Technical Volume 1 "Description and Context of the Accident"





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The Fukushima Daiichi Accident Technical Volume 1

INTRODUCTION



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Writing Technical Volume 1

Key statistics

- 3 year process (2013-2015)
- 6 Working Group meetings,
- 6 additional meetings of Co-Chairs, and
- Participation of Co-Chairs and experts in consultancy meetings in Japan and at the IAEA
- Numerous hours spent by experts outside of Working Group meetings drafting sections of the report in their respective countries



Writing Technical Volume 1

A complex process

- Define the purpose and develop a plan but remain flexible
- Put together a team to coordinate the process
- Identify areas of expertise and assign specific section of the report to experts
- Ensure continuous review and feedback from external experts

A meticulous task

- Reference sources: key to credibility of information and traceability
- TV1 formed the basis for the assessment of the various aspects and causal factors of the accident
- Specific investigations of the facts are presented in subsequent TVs



Interface with other Working Groups

Interfaced with other Working Groups through strong collaboration during the drafting process by providing factual information on:

- Technical and regulatory aspects
- Human and organizational factors
- Source term (amount of radionuclides released)
- Emergency response structure and requirements
- Stabilization, remediation, recovery, decommissioning and waste management



The Content

Describes in detail the accident for addressing the causes, consequences, as well as lessons and observations

- Description of the event is based on objective and factual information, and is presented largely in a chronological manner
- Describes the Fukushima Daiichi NPP site
- The reactor designs
- Structure of the nuclear industry in Japan
- Japanese regulatory framework at the time of the accident.
- Actions taken at the Fukushima Daiichi NPP and elsewhere for accident and post-accident management up to December 2014¹

¹ In some cases information until May 2015 was included, where needed.



Highlights

- Provides an overall picture of situation before, during and after the accident
 - Includes a description of the nuclear industry in Japan and the Japanese regulatory framework at the time of accident
 - Describes the initial status at the units and the sequence of events at each unit from the plant manager's perspective
 - Addresses safety aspects such as site selection, station blackout, emergency preparedness and mitigation measures/equipment
- Compares accident consequences with other affected nuclear power plants by the earthquake and tsunami





The Fukushima Daiichi Accident **Technical Volume 1**, Section 1-1

SUMMARY OF THE ACCIDENT



Summary of the Accident

- Gives the "description of event"
- Presents the main events in a chronological order to provide an overview
- Demonstrates events that occurred in parallel or affected actions at different parts of the site
- Illustrates the integrated response to a multi-unit site accident from the perspective of:
 - Emergency response centre(s) (ERCs)
 - Common main control rooms (MCRs)
 - The off-site organizations



Event Description

14:46, 11 March 2011 Great East Japan Earthquake

Loss of off-site power, all operating reactors automatically shut down





11 March, 15:27-15:37

Tsunami waves overwhelmed the tsunami barriers of Fukushima Daiichi nuclear power plant (NPP) site. Flooding primary and backup power systems and equipment, as well as the ultimate heat sink systems and structures, of all six units on the site



Compounding off-site power loss that occurred due to the earthquake damage to the transmission system. Flooding resulted in the loss of on-site power sources (and/or on-site power distribution systems)



11 March, 15:42

Station blackout (SBO) occurred in Units 1-5. The units experienced extended SBO events, which exceeded 9 days in Units 1 and 2, and 14 days in Units 3 and 4

12-15 March, 2011

The nuclear units were unable to cope with the extended loss of electrical power and plant heat removal, and the reactors of Units 1, 2 and 3 suffered damage as the fuel overheated and melted. The reactor pressure vessels (RPVs) that enclose the reactor cores were eventually breached in those units, and radioactive material escaped from the reactors

The radioactive material confined in the primary containment vessels (PCVs) was further released directly to the environment either in a controlled manner, i.e. by venting of the reactors' PCVs, or in an uncontrolled manner upon damage and failure of the confinement structures



The radioactive releases resulted in radiological exposure of the workers at the site and the general public residing in the surrounding communities and caused radiological contamination of the environment in those areas



25 March 2011 - Present

In order to reduce radiation exposures, people within a radius of 20 km of the site, as well as other specified areas, were evacuated, and restrictions were placed on the distribution and consumption of food and drinking water

