Internal Exploration of the Unit 2 Primary Containment Vessel (PCV) ～Reevaluation of Dose Rate Estimate～

July 27, 2017

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1．Overview

- During the internal PCV exploration conducted during January and February 2017 dose rates inside the PCV were estimated from the noise level (four locations), and based on measurement by integrating dosimeters (one location).
- Since the dose rates estimated during the exploration differed greatly from those estimated during past investigation (August 2013), by the validity of methods for estimating dose rates from noise level and dose rates measurement by integrating dosimeters was verified. The following conclusions were drawn.

① Estimating dose rates from level of images noise

・The threshold values which differentiate background noise from the noise caused by radiation were set lower than the values in calibration, which resulted in the larger estimate of dose rate. When irradiation tests and analysis were conducted to compare the amount of noise in images caused by the radiation sources to create a calibration curve (Co-60) and that of primary radiation sources inside the PCV (Cs-137), it was found that the primary radiation source inside the PCV (Cs-137) generates more noise in images which resulted in the larger estimate of dose rate.

② Calculating dose rate by integrating dosimeters

・Dose rate was calculated from the difference in measurement of two out of four integrating dosimeters, but when the measurement of each dosimeter were checked, it was found that the measurements from one of the dosimeters had a tendency to consistently record much higher measurement results than the other three dosimeters (and needs appropriation).

※： Standard levels of noise brightness above a certain level used to count the noise caused by radiation

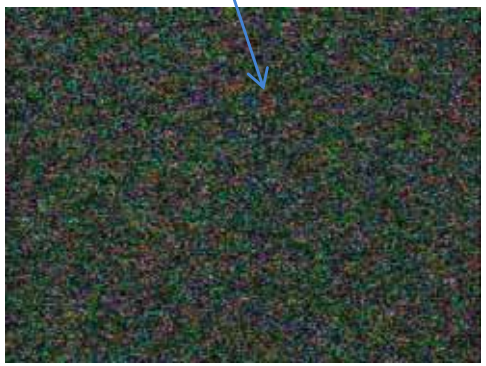
2. Dose rate estimates from level of images noise（1/2）

- During calibration using irradiation tests it was assumed that radiation levels inside the PCV are quite high, so pixels brighter than the threshold level of 70 were counted as being noise caused by radiation. However, when making preparations to conduct the internal exploration of the PCV in a low radiation level environment, the threshold values were lowered to 50 in order to check operation of the equipment, but were never returned to 70 before conducting the PCV internal exploration.
- Therefore, pixels that should NOT have been counted because they fell below the brightness threshold value were counted as being radiation noise thereby inflating the pixel count and resulting in an overestimated dose rate.

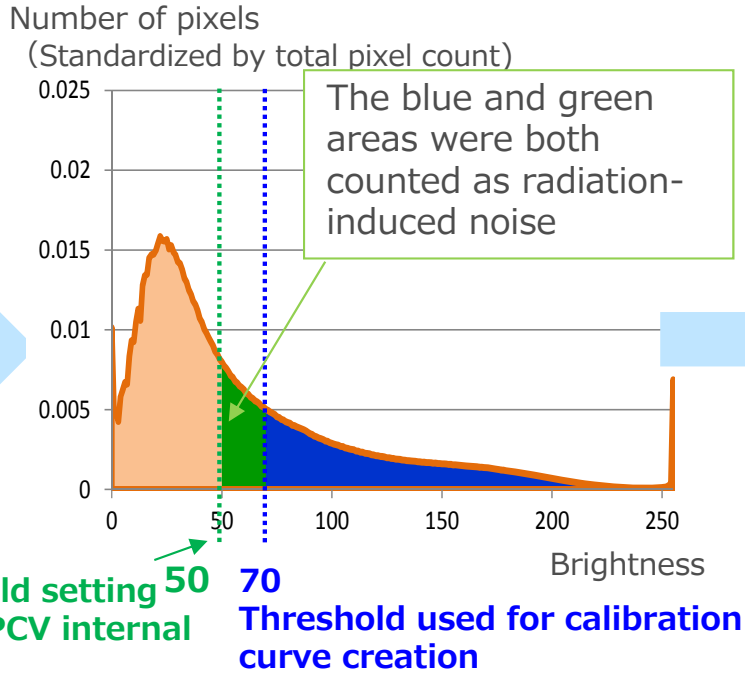
- Furthermore, whereas dose rates were estimated using a calibration curve based upon camera irradiation test results using Co-60 radiation sources, the dominant source of gamma radiation inside of the Unit 2 PCV is assumed to be Cs-137, so irradiation tests and analysis were conducted to examine the amount of noise produced by Cs-137.
- It was confirmed that Cs-137 causes more noise than Co-60, thereby resulting in overestimates of dose rates.

