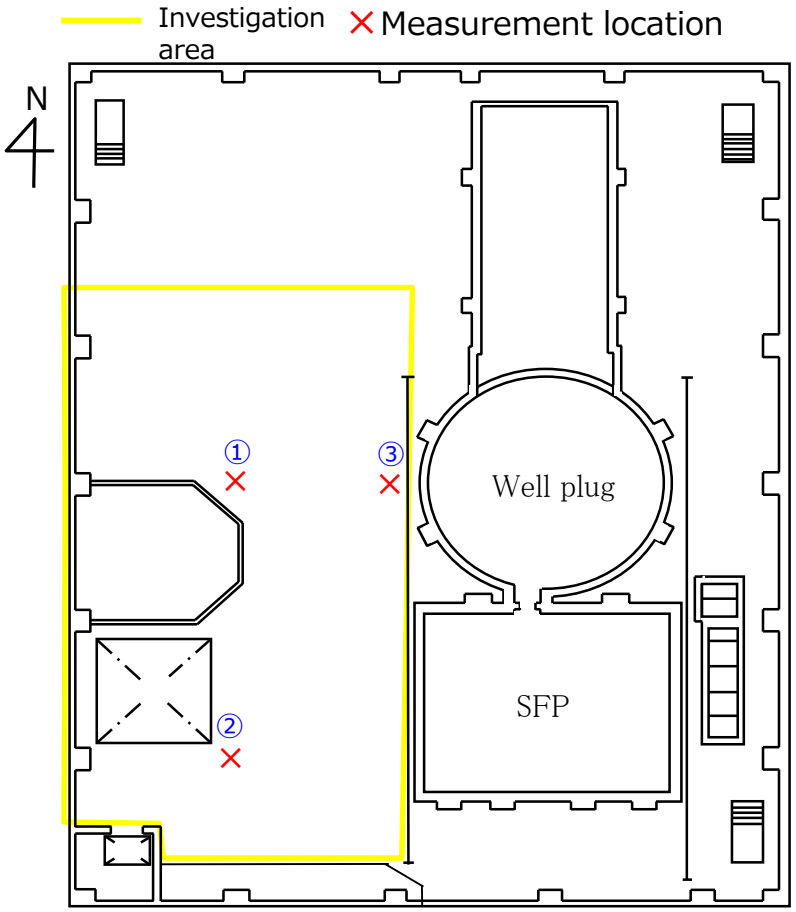
※1　1cm Dose equivalent rate

※2　70μm Dose equivalent rate : If highly energetic β rays exist, this value will be significantly higher than the 1cm dose equivalent rate

3. Results of operating floor investigation after opening made in west wall （3） Concentration of radioactive substances in the air

■ Measurement results for the concentration of radioactive substances in the air (dust measurements)

【Measurement location】



【Measurement results】

Sampling location		Concentration of radioactive substances in the air (Bq/cm³)			
		Gamma ray emitting nuclides		Beta ray emitting nuclides	Alpha ray emitting nuclides
		Cs-134	Cs-137	Gross β	Gross α
① ※1	When static	5.0×10^{-6}	4.0×10^{-5}	Under analysis	
	When dynamic	$<1.2\times10^{-6}$	$<9.4\times10^{-7}$		
② ※1	When static	9.8×10^{-6}	8.6×10^{-5}		
	When dynamic	2.5×10^{-5}	2.5×10^{-4}		
③ ※2	When static	1.0×10^{-4}	9.3×10^{-4}		

※1 In order to compare dust conditions when the robots were in motion, dust was sampled from around the dust measurement apparatus when the robot was “dynamic" and when it was "static."

