Plant Data of Fukushima Daiichi Nuclear Power Station at the time of the Tohoku-Chihou-Taiheiyou-Oki Earthquake

May 16th, 2011

Tokyo Electric Power Company

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1. Description of data

Fukushima Daiichi Nuclear Power Station was hit by the Tohoku-Chihou-Taiheiyou-Oki Earthquake occurred at 14:46 on March 11th, 2011, and the following massive tsunami, and the plant facilities got severely damaged. While plant data at around the time of the earthquake remained at the site including the main control room of each unit, we had no choice but to focus on the work for stabilization of the plants. Since it was difficult to take the printed data directly to the uncontaminated area due to the high level air dose around the plants including the main control rooms and the prints themselves were contaminated, we could not computerize the data by staying in the main control rooms for long hours. However, as the situation gradually improved, we collected and organized as much plant data as possible in accordance with the instructions from the national government. Data collected and organized are as below.

(1) Charts
Recording papers widely used to record various data of the plants. Plant data are recorded in roll paper with color ink.

(2) Data of abnormal events including alarm records
A kind of data output from process computers, including the times of abnormal events and operation logs of the plant systems. They are basically printed out and kept as printed records.

(3) Operation logs
Operation records, data recorded by operators in the main control rooms and daybooks with handover messages for operators of the next shift.

(4) Data of process computers
Process computers also store data indicating plants' behavior. Their functions are similar to the transient recorders described below.

(5) Data of transient recorders
Triggered its operation by the occurrence of abnormal events, a transient recorder records numerical data on plant's behavior for a few minutes prior to and 30 minutes after the event.

The amount of data above varies, depending on the plant situation and the type of the computer. For example, Unit 4 was in the regular inspection and all of the fuels were taken out to the spent fuel pool in order to replace its shroud. Since the process computer was being replaced at the same time, related data does not exist. Also, since the transient recorder of Unit 6 was not in operation due to the unit's regular inspection, transient record of Unit 6 does not exist. Data organized in this report are described in Table-1.

While most of major data were collected and organized in this report, please note that there still can be some data unrecorded due to the damage of the detectors caused by tsunami. As further facts are getting revealed by detailed analyses of other parameters and reliable

evidences from persons involved, it is expected that additional information such as operation records of equipments will be known in the future. In such a case, we will report them accordingly.

2. References

(1) Unit 2, Fukushima Daiichi Nuclear Power Station
Restoration of alarm records

(2) Unit 3, Fukushima Daiichi Nuclear Power Station
Adjustment of the recorded times of the transient recorders