Although no loss of life has been attributed to the radiological releases, the accident caused social and economic impacts, especially in Japan

Following the stabilization of the conditions of the affected reactors, activities to prepare these reactors for their eventual decommissioning have also been initiated



The Fukushima Daiichi Accident **Technical Volume 1**, Section 1-2

CONTEXT WITHIN WHICH THE ACCIDENT OCCURRED



Situation at the Time of the Accident

- Addresses the Japanese nuclear power program, its nuclear industry and the governmental/legal/regulatory framework in place at the time of the accident
- Describes the characteristics of the Fukushima Daiichi site, the plant systems and its six units
- Describes the plant's resources and capacity with respect to the qualifications and abilities of its staff as well as the tools available to them at the time of the accident

To determine technical, regulatory and human/organizational contributing causes.

Assessment in Technical Volumes 2 and 3



Nuclear Industry in Japan

Provide relevant aspects of:

- The nuclear power policies in Japan
- Industry programmes and processes
- Safety culture
- Industrial and international cooperation at time of or before the accident





Nuclear Law and Regulation in Japan

The key aspects of the main laws and their evolution are of particular relevance to the Fukushima Daiichi accident:

- Atomic Energy Basic Act (the Basic Act)
- Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors (Reactor Regulation Act)
- Electricity Utilities Industry Law (the Electricity Business Act), and
- Act on Special Measures Concerning Nuclear Emergency Preparedness (Nuclear Emergency Act)

Legislation	Cabinet Order	Ministerial Ordinance	Ministerial Public Notice
Atomic Energy Basic Act			
Reactor Regulation Act	Cabinet Order for Reactor Regulation Act	Ministerial Ordinance for Commercial Power Reactors	Ministerial Public Notice for Dose Limit Based on Provisions of Commercial Power Reactor
			Ministerial Public Notice for Criteria on Person Responsible for Operation
		Ministerial Ordinance for Reactors at the Stage of Research and Development	Ministerial Public Notice for Technical Details of Transport of Nuclear Fuel Material, etc. in Factory or Place of Business
			Ministerial Public Notice for Important Safety Related Equipment
Radiation Hazard Prevention Act	Cabinet Order for Radiation Hazard Prevention Act	Ministerial Ordinance for Radiation Hazard Prevention Act	Ministerial Public Notice for Dose Limit Based on Provisions of Reactors at the Stage of Research and Development
Electricity Business Act	Cabinet Order for Electricity Business Act	Ministerial Ordinance for Electricity Business Act	Ministerial Public Notice for Technical Requirements on Dose Equivalent, etc. due to Radiation
		Ministerial Ordinance for Establishing Technical Standards for Nuclear Power Generation Facilities	Relating to Nuclear Power Generation Facilities
Disaster Countermeasures Basic Act		Ministerial Ordinance for Establishing Technical Requirements for Nuclear Fuel Material of Power Generation	
Act on Special Measures Concerning Nuclear Emergency Preparedness	Cabinet Order for enforcement of the Act on Special Measures Concerning Nuclear Emergency Preparedness	Ministerial Ordinance for enforcement for the Act on Special Measures Concerning Nuclear Emergency Preparedness	



Regulatory Oversight of Nuclear Industry

Commercial nuclear power reactors are exempt from certain provisions of the Reactor Regulation Act

- Approval of design and construction methods
- Pre-service inspection
- Welding methods
- Inspection

These activities are subject to the 'Electricity Utilities Industry Law'



Onset and progression of the accident

- Explains how an extreme natural event, combined with design and operational issues, led to a severe nuclear accident
- Describes the effects of the initiating event (the Great East Japan Earthquake) and its concurrent and dependent natural event (the tsunami) on the Fukushima Daiichi NPP site
- Provides a sequence of events at each unit
- Describes the human and organizational response to the accident and during the following month