※2 Dust was sampled from location ③ when the robot was "static" in order to check the impact of dust from above the well plug

4. Investigation result summary

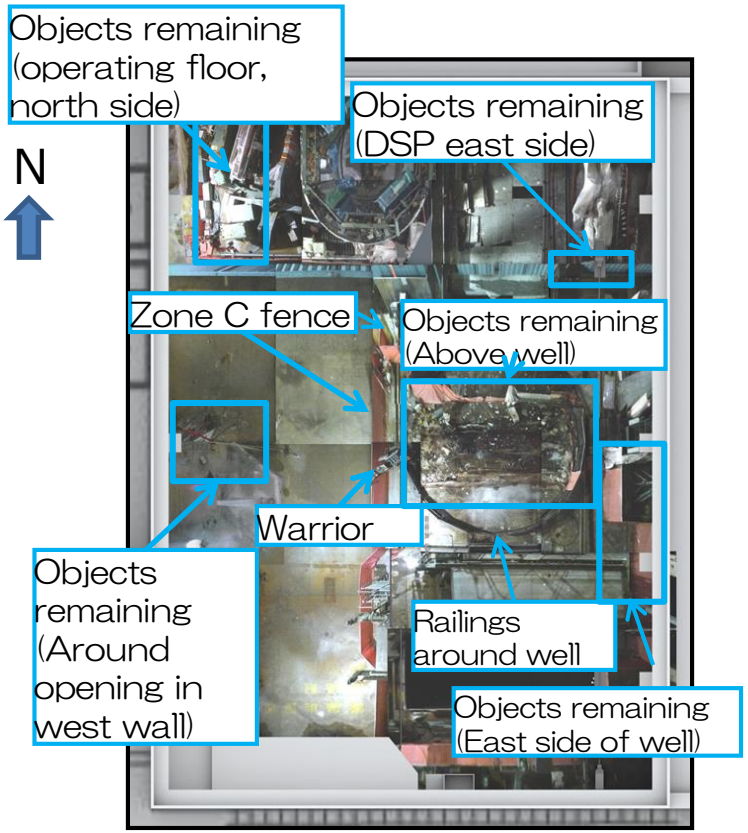
- Measurement results for air dose rate, surface dose rate, and surface contamination density obtained during the investigation performed after making an opening in the west wall, showed that remotely operated unmanned robot contamination will not hinder maintenance efforts engaged in by personnel in the anticum, so the relocation/cleanup of objects remaining on the operating floor and the investigation performed after relocation/cleanup of objects remaining on the operating floor, shall be implemented as planned.
- When engaging in work in the anticum (work that involves directly touching remotely operated unmanned robots), thorough radiation control measures shall be implemented based on this information on contamination.

5. Relocation/cleanup of objects remaining on the operating floor

【Objectives】

- To relocate/cleanup materials and equipment remaining on the operating floor that may hinder the investigation to be performed “ after relocation/cleanup of objects remaining on the operating floor.”

- The primary objects to be relocated/cleaned up are as follows:
  - ・Zone C fence ・Railings around the well ・Warrior
  - ・Chanel attachment/removal device ・Tool rack, etc.