Table-1

		Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Remarks
Plant status		In operation	In operation	In operation	In outage (All fuel pulled out)	In outage (During pressure test on RPV)	In outage (RPV closed)	
Chart		Plant charts continued to record data after the earthquake. However, the amount of data actually collected was very little as the tsunami caused the loss of signals and power for measurement instruments in most cases. Data recording resumed after the restoration of power supplies for instruments for some of the plant charts, but plant-related parameters have been gathered and attached for data continuity.						
Process computer	Alarm activation records and other data	Data entries up to 15:00 on March 11 obtained		Data entries up to 19:00 on March 11 obtained	Process computer system being replaced	Periodic data recording function was suspended as the plant was in outage.	Periodic data recording function was suspended as the plant was in outage.	BOP (Operation information)
		Core performance data up to 14:00 on March 11, and typer output on control rod position data, etc. up to 15:00 on March 11		Core performance data up to 19:00 on March 11 and typer output on control rod position data, etc. up to 18:00 on March 11				Core performance calculation, control rod positions, etc.
		Typer output for approx. 10 minutes after the scram	Typer output for approx. 2 minutes after the scram; Data up to 15:50 on March 11 was recovered from the collected hard disk.	Typer output up to 18:00 on March 11		Typer output for approx. 2 minutes after the earthquake Typer output resumed from around 0:00 on March 12 Data up to 16:18 on March 12 was recovered from the collected hard disk.	Typer output up to around 15:39 on March 11 Backup output from 15:40 to 14:07 on March 11 Typer output resumed at around 0:00 on March 12	Alarm activation records
	Process computer system data (Operation data)	No electronic storage function	Hard disk from the data storage server recovered	No electronic storage function		Hard disk from the data storage server recovered	No electronic storage function	
	Additional description of the process computer system's performance	No re-output function for alarm activation records, etc.	Re-output function available for alarm activation records, etc. Power supplies required if records are not found	No re-output function for alarm activation records, etc.		Re-output function available for alarm activation records, etc.	No re-output function for alarm activation records, etc.	
		Normally on AC power, and switched to battery power upon the loss of AC power (Using regular power supplies for some devices at Unit 2)				Normally on AC power, and switched to battery power upon the loss of AC power (specifically for computers at Unit 4)		
Operation log		Operation log for March 11 obtained						
Shift turnover logs		There are separate shift logs for shift supervisors and shift members. Both logs from two night shifts on March 10 and one day shift from March 11 have been obtained. The log for March 11 from the time of the earthquake was written on the whiteboard in MCR and transcribed to the logbook later. Notes and memos showing the information written on the whiteboard have also been obtained.		There are separate shift logs for shift supervisors and shift members. Both logs from two night shifts on March 10 and one day shift from March 11 have been obtained. Notes and memos written by shift members at the Anti-Seismic Building have also been obtained.		There are separate shift logs for shift supervisors and shift members. Both logs from two night shifts on March 10 and one day shift from March 11 have been obtained.		
Nuclear plant Advanced Transient data Recording and Analysis Support system data	Status	The recorder had its hard disk removed and data recovered.		Difficult to recover the hard disk itself, but the device was turned on to recover data.	Transient event recorder being replaced	The recorder had its hard disk removed and data recovered.	Event recording function was suspended for outage. Difficult to recover the hard disk itself, resulting in no data recovery	
		・Normally on AC power, and switched to battery power upon the loss of AC power				Normally on AC power, and switched to battery power upon the loss of AC power (specifically for computer systems at Unit 5)		
	Short-cycle event data (reported on May 16, 2011)	・10ms cycle data over approx. 35 minutes from 14:42:03 on 3/11	・10ms cycle data over approx. 35 minutes from 14:41:56 on 3/11 and 35 minutes from 15:12:06 on 3/11	・0.1s cycle data from around 14:41 to 16:05 on 3/11	—	・35-minute 10ms cycle data at every hour (starting 5 minutes to the hour) from 14:00 to 23:00 on 3/11	—	
	Miscellaneous (Reported on July 17, 2013)	・1min cycle data from 12:00:59 to 15:36:59 on 3/11 (Records starting at 10:59:59 on 3/3)	—	・Average, maximum, minimum and RMS figures in 10min cycle data from 12:09 to 19:09 on 3/11 (Records starting at 7:59 on 3/8)	—	・10min cycle data from 12:00 on 3/11 to 16:50 on 3/12 and from 12:03:56 on 3/11 to 16:43:56 on 3/12 (Records starting at 15:00 on 3/2 and 11:53:56 on 3/2 respectively)	—	Some of the data has been deemed unnecessary.※

※Average, maximum, minimum and RMS binary data in 1h cycle up to 15:00 on 3/11 at Unit 1, instantaneous, average, maximum, minimum and RMS binary data in 1h cycle up to 15:00 on 3/11 at Unit 2, average, maximum, minimum and RMS binary data in 10min cycle up to 16:50 on 3/12 at Unit 5 are available. However, they have been deemed unnecessary based on the amount of data already reported and additionally reported this time (July 17, 2013).

Reference-(1)

Unit 2, Fukushima Daiichi Nuclear Power Station
Restoration of alarm records

1. Introduction

It is recognized that the alarm equipment (function of output alarm records to Alarm Typer) of Unit 2, Fukushima Daiichi Nuclear Power Station produced records for approximately 2 minutes immediately after the scram, but stopped thereafter for some reasons. We restored alarm records based on the data stored in hard drives.

