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

Disclaimer

This English translation is only for reference purpose. When there are any discrepancies between original Japanese version and English translation version, the original Japanese version always prevails.

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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 StationAdjustment of the recorded times of the transient recorders

		Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6			
		T	T	T	In regular inspection	In regular inspection	In regular inspection	Note		
	Plant Status	In operation	In operation	In operation	(all fuels removed)	(RPV in pressure test)	(RPV shut down)			
	Charts	While the charts have so	me records after the earth	quake, data after tsunami are qui	te limited because powe	r and signals of indicators	were lost due to tsunami.			
	Charts	Some indicators are in operation again after the restoration of the power, but we collected and attached plant parameters with consideration of data continuity.								
		Data until 15:00 M	March 11 collected	Data until 19:00, March 11				BOP		
				collected.		Regular recording	Regular recording	(Operation data)		
				Data printed with Typer		function does not work	function does not work	Calculation of core		
		Data printed with Typer		-Core performance: Until		due to the regular	due to the regular	nerformance		
		-Core performance: Until	14:00, March 11	19:00, March 11		inspection.	inspection.	performance,		
		-Position of control rods:	Until 15:00, March 11	-Position of control rods: Until				rods atc		
	Data including			18:00, March 11						
Process Computers	Data including alarm records Data of Process	Data until approx. 10 minutes after scram printed with Typer	Data until approx. 2 minutes after scram printed with Typer. Data until 15:50, March 11 have been restored by hard drives collected. Hard drives of data	Data until approx. 18:00, March 11 printed with Typer	Process Computers are being replaced.	Data until approx. 2 minutes after earthquake printed with Typer. Data until 16:18, March 12 have been restored by hard drives collected. Hard drives of data	Data until approx. 15:40, March 11 printed with Typer	Alarm records		
	Computers	Difficult to obtain	storage servers	Difficult to obtain		storage servers	Difficult to obtain			
	(Operation data)	collected.				collected.				
	Supplemental Description on Functions of	No reproduction function of alarm records	Reproduction function of alarm records exists. To collect undiscovered data, power will be needed.	No reproduction function of alarm records		Reproduction function of alarm records exists. Power needed.	No reproduction function of alarm records			
	Process Computers	Unusually powered batteries. (A part o	by AC. When AC power los of equipments of Unit 2 po	st, power source switched to wered by regular source.)		Unusually powered by A power source switched t Unit 5 are exclus	AC. When AC power lost, o batteries. (Batteries of ive to computers.)			
	Operation Logs			Operation logs of March	11 are collected.					

Table-1

	There are 2 kinds of daybooks, being for chief					
Daybooks with handovers for next operators	operators and for members. Both daybooks on the 2^{nd} shift of March 10 and the 1^{st} shift of March 11 are collected. Actions taken on March 11 after earthquake were described on the white boards in the main control rooms, and transcribed to the daybooks thereafter. Memorandums also collected.	There are 2 kinds of dayb operators and for members. Bo shift of March 10 and the 1 st collected. We also collected operations, which were Anti-Earthquake Building.	ooks, being for chief oth daybooks on the 2 nd shift of March 11 are memorandums about organized in Main	There are 2 kinds of d operators and for member 2 nd shift of March 10 and are collected.	aybooks, being for chief ers. Both daybooks on the l the 1 st shift of March 11	
Transient Recorders	Data collected from hard drives removed.	Difficult to remove hard drives. Data collected by repowering.	Transient Recorders	Data collected from hard drives removed.	Event recording function does not work due to the regular inspection.	
	Unusually powered by AC. When AC power lebatteries.	ost, power source switched to	are being replaced.	Unusually powered by A power source switched t Unit 5 are exclusive to co		

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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.