Remotely operated unmanned heavy machinery/robots used

BROKK400D

Primary use:
- Warrior relocation
- Fence cutting/clean up

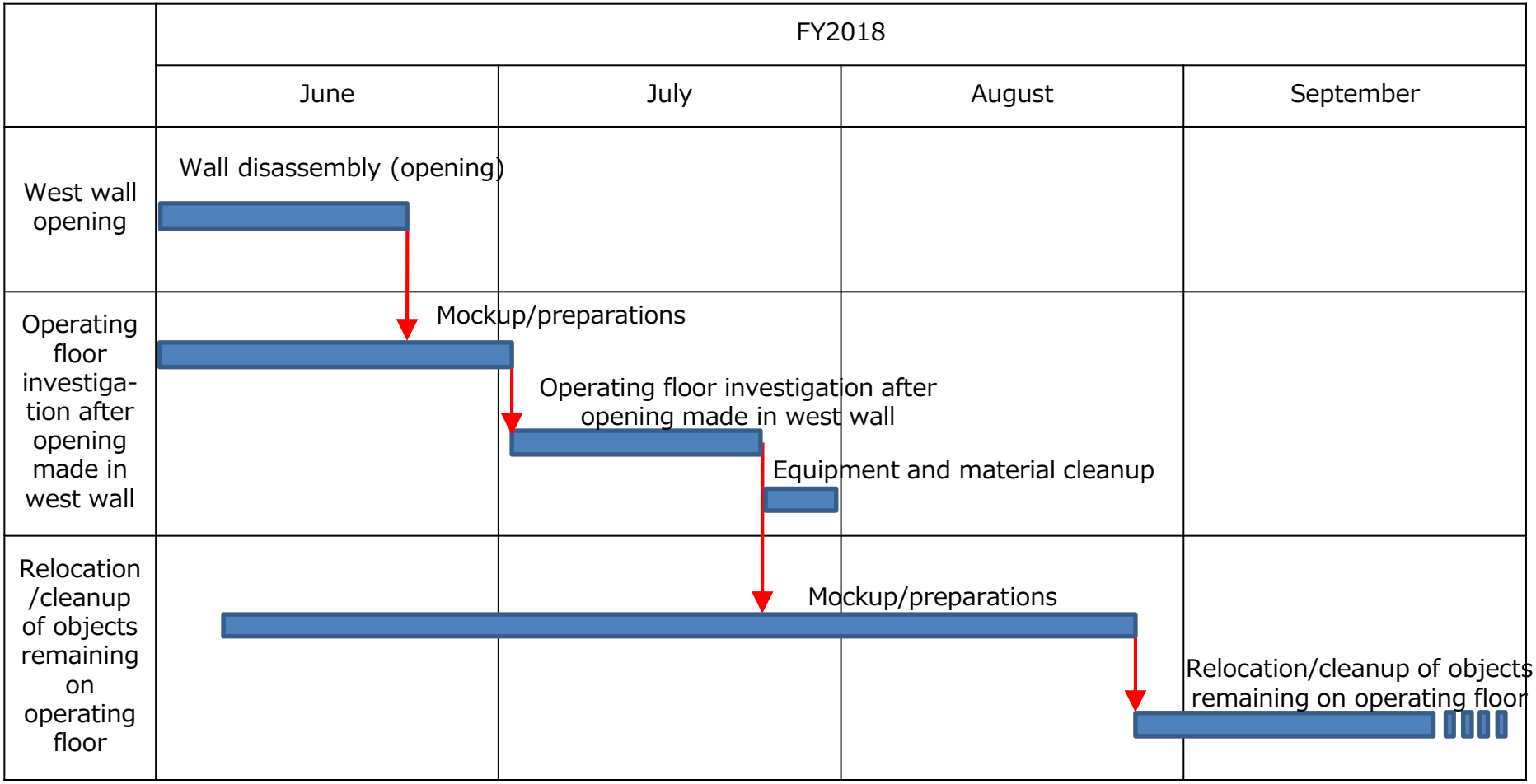
BROKK100D

Primary use:
- Cleanup of (small) objects remaining
- Fence cutting/clean up

Kobra (left) Packbot (right)

Primary use:
- Camera work in locations that are blind spots when BROKK is working (used depending on work conditions)

6. Operating floor investigation schedule



※The commencement of work will be at the end of August due to time taken to make improvements to heavy machinery that were deemed necessary after working on the mockup

The following slides are for reference

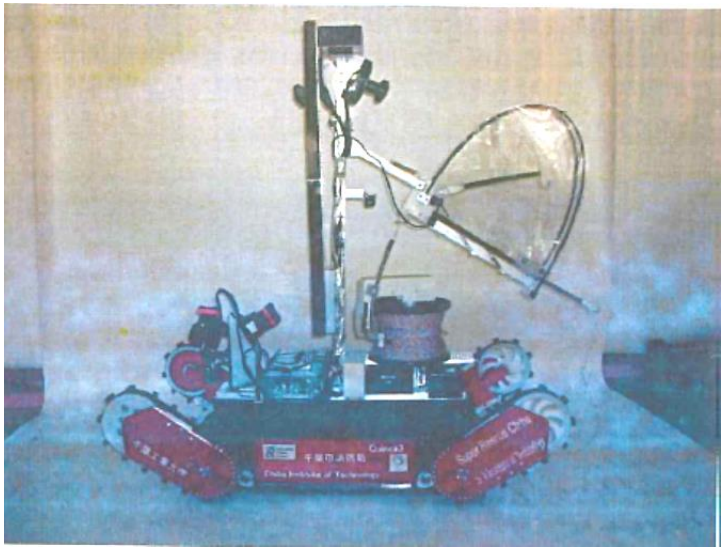
【Reference】 Past investigations of the operating floor (dose rates)