2. Overview of the functions of alarm equipments

The alarm equipments have functions to collect information about plant status from process computers and produce alarm records to Alarm Typer.
Items of information produced to Alarm Typer are as below.

① Status changes of Digital Input Points (changes of contact points)
② Changes of the position of control rods
③ Monitoring Alarm (excess of the limits/restoration)
④ Operation records (data insertion / alarm exclusion / scan exclusion)
⑤ Transferred results of outputs from computers
⑥ Time and messages

The restoration of alarm records this time was conducted as to ① and ③, based on the record of plant process data produced by the process computer of Unit 2. The ways to produce ① and ③ are as below.

a. Way to produce the status changes of Digital Input Points
   In the case of occurrence of change of contact point the time and the situation are output to Alarm Typer.
b. Way to produce Monitoring Alarm (excess of the limits/restoration)
   In the case that the monitored Analogue Input Point exceeds the alarm limit or deviates from the designated range or that indicator trouble occurs, the time and the situation are output to Alarm Typer.

3. Methodology for the restoration of alarm records

Among records, 1171 Analogue Input Points and 503 Digital Input Points of the plant process data were used for the restoration of alarm records. Position data related to the movement of control rods were not used.
In the restoration, automatic process methods searching for record data (excel files) were

adopted as below.

(1) Digital Input Point

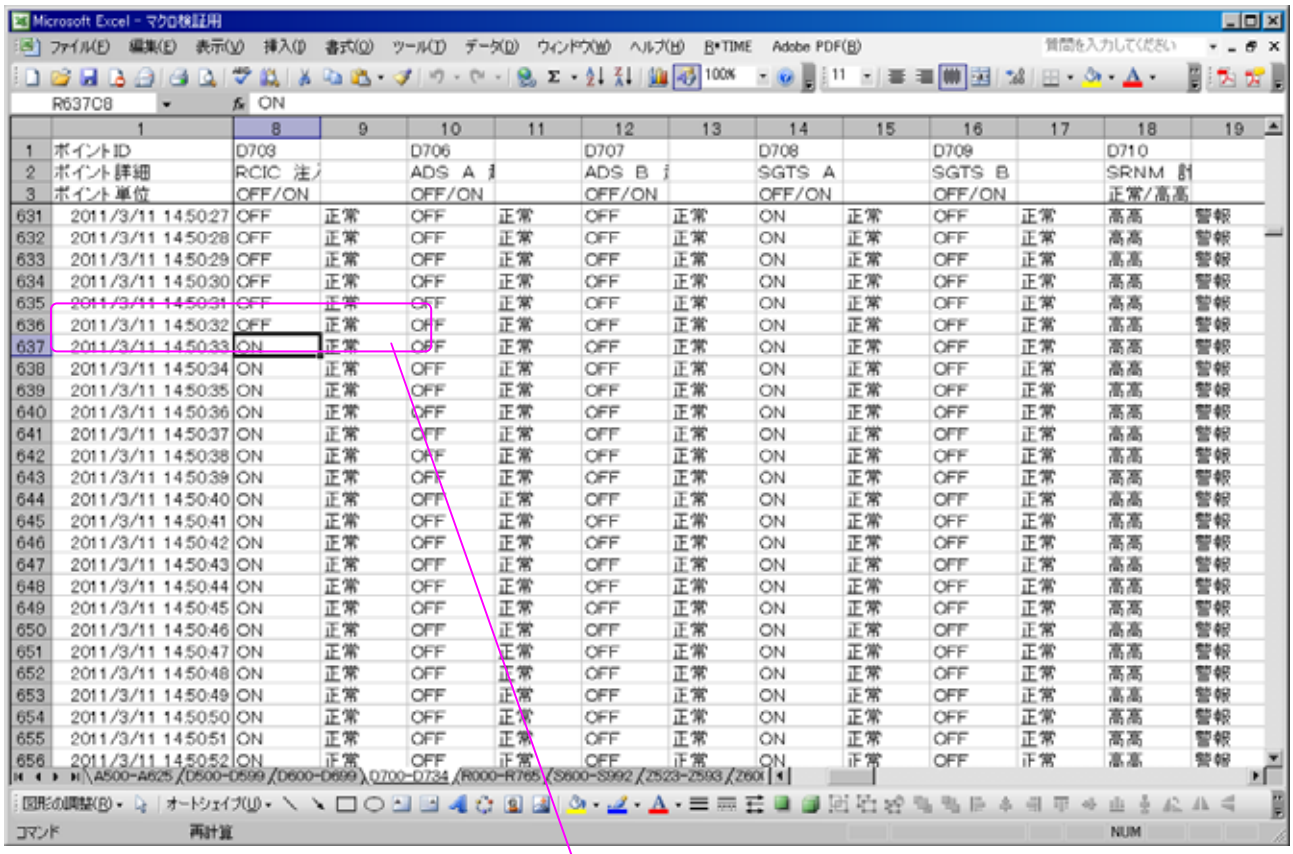
Search for the time of occurrence of change in status of the target input point and output the time, PID and the value before and after the change