Fundamental Safety Functions and Detailed SOE

11 Mar 16:00	Primary containment vessel cove No fuel in core, only secondary c (15:3 ³) Tsunami damakes some (16:03) RCIC from condensat Reactor core isolation cooling syst I dama conduct a system (1)	(15:50) (15:50) (15:36) T (15:36) T (15:37) (15:37)	No coolin No coolin No coo	No coolin 10	eight ÖP+14.5 m) 5:42 Station blacko nits 1–5 6:36 Presumed sev	vere accident	r -				
	ontai Sunai 3) RCI ore isc	Loss of Loss of Loss of Emer Emer Emer Emer	oling oling oling oling		conditions in Units 1 and 2, classification of a nuclear						
18:00 🕳	, only s , only s from c from c from c from	of DC power fDC power of DC power engency of ergency of ergency of ergency of ergency of	or make nake-up or make or make	nake-up	Date and time ¹	Time elapsed after initiating event	Event/action	Auto/manual; local/remote	Set point; criterion/value	Remarks	Time Elapsed after SBO
19:00	econd ages s cooling	ver thr throug er throug liesel diesel diesel diesel iesel	e-up,		2011-03-11 14:46	00:00 (min)	Occurrence of earthquake.	-	M9.0	Initiating external event.	-51:00 (min)
20:00 🖝	ary c ary c some	ought hflood nugh fil gene gene gene gene gene	(15:50) No (15:50) No (15:50) No	- 2 a	2011-03-11 14:46	00:00 (min)	Reactor trip at the seismic trip set point.	Auto	100 Gal V 135 Gal H	Sensors B and C (two out of four).	-51:00 (min)
21:00 • 22:00 • 23:00 •	Lover open, only secondan lary containment (reactor b some equipment in subport neate storage tank a sytem RECC from conden a sytem RECC from conden	looding (21:27) Por ing (20:47) Portable coding (21:19) Portable coding (21:19) Portanerators (EDGS) tr interators (EDGS) tr interators (EDGS) trip causing rators trip causing rators trip causing rators trip causing ators trip causing	indication for indication for indication for	- 2 - 2 - ai - 3 - fc	2011-03-11 14:46	00:00 (min)	Loss of off-site power.	-	-	Concurrent event The earthquarks caused damage to the breakers of the switchyards of Units 1 and 2. With reference to the TEPCO nuclear line (66 kV) from Tohoku Electric Power, cohles were damaged althought it was not possible to find the cause. Regarding Units 3 and 4, in addition to the Okuma No. 3 transmission line under construction, the breakers of Nos 3 and 4 transmission lines on the side of the Shar Fukutum Power Substantion field. In the case of Units 3 and 6, one transmission line tower (No. 27 tower) connecting to the switchyards of Units 5 and 6 collapsed.	-51:00 (min)
12 Mar 00:00 - 01:00 -	Prima of low three stores	table batteri e generator able batterie ip, one rema a station bl a station bl c a station bl	water level a water level a water level a	-2: Vi p	2011-03-11 14:47	01:00 (min)	Reactor water level dropped initially because of the collapsing steam voids.	T.	TAF + 3580 mm	Since the reactor water level was within the normal band, the operators did not have to initiate HPCI (the HPCI set point was L2, which was <148 cm from the bottom of the separator). The level recovered as a neutral of feedwater (time is approximate, level drop and recovery between 14:47 and 14:48).	-50:00 (min)
01.00	w cont pressi orage ta	es ains o ackou ackou ackou ackou ackou	and temperature and temperature and temperature	- U	2011-03-11 14:47	01:00 (min)	Reactor pressure dropped initially after trip.	-	~6 MPa	Consequently, reactor pressure started rising due to decay heat after isolation by MSIV closure (time is approximate).	-50:00 (min)
02:00 🕳	ainm ank und i	the	tempe tempe	0			Level 3 state of emergency declared and Emergency Plan activated.	-	Seismic intensity >6 on the Japanese scale	TEPCO Headquarters and other offices simultaneously declared a Level 3 state of emergency	
03:00 🗲	ore co	ational	ratur	-0	2011-03-11 14:47	01:00 (min)	AOP Natural Disaster Accident, Section IV, Natural Event activated.	-	>45 Gal	and established the ERC according to the Operation Plan for Disaster Preparation for general disasters and internal rules. Post-earthquake actions initiated in accordance with event based	-50:00 (min)
04:00	able		0 	- m ir			Earthquake Emergency Response Team activated at the ERC.	-	_	AOP, Natural Disaster Accident, Section IV, Natural Disasters, Chapter 22.	
				- tł	2011-03-11 14:47	01:00 (min)	All control rods fully inserted.	Auto	ARI	-	-50:00 (min)
05:00	eeds maxir			- 0.	2011-03-11 14:47	01:00 (min)	PCIS generated.	Auto	Low Rx Level L3 (18 cm from the bottom of the separator)	or the reactor protection system power loss. It is not known what initiated the isolation.	-50:00 (min)
	aximum desig (06:06) He 00) RCIC from			a 1	2011-03-11 14:47	01:00 (min)	Normal HVAC stopped.	Auto	LOOP	PCV cooling ceased.	-50:00 (min)
07:00 - 08:00 - 09:00 -	design pressure 06) Head vent nozzle is oper from suppression chamber	(03/3) Connection to Unit G EDG (for		- 0 - 0 - (F - 0	2011-03-11 14:47	01:00 min	SFP cooling and make-up lost.	_	LOOP	The SFPs, which store the used and new field assemblies, are filled with water providing radiation shielding and removal of heat from the nuclear fuel located there. However, without cooling, the pool water would heat up and eventually start evaporating. Alternative SFP cooling would have been possible via the residual heat removal system (RHR), which was supplied with power by the EDG. However, switching from RHR cooling to SFP cooling would have required manual actions, which had not taken place before the arrival of the tsuamu which affected the RHR components.	- 50:00 min
	is ope	necti		-1	2011-03-11 14:47	01:00 (min)	Turbine trip on high vibration.	Auto	-	Chart shows manual trip here	– 50:00 (min)
11:00 🛥	aned	on to		a	2011-03-11 14:47	01:00 (min)	6.9 kV power loss.	-	-	Buses 1C and 1D power loss	-50:00 (min)
12:00		Unit 6		1	2011-03-11 14:47	01:00 (min)	EDGs started and loaded.	Auto	Loss of AC	-	-50:00 (min)
13:00 - 14:00 - 15:00 - 16:00 -	HPCI	EDG (for certain equipment)		of se hi	4:00 Operators op f Unit 1 and receiv f venting at 14:30 5:30 Establishment eawater injection lin ower lines to Units gly voltage power s 5:36 Explosion in Ur fwater and power p errading site radiole	of temporary ne to Unit 1 and 1 and 2 with upply trucks nit 1: destructio provisions,	Main event Core Cooling Powe	s: De		ed SOE for Units 1-3	Other Unit E
Available Operating	Limited or partially availab Alternative measure	le/operating Not avai Not appl	able * In icable 1-6	ncludes	egrading site radiolo DC power and ins hima Daiichi NPF	strument air					