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

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

	1	8	9	10	11	1.2	12	1.4	15	16	17	1.9	10
1	ポイントID	D703		D706	- 0	D707	15	D708	10	D709	17	D710	10
2	ポイント単細	RCIC 注		ADS A	4	ADS B	1	SGTS A		SGTS B		SRNM R	
3	ポイント単位	OFE/ON		OFE/ON	1	OFF/ON	1	OFF/ON		OFF/ON		正常/高高	
631	2011/3/11 14:50:27	OFF	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
632	2011/3/11 1450:28	OFF	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
633	2011/3/11 14:50:29	OFF	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
634	2011/3/11 14:50:30	OFF	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
635	2011/3/11 14:50:31	OFF	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
536	2011/3/11 14:50:32	OFF	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
637	2011/3/11 14:50:33	ON	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
638	2011/3/11 14:50:34	ON	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
639	2011/3/11 14:50:35	ON	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
640	2011/3/11 14:50:36	ON	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
641	2011/3/11 14:50:37	ON	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
542	2011/3/11 14:50:38	ON	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
643	2011/3/11 14:50:39	ON	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
644	2011/3/11 14:50:40	ON	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
645	2011/3/11 14:50:41	ON	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
646	2011/3/11 14:50:42	ON	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
647	2011/3/11 14:50:43	ON	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
648	2011/3/11 14:50:44	ON	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
649	2011/3/11 14:50:45	ON	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
650	2011/3/11 14:50:46	ON	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
651	2011/3/11 14:50:47	ON	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
652	2011/3/11 14:50:48	ON	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
653	2011/3/11 14:50:49	ON	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
654	2011/3/11 14:50:50	ON	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
655	2011/3/11 14:50:51	ON	正常	OFF	正常	OFF	正常	ON	正常	OFF	正常	高高	警報
656	2011/3/11 14:50:52	ION	正常	OFF	正常	OFF	正常	ON.	正常	OFF	正常	高高	警報