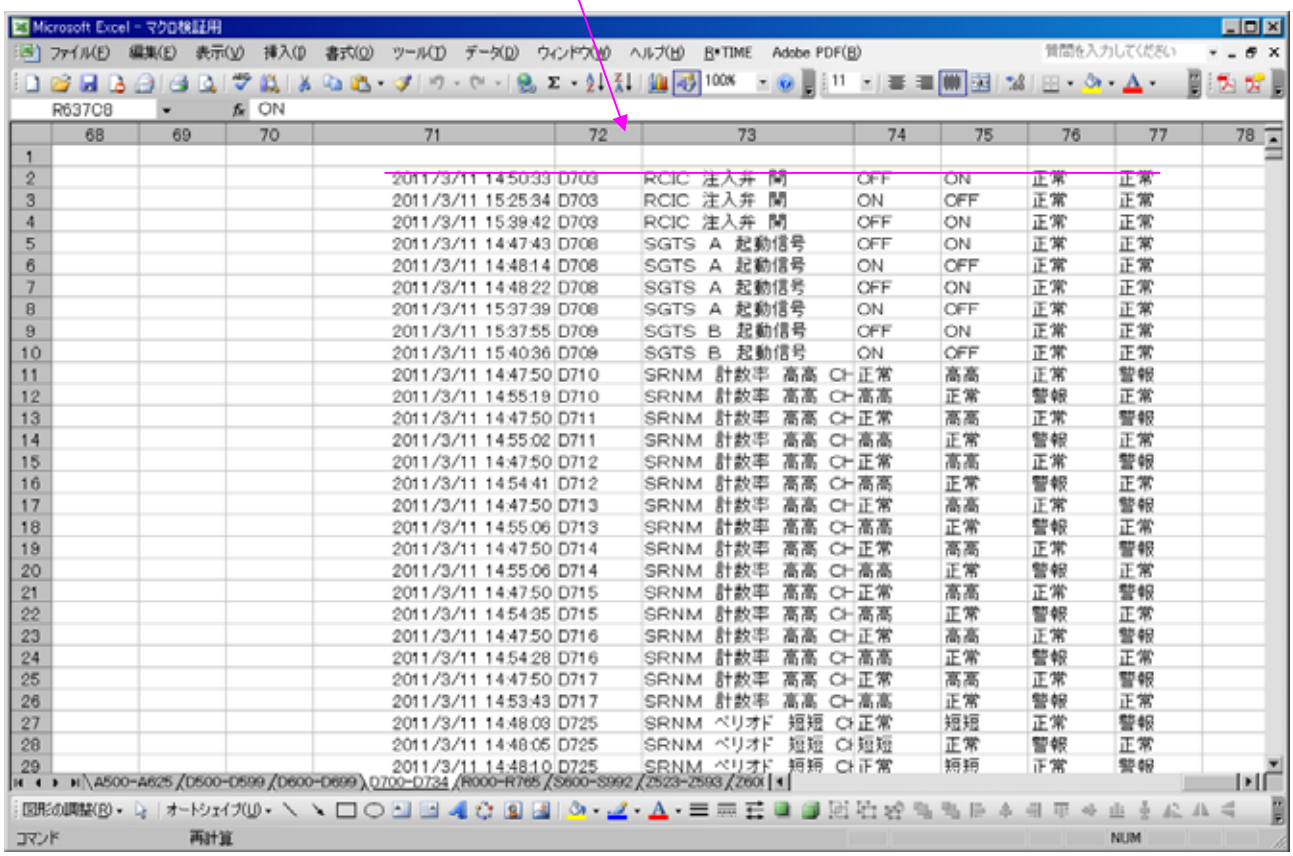
(2) Analogue Input Point

Search for the time of occurrence of change in quality information of the target input point and output the time, PID and the value before and after the change

