Appendix B: Responses to Phase 2 Information Request

Human and Organisational Factors Lessons Learnt Implementing Post-Fukushima Actions

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Table 1. Lesson Learnt Applicability to Off-site and On-Site Activities

	Off-site	On-site
CA-01 - Emergency Management Center (EMC)	■	■
CA-02 - Emergency Mitigating Equipment (EME)		■
CA-03 - Incident Management System (ISM)	■	■
CA-04 - Public Alerting Systems	■	■
CA-05 - Remote Automated Gamma Monitoring System	■	■
CA-06 - Emergency Satellite Communication System (ESCS)	■	■
CA-07 - Unified RASCAL (Radiological Assessment System for Consequence Analyses) Interface (URI)	■	■
CA-08 - Web Emergency Operating Centre (WebEOC)	■	■
CZ-01 - Provision of Mobile Diesel Generators (MDG)		■
CZ-02 - Enhancement of Communication Equipment	■	■
CZ-03 - New Backup (Diverse) and Alternate (Mobile) Emergency Response Center	■	
CZ-04 - Improved Procedures for Diverse and Mobile Equipment & Emergency Operating Procedures		■
CZ-05 - New Extensive Damage Mitigation Guidelines (EDMG)	■	■
FR- 01 - Implementation of Operations Team Minimum Staffing	■	■
KR-01 - Stress Test		■
KR-02 - Preparation for prolonged emergency		■
KR-03 - Reinforcing emergency exercise		■
KR-04 - Mobile power generating equipment		■
KR-05 - Emergency plan for emergency at multiple units	■	■
KR-06 - Response Form - Seismic alarm in MCR		■
KR-07 - Education and Training		■
KR-08 - SAMG revision		■
KR-09 - Low power shutdown SAMG		■
KR-10 - Improving the emergency response facilities	■	
KR-11 - Assessment of manpower		■
KR-12 - Development of accident coping strategies		■
KR-13 - Accident Management Program		■
KR-14 - Mobile Equipment		■
KR-15 - MACST Team		■
SP-01 - Verification and Validation for Emergency Situations		■
SP-07 - Stress Management Guide and Posters	■	■
SP-08 - Leadership During Emergency Situations	■	■
SP-09 - Command and Control in Emergencies Guide	■	■
SP-02- Communication During Emergencies		■
SP-03 - Magnetic Help Guides for Portable Equipment		■
SP-04 - Visual Aids for Identifying Emergency Equipment		■
SP-05 - Training for Emergency Equipment Transport		■
SP-06 - Communication System Improvements		■
US-01 - Development and Application of HRA Methods for Use of FLEX Strategies and Equipment		■
US-02 - FLEX Diesel Generator Experience		■
Grand Total	**16**	**38**

Table 2. Lesson Learnt Applicability to Plant Location

	Main Control Room	Tech. Support Center	Remote Shut Down	EOF	Other Local Control	[other]
CA-01 - Emergency Management Center (EMC)		■		■		
CA-02 - Emergency Mitigating Equipment (EME)	■				■	
CA-03 - Incident Management System (ISM)	■	■		■		
CA-04 - Public Alerting Systems				■		
CA-05 - Remote Automated Gamma Monitoring System				■		
CA-06 - Emergency Satellite Communication System (ESCS)	■	■		■		
CA-07 - Unified RASCAL (Radiological Assessment System for Consequence Analyses) Interface (URI)		■		■		
CA-08 - Web Emergency Operating Centre (WebEOC)		■		■		
CZ-01 - Provision of Mobile Diesel Generators (MDG)	■		■		■	
CZ-02 - Enhancement of Communication Equipment	■	■	■	■	■	
CZ-03 - New Backup (Diverse) and Alternate (Mobile) Emergency Response Center		■		■	■	
CZ-04 - Improved Procedures for Diverse and Mobile Equipment & Emergency Operating Procedures	■	■			■	
CZ-05 - New Extensive Damage Mitigation Guidelines (EDMG)	■	■		■	■	
FR- 01 - Implementation of Operations Team Minimum Staffing	■	■			■	
KR-01 - Stress Test	■	■		■	■	
KR-02 - Preparation for