Observed image

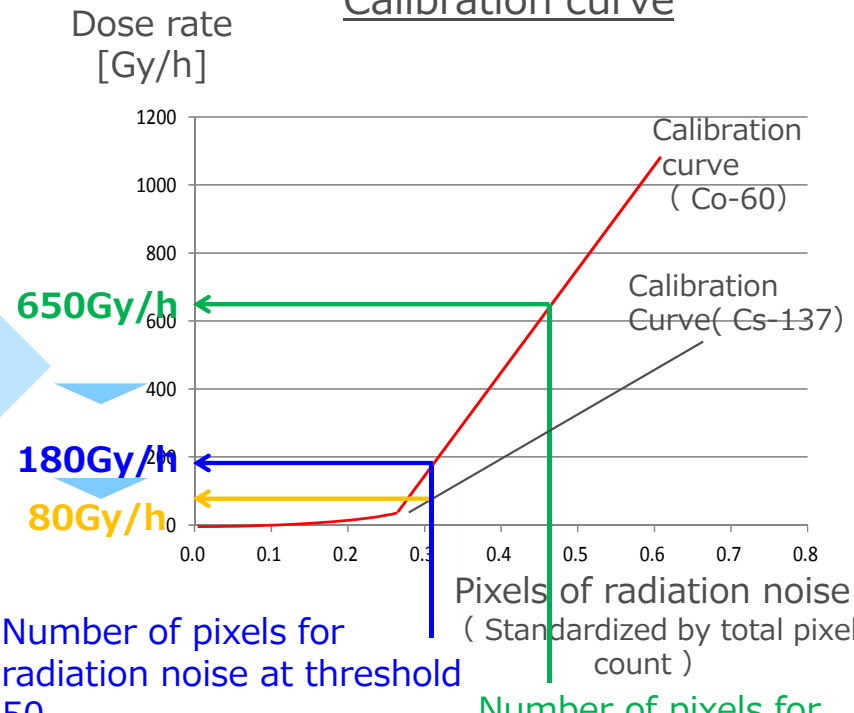
The brightness of each pixel on the screen was measured



Brightness distribution



Calibration curve



2. Dose rate estimates from level of images noise（2/2）

■If the threshold value for determining if noise is caused by radiation is used as the calibration value and the primary radiation source in the PCV is assumed to be Cs-137, the resulting estimated dose rates are as shown in the chart below.

		Dose rate estimated from the field exploration※1 [Gy/h※2]	Results of reevaluation	
			①Dose rate after revision of threshold values※3 [Gy/h]	②Dose rate after revision of threshold values and with assumption that Cesium 137 is the single major radiation source in the Primary Containment Vessel [Gy/h]
		Estimated results (range including the margins of error)※4,5	Estimated results (range including the margins of error)※4,5	Estimated results (range including the margins of error)※4,5
Preliminary exploration inside of the penetration	In the vicinity of scaffolding	30（10～60）	10（0～10）	Less than 10※6
	In the vicinity of center of the Control Rod Drive (CRD) rail	530（370～690）	170（120～220）	70（50～90）
Preliminary exploration inside of the pedestal		20（0～40）	10（0～10）	Less than 10※6
Observation during the removal of sediment		650（450～850）	180（130～240）	80（50～100）

※1 : Values read visually in the field (there were errors with results from a reassessment using recorded images)

※2 : The unit Sv/h was originally used when data was disclosed on Feb. 23, 2017, but corrected to Gy/h in light of dose adsorption by the equipment

※3 : The dose rate for each frame was estimated using approximately 300 to 500 frames taken when the lights were turned off. Values are estimate averages

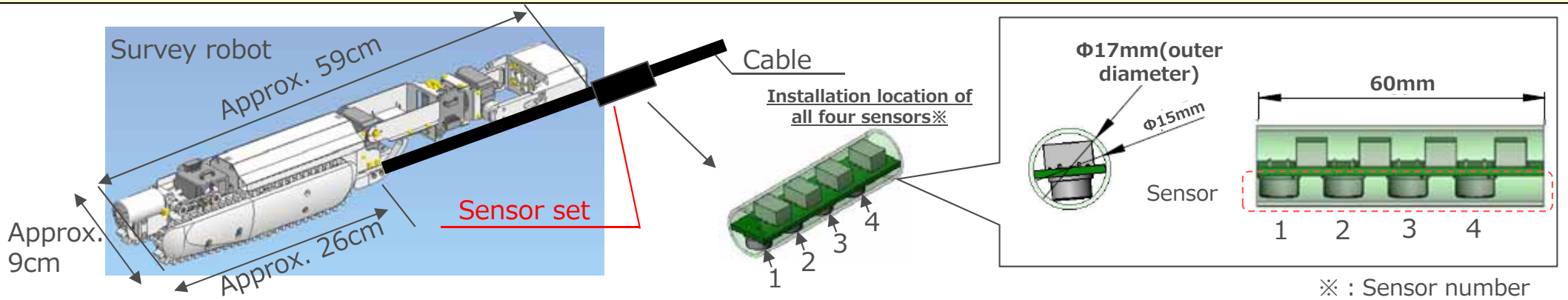
※4 : Numbers in parenthesis indicate the range from which the estimate can be taken after adding error