Measurement method: Remotely operated self-propelled investigation robot

Measurement equipment: DOSEi-γ

Measurement height: Approx. 1m

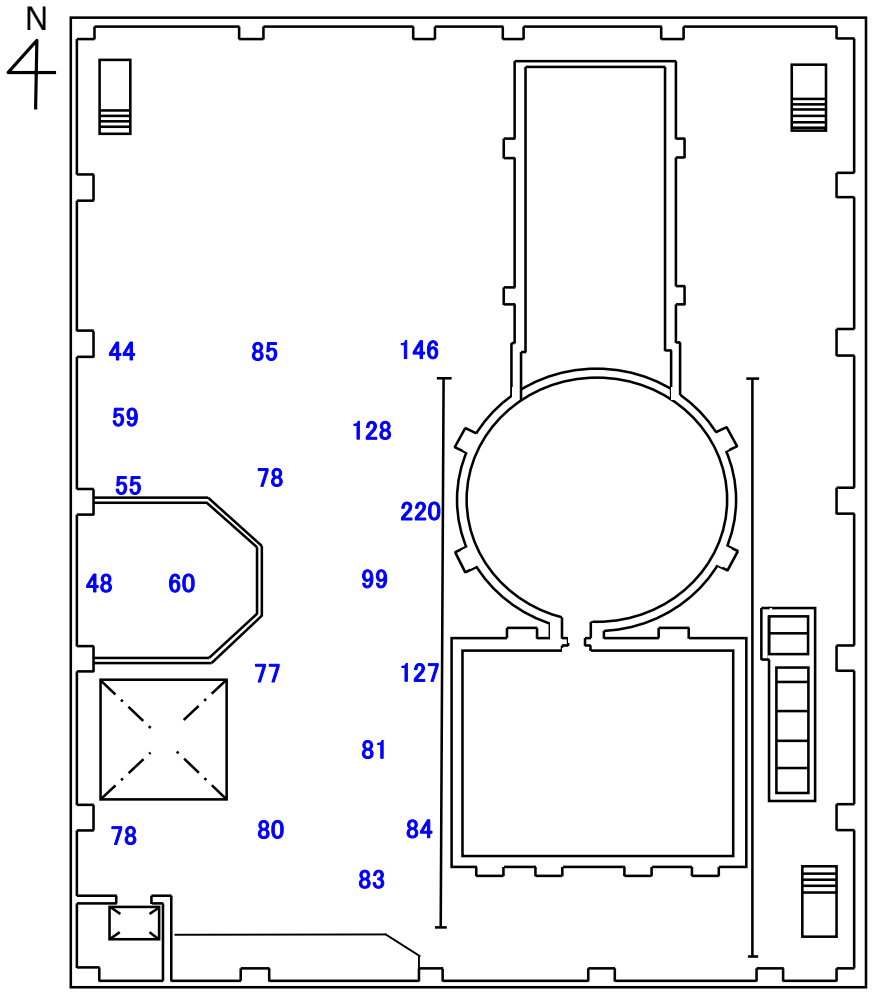
Measurement date: Measurements as of February 27, 2012



Remotely operated self-propelled investigation robot (Quince)

※ Measurements for areas outside the scope of this investigation were deleted to make it easier to compare air dose rates taken during this investigation