The Fukushima Daiichi Accident **Technical Volume 1**, Section 1-4

RADIONUCLIDE INVENTORY AND RELEASES



Radionuclide Inventory and Releases

- Reconstructs the source term
- Describes the initial releases of radionuclides to the environment, resulting from the failure of the fission product barriers at the time of the accident
- Presents other events afterwards that caused additional radioactive releases from the accident site

To Determine Radiological Impacts on People and the Environment



What Happened?

- Radioactive materials were emitted into the atmosphere and transferred to the land and ocean through wet and dry deposition
- Contaminated fresh and seawater was directly released to the ocean

Assessments are in Technical Volume 4





The Fukushima Daiichi Accident **Technical Volume 1**, Section 1-5

ACTIONS BY ORGANIZATIONS OTHER THAN TEPCO



Accident Response in Japan and the World

Addresses the response to accident progression by:

- Offsite entities
- Actions of Japan's national, prefectural and local governments
- IAEA and other international and regional organizations





The Fukushima Daiichi Accident **Technical Volume 1**, Section 1-6

ACTIONS TAKEN IN THE AFTERMATH OF THE ACCIDENT



Post-accident Recovery

Covers subsequent actions taken at the Fukushima Daiichi NPP by TEPCO, government organizations, the Japan's nuclear industry and internationally to address challenges and issues after the accident

- Includes current activities and plans on the site decommissioning and remediation
- Assessments are in Technical Volume 5





The Fukushima Daiichi Accident Technical Volume 1

CONCLUSION



Conclusion

TV1 is a comprehensive description on the background and context of the accident

- It comprises a detailed timeline of the accident
- It provides factual information required for an appropriate assessment of the accident
- It is the result of a multi-national/organizational efforts
- It will be a valuable resource for countries to validate and compare their action plan post-Fukushima
- Is a general reference account of the accident and the aftermath

TV1 is a basis for analysis in other TVs



THANK YOU