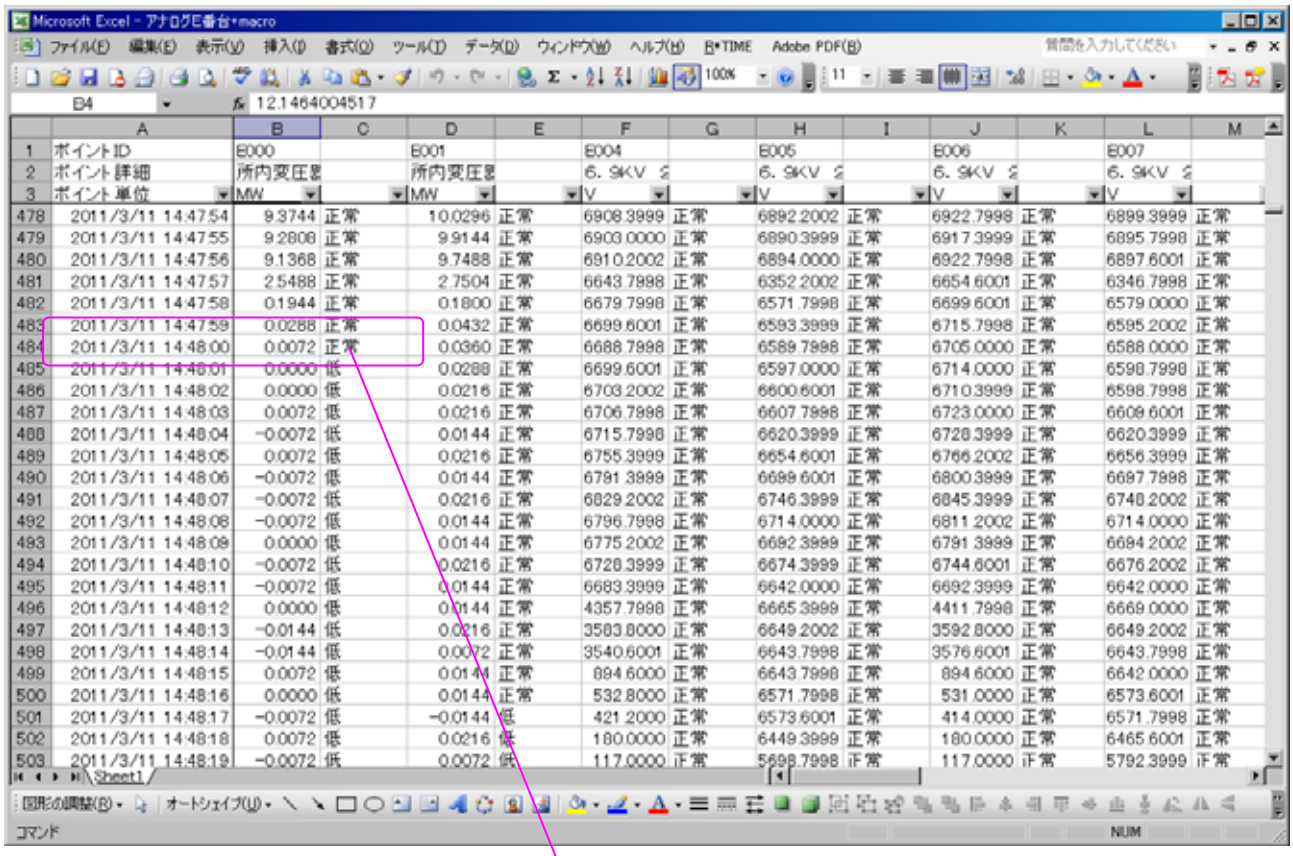
End

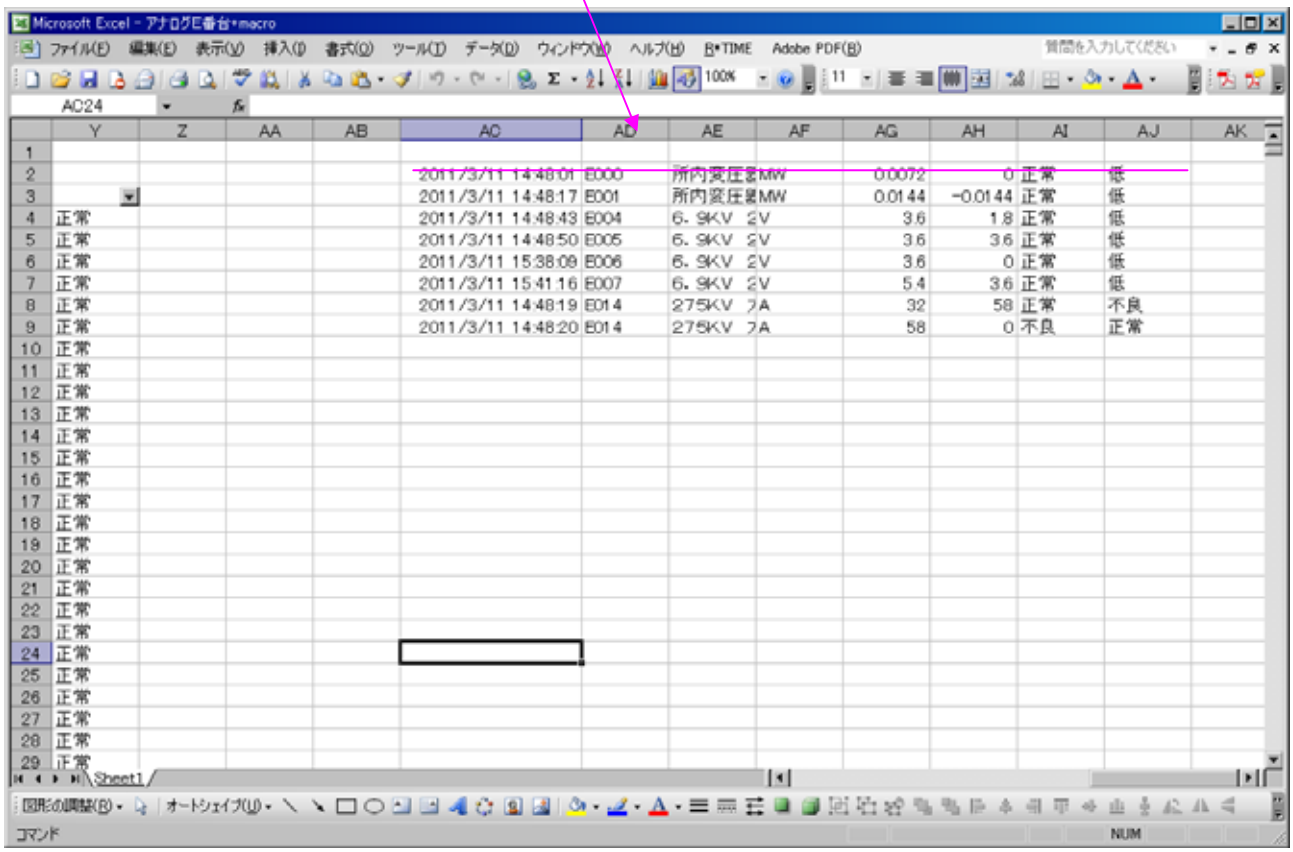
【In the case of Digital Input Point】





【In the case of Analogue Input Point】





Reference-(2)