Units : mSv/h

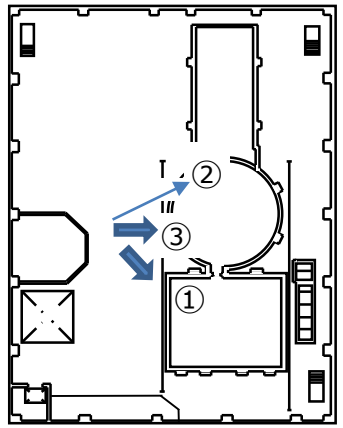


5th Floor plan

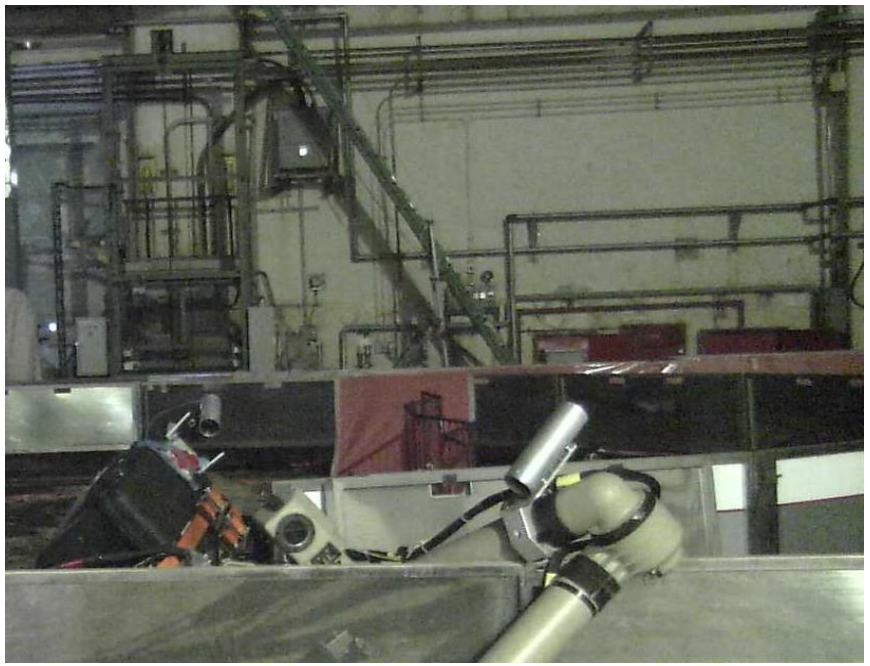
【Reference】 Conditions on the operating floor

① 【Fuel Handling Machine】

Direction of photo
(← :Top)



② 【Ceiling crane】



③ 【Warrior】

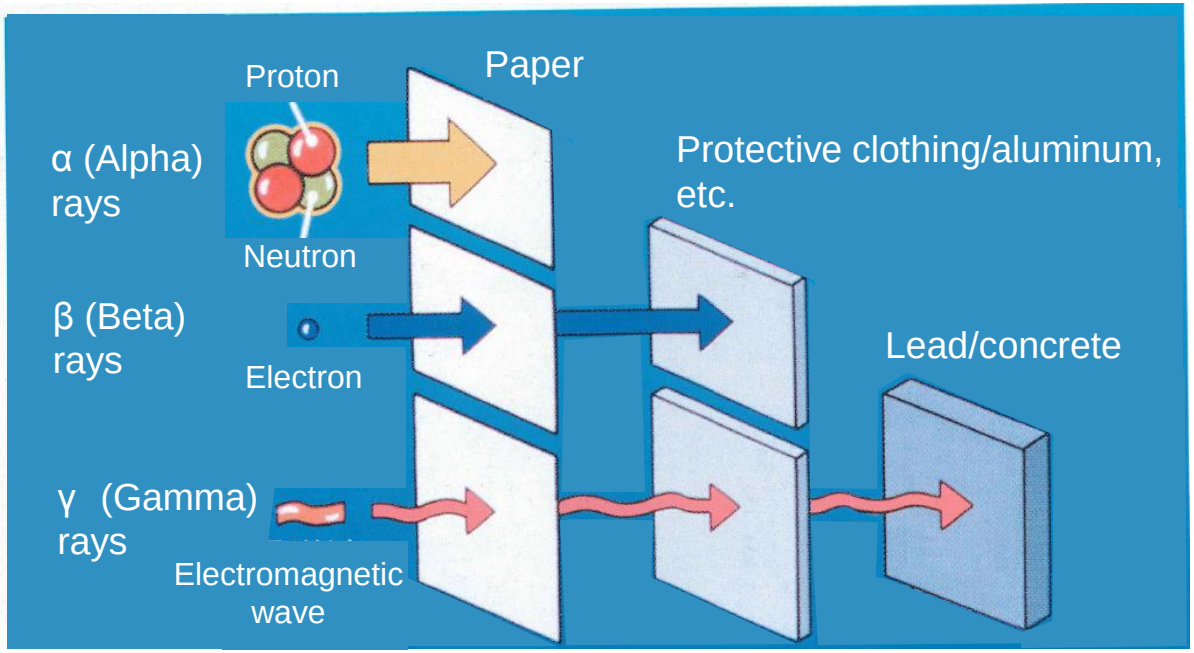
【Reference】 Radiation types and attributes