【In the case of Digital Input Point】

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1	68	69	70	71	72	73	74	75	76	- 11	78
2				2011/3/11 14:50:3	3 D703	RCIC 注入弁 間	OFF	ON	正常	正常	
3				2011/3/11 15:25:3	4 D703	RCIC 注入弁 開	ON	OFF	正常	正常	
1				2011/3/11 15:39:4	2 D703	RCIC 注入弁 開	OFF	ON	正常	正常	
5				2011/3/11 14:47:4	3 D708	SGTS A 起動信号	OFF	ON	正常	正常	
3				2011/3/11 14:48:1	4 D708	SGTS A 起動信号	ON	OFF	正常	正常	
7				2011/3/11 14:48:2	2 D708	SGTS A 起動信号	OFF	ON	正常	正常	
3				2011/3/11 15:37:3	9 D708	SGTS A 起動信号	ON	OFF	正常	正常	
3				2011/3/11 15:37:5	5 D709	SGTS B 起動信号	OFF	ON	正常	正常	
0				2011/3/11 15:40:3	6 D709	SGTS B 起動信号	ON	OFF	正常	正常	
1				2011/3/11 14:47:5	D710	SRNM 計数率 高高 CI	正常	高高	正常	警報	
2				2011/3/11 14:55:1	9 D710	SRNM 計数率 高高 CA	高高	正常	警報	正常	
3				2011/3/11 14:47:5	0 D711	SRNM 計数率 高高 Ci	正常	高高	正常	警報	
4				2011/3/11 14:55:0	2 D711	SRNM 計数率 高高 CI	高高	正常	警報	正常	
5				2011/3/11 14:47:5	D712	SRNM 計数率 高高 O	正常	高高	正常	警報	
ő				2011/3/11 14:54:4	1 D712	SRNM 計数率 高高 Ci	高高	正常	警報	正常	
7				2011/3/11 14:47:5	D713	SRNM 計数率 高高 CI	正常	高高	正常	警報	
8				2011/3/11 14:55:0	6 D713	SRNM 計数率 高高 CA	高高	正常	警報	正常	
9				2011/3/11 14:47:5	0 D714	SRNM 計数率 高高 Ci	正常	高高	正常	警報	
0				2011/3/11 14:55:0	5 D714	SRNM 計数率 高高 CI	高高	正常	警報	正常	
1				2011/3/11 14:47:5	0 D715	SRNM 計数率 高高 C	正常	高高	正常	警察	
2				2011/3/11 14:54:3	5 D715	SRNM 計数率 高高 CI	高高	正常	警報	正常	
3				2011/3/11 14:47:5	D716	SRNM 計数率 高高 CI	正常	高高	正常	警報	
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5				2011/3/11 14:475	0 D717	SRNM 計数率 高高 Ci	正常	高高	正常	122 4日	
6				2011/3/11 1453:4	3 D717	SRNM 計数率 高高 C	高高	正常	警報	正常	
7				2011/3/11 14:48:0	3 D725	SRNM ベリオド 短短 C	正常	短短	正常	50° 460	
8				2011/3/11 14:48:0	5 D725	SRNM ペリオド 短短 C	短短	正常	100 AG	正常	
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479	2011	/3/11	14:47:55	9.2808	正常	9.9144	正常	6903.0000	正常	6890.3999	正常	6917.3999	正常	6895.7998	正常
480	2011	/3/11	14:47:56	9.1368	正常	9.7488	正常	6910.2002	正常	6894.0000	正常	6922.7998	正常	6897.6001	正常
481	2011	/3/11	14:47:57	2.5488	正常	2.7504	正常	6643.7998	正常	6352 2002	正常	6654,6001	正常	6346.7998	正常
482	2011	/3/11	14:47:58	0.1944	正常	0.1800	正常	6679.7998	正常	6571.7998	正常	6699.6001	正常	6579.0000	正常
483	2011.	/3/11	14:47:59	0.0288	正常	0.0432	正常	6699.6001	正常	6593.3999	正常	6715.7998	正常	6595.2002	正常
484	2011	/3/11	14:48:00	0.0072	正常	0.0360	正常	6688.7998	正常	6589.7998	正常	6705.0000	正常	6588.0000	正常
485	2011.	/3/11	14:48:01	0.0000	低	0.0288	正常	6699.6001	正常	6597.0000	正常	6714.0000	正常	6598.7998	正常
486	2011	/3/11	14:48:02	0.0000	低	0.0216	正常	6703.2002	正常	6600.6001	正常	6710.3999	正常	6598.7998	正常
487	2011	/3/11	14:48:03	0.0072	低	0.0216	正常	6706.7998	正常	6607.7998	正常	6723.0000	正常	6609.6001	正常
488	2011	/3/11	14:48:04	-0.0072	低	0.0144	正常	6715.7998	正常	6620.3999	正常	6728.3999	正常	6620.3999	正常
489	2011	/3/11	14:48:05	0.0072	低	0.0216	正常	6755.3999	正常	6654.6001	正常	6766.2002	正常	6656.3999	正常
490	2011	/3/11	14:48:06	-0.0072	低	0.0144	正常	6791.3999	正常	6699.6001	正常	6800.3999	正常	6697.7998	正常
491	2011	/3/11	14:48:07	-0.0072	低	0.0216	正常	6829.2002	正常	6746.3999	正常	6845.3999	正常	6748.2002	正常
492	2011	/3/11	14:48:08	-0.0072	低	0.0144	正常	6796.7998	正常	6714.0000	正常	6811.2002	正常	6714.0000	正常
493	2011	/3/11	14:48:09	0.0000	低	0.0144	正常	6775.2002	正常	6692.3999	正常	6791.3999	正常	6694.2002	正常
494	2011	/3/11	14:48:10	-0.0072	低	0.0216	正常	6728.3999	正常	6674.3999	正常	6744.6001	正常	6676.2002	正常
495	2011	/3/11	14:48:11	-0.0072	低	0,0144	正常	6683.3999	正常	6642.0000	正常	6692.3999	正常	6642.0000	正常
496	2011	/3/11	14:48:12	0.0000	低	0.0144	正常	4357.7998	正常	6665.3999	正常	4411.7998	正常	6669.0000	正常
497	2011	/3/11	14:48:13	-0.0144	低	0.0216	正常	3583.8000	正常	6649.2002	正常	3592,8000	正常	6649.2002	正常
498	2011	/3/11	14:48:14	-0.0144	低	0.0072	正常	3540.6001	正常	6643.7998	正常	3576.6001	正常	6643.7998	正常
499	2011	/3/11	14:48:15	0.0072	低	0.0144	正常	894.6000	正常	6643.7998	正常	894.6000	正常	6642.0000	正常
500	2011	/3/11	14:48:16	0.0000	低	0.01 44	正常	532,8000	正常	6571.7998	正常	531.0000	正常	6573.6001	正常
501	2011	/3/11	14:48:17	-0.0072	低	-0.0144	低	421.2000	正常	6573.6001	正常	414.0000	正常	6571.7998	正常
502	2011	/3/11	14:48:18	0.0072	低	0.0216	低	180.0000	正常	6449.3999	正常	180.0000	正常	6465.6001	正常
503	2011	/3/11	14:48:19	-0.0072	低	0.0072	低	117.0000	正常	5698.7998	正常	117.0000	正常	5792.3999	正常 🔳
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【In the case of Analogue Input Point】

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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.

21. AnaloguePIDA754, Voltage of D/G 3A R-T



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