Unit 3, Fukushima Daiichi Nuclear Power Station
Adjustment of the recorded times of the transient recorders

1 Outline of the recording by the transient recorder of Unit 3

The transient recorder installed at Unit 3 starts recording data in the case of an event that makes substantial change in preset plant parameters. At the time of the Tohoku-Chihou-Taiheiyou-Oki Earthquake on March 11, the transient recorder started recording at 14:46, 14:47, 14:59, 15:09, 15:19 and 15:29 and recorded data for 5 minutes before and after the each starting time (10 minutes in total for each). It should be noted that every parameter triggered the recording was on the vibration of the upper part of the recirculating pump except for the reactor scram at 14:47.

Since these data do not have the recorded times, time-series data is necessary to be developed through the restoration of fragmented information based on the times of the trigger events. In the process of the restoration, we compared the data of the transient recorder with other records (charts, Alarm Typer etc.) and made adjustments to a part of the time data, as we found inconsistency in a part of the data.

2 Discontinuity of the recorded data

Figure 1 shows the data of the water level of the reactor (narrow band).
This shows that the water level rapidly increased at around 14:59 (signed with arrow) and went over the scale limit (1,500 mm) only in 0.1 second from approx. 1,300 mm. Similar fluctuation was recorded in broad band data, but the fluctuation range was approx. 400 mm, which was inconsistent. On the other hand, Alarm Typer recorded fluctuation of the water level around 1,000 mm at around 15:00.
Taking into account those inconsistencies, we examined other data than water level and found several discontinuities in parameters. Examples are;

- D/G (A) Current 72A → 146A
- Rotation Velocity of Turbine 263 rpm → 5 rpm

Consequently, we determined that the recorded data this time has discontinuity at around 14:59.

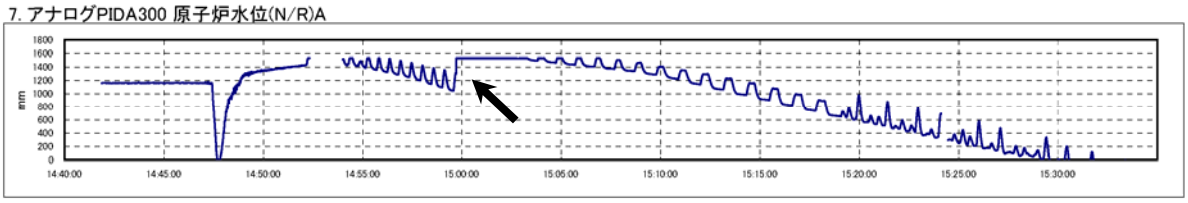


Figure 1: Data of the water level of the reactor (narrow band)

3 Consistency with other records

Since inconsistencies have been found among the recorded times, as described in section 2, we conducted estimation of correct times through comparing with other records (charts, Alarm Typer etc.).

3.1 Comparison with the water level in the reactor

Figure 2 is the chart of the water level in the reactor (narrow band).

Figure 2 tells that the water level of the reactor went over the scale limit at around 15:30 and went blow the limit at around 16:00. These can be confirmed in the Alarm Typer records indicating that the water level went over the upper scale limit at 15:25 and went below the lower scale limit at 15:59. Based on the information above, data recorded by the transient recorder from 15:00 to 15:30 can be estimated as data from 15:30 to around 16:00 in actual.

And, Alarm Typer has records that the water level went in the reactor over the scale limit and came back 4 times at around 15:35, and these movements are in line with the transient recorder's data at around 15:05. This concurrence also supports the estimation that the transient recorder recorded data 30 minutes late.