The main types of radiation are alpha rays (α rays), beta rays (β rays), and gamma rays (γ rays). Radiation can pass through matter (penetration power), but the degree of penetration power depends on the type of radiation.

α rays
Very weak penetrating power; can be absorbed by a single sheet of paper

β rays
Weak penetrating power; the majority of the rays can be absorbed by the air or protective clothing

γ rays
Strong penetrating power; this type of radiation is the focus of radiation control in consideration of worker exposure



【Reference】 Measurements required for radiation control and contamination control

As shown below, air dose rates are measured because they are useful for radiation control. Surface contamination density and surface dose rates are measured because this information is useful for contamination control.

Radiation Control

【Measurement Item】
Air dose rate
(mSv/h)

Gamma ray dose rates are used to assess worker exposure. Gamma ray dose rates are measured at about the chest height of workers in order to determine whether workers may engage in work at specific locations

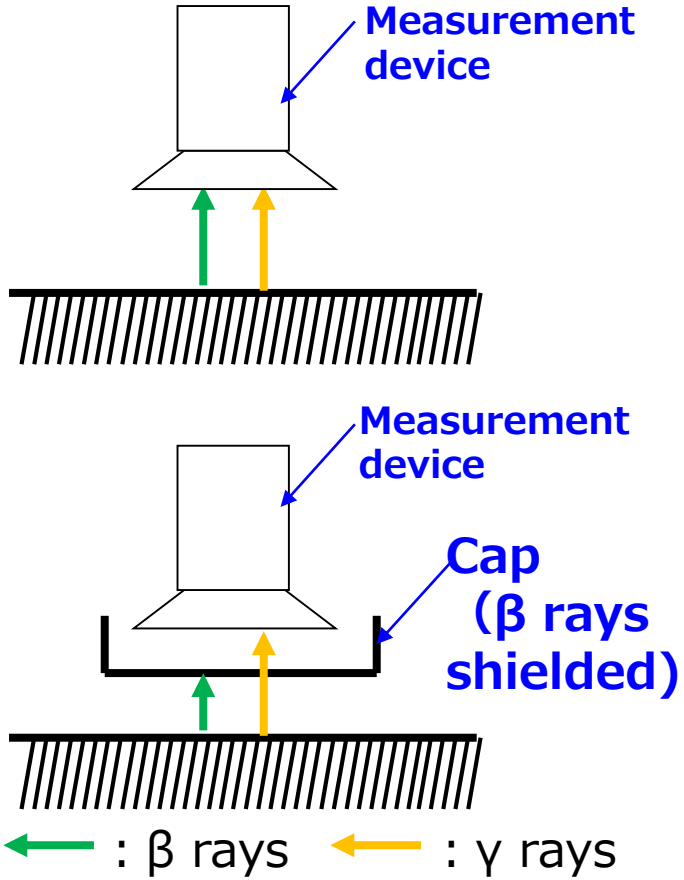
Contamination Control

【Measurement Item】
Surface contamination density
(Bq/cm^2)
Surface dose rate
(mSv/h)