※5 : Error is as follows based on the discrepancies in radiation resistance test results conducted during calibration curve creation
Less than 50Gy/h : ±80%　More than 50Gy/h : ±30%

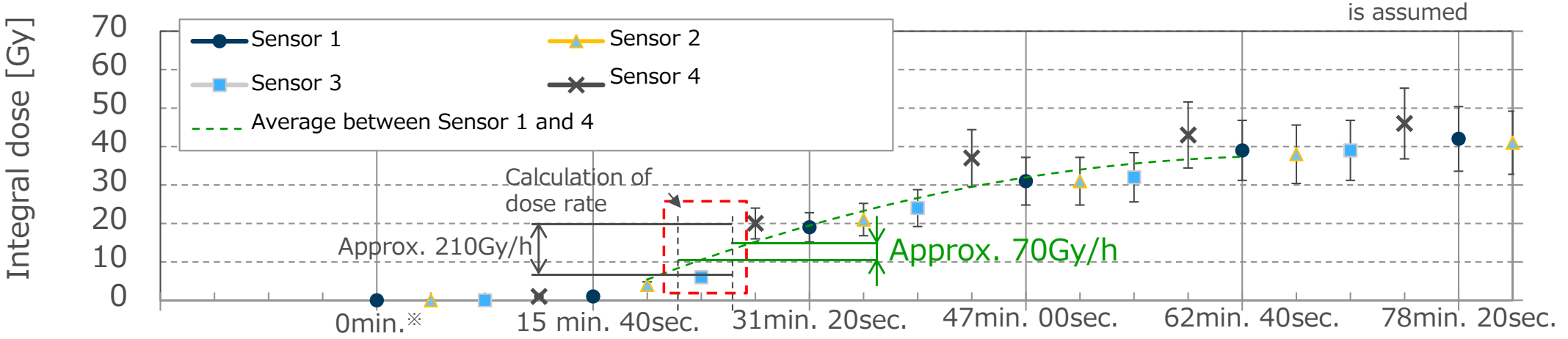
※6 : Includes error

3. Verifying the results of dose rate calculations by integrating dosimeters

- When using the difference in readings from two integral dosimeters out of four installed dosimeters (sensors) to calculate dose rate in order to shorten measurement time, the dose obtained was approximately 210Gy/h
- Upon conclusion of the exploration, it was found when checking the readings from each of the four sensors, that the No. 4 sensor, which produced the approximate 210 Gy/h reading from the aforementioned location, was generating higher readings than the other three sensors. When dose rate was calculated from the average readings from each sensor in consideration of the discrepancies between the No. 1 through No. 4 sensors, the resulting dose rate for the aforementioned location was approximately 70 Gy/h.