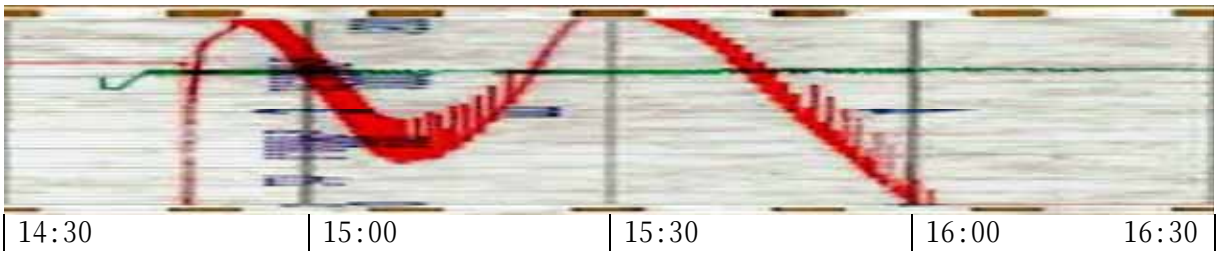


Figure 2: Water level in the reactor (narrow band) and Chart (in red)

※ Note: Because of the differences of the feeding speed and the up/down direction of paper, the figure is enlarged and reversed.

3.2 Comparison with the time when the emergency diesel generator (D/G) stopped (Alarm Typer)

Figure 3 shows the voltage of the emergency diesel generator (A), which was recorded by the transient recorder. Based on this figure, it seems that D/G stopped at approx. 15:08, but Alarm Typer recorded D/G's trip at 15:38. Here is approx. 30 minutes gap with the data of the transient recorder again.

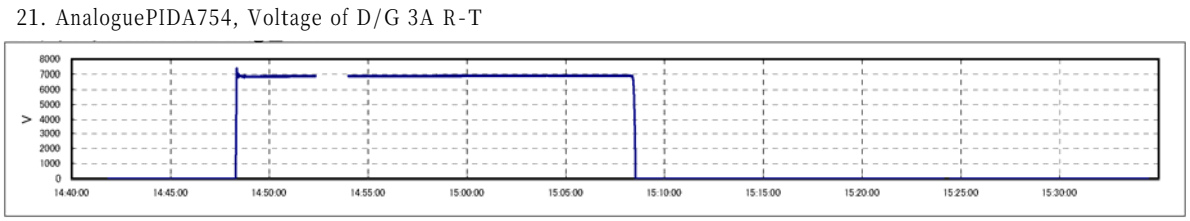


Figure 3: Voltage of D/G 3A

3.3 Comparison with the movement of Safety Relief Valve (Alarm Typer)

Figure 4 shows the movements of Safety Relief Valve, indicating that Safety Relief Valve had not moved since around 15:18. However, compared with the record that Alarm Typer printed the movements of Safety Relief Valve until 15:39, here is approx. 30 minutes gap with the data of the transient recorder again.

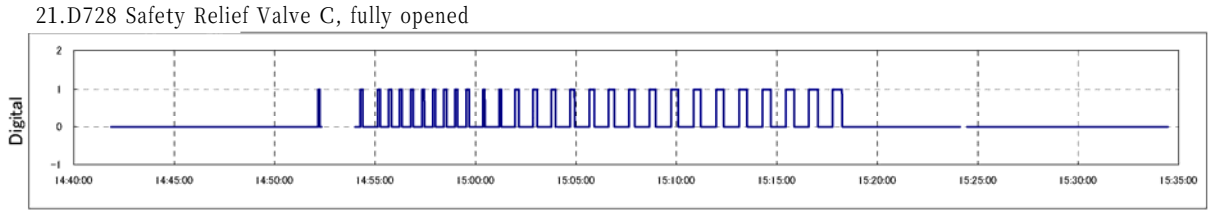


Figure 4: Movements of Safety Relief Valve

4 Adjustment of the recorded times

As described above, the duration of the interruption of the data is estimated to be approx. 30 minutes, based on the judgment that there is discontinuity of data at around 14:59:43 on March 11. Therefore, we made adjustment to the time, approx. 30 minutes, after 14:59:43 on March 11.

End