Contamination control methods are determined upon ascertaining work environment contamination conditions (nuclides that emit alpha rays/beta rays/gamma rays) in advance in order to prevent worker internal exposure and contamination from being brought out of controlled areas

【Reference】Concept diagram of β ray dose measurement

- Since there is not a device that can only measure β dose rates, β dose rates are measured by （γ+β ray dose rate） －（γ ray dose rate)
- As shown below, if ① is higher than ②, a β ray emitting nuclide exists at the measurement location



①γ+β ray dose rate
- ✓ β ray and γ ray dose rates measured

②γ ray dose rate
- ✓ Only γ ray dose rate measured
- ✓ β ray measurement is prevented by placing a cap over the measurement device to shield it

【Reference】BROKK100D conditions observed during mockup tests

【History】

- During operations training conducted from the middle of June, when the engine of the BROKK100D was started up in preparation for training, engine rpm's were not sufficient enough to start up the machine.
- When the inside of the machine was checked it was found that there was damage to the solenoid (electromagnetic coil) that serves as an actuator for moving the lever to adjust engine rpm's, as well as damage to the bracket that supports the aforementioned solenoid.

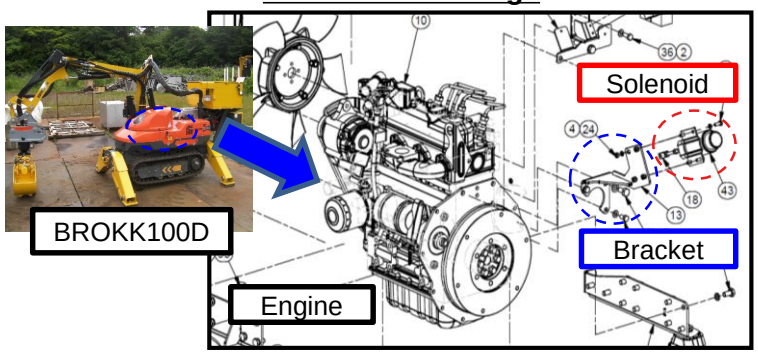
【Assumed causes】

- The BROKK100D is an engine-equipped version of the battery-operated BROKK100 that was newly designed and built for long-term use by BROKK. (The machine has never been used before)
- In order to install an engine, brackets had to be made smaller. So, it is assumed that when the actuator operated, stress was concentrated on the curved part of the bracket causing a fracture and leading to failure of the bracket.
- It is assumed that when the bracket failed, the solenoid that it was supporting fell and was damaged thereby preventing the machine from being started up.
- The BROKK100D is different in design from the BROKK400D, and we have had no similar problems with other engine-equipped machinery. so it is assumed this is a problem unique to the newly designed and built machine.

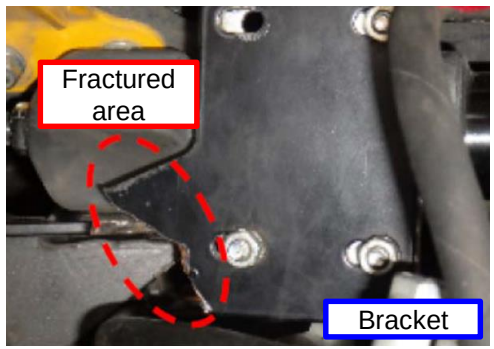
【Countermeasures】

- Brackets were replaced with stronger brackets.（Replaced on July 24）
- The brackets are periodically checked when working inside the mockup to verify effectiveness and confirm that the event dose not happen again.

Location of damage



Broken part



Replacement part

Plate width and curved sections of the bracket are improved