※ : Sensor number is assumed



※ : using the starting location of the survey robot as the starting point

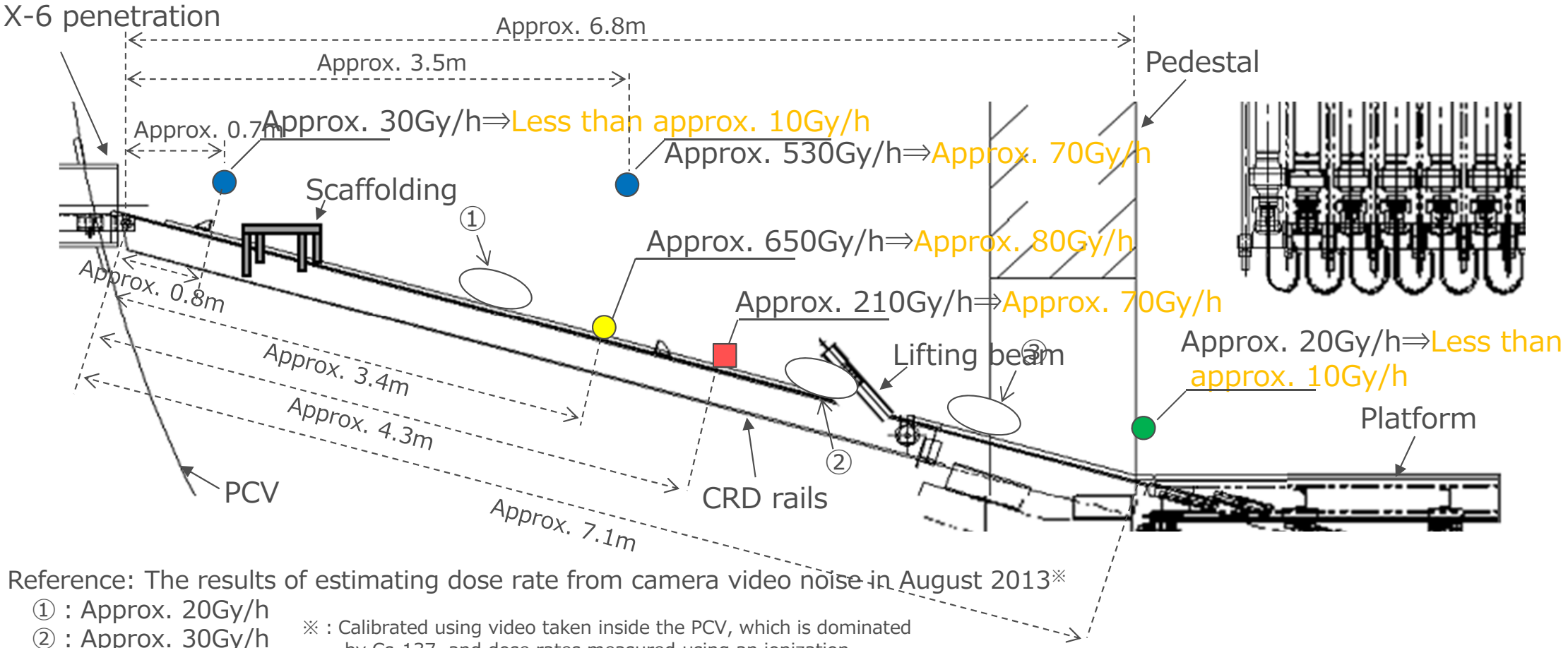
（Reference） Dose rate-related survey results

Key
【Prior to check】⇒【After check】

Dose rate estimated from camera video noise

Dose rate calculated using integral dosimeters

- Inside the X-6 penetration, advance survey of CRD rails:1/26
- Advance survey of inside of pedestal:1/30
- Front camera on deposit removal robot:2/9
- Self-propelled survey robot:2/16



Reference: The results of estimating dose rate from camera video noise in August 2013※

① : Approx. 20Gy/h
② : Approx. 30Gy/h
③ : Approx. 40Gy/h

※ : Calibrated using video taken inside the PCV, which is dominated by Cs-137, and dose rates measured using an ionization chamber

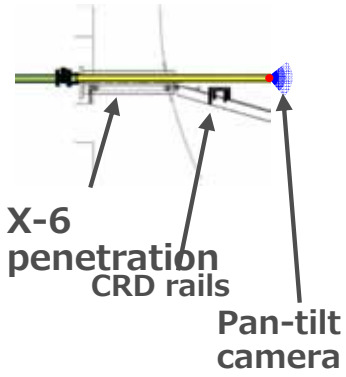
（Reference） Details of dose rate calculations taken during each survey

Dose rate estimated from noise level of images

Dose rate calculated by integrating dosimeters

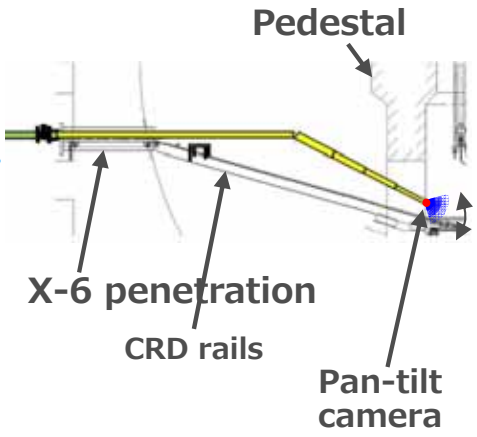
Advance survey of CRD rails conducted inside the X-6 penetration seal through a guide pipe inserted for prior examination

Conducted on1/26



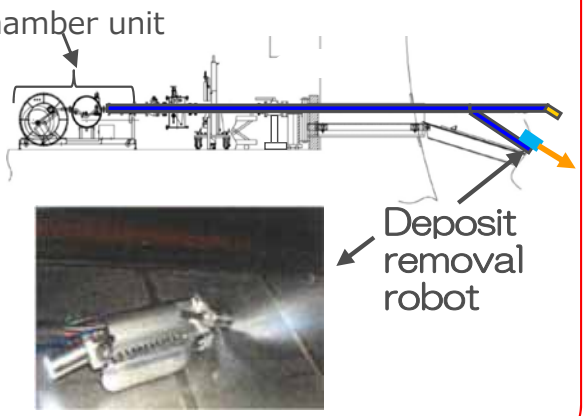
Advance survey of inside of pedestal through guide pipe

Conducted on 1/30



Insertion of deposit removal robot

Conducted on 2/9



Internal exploration conducted using self-propelled robot

Conducted on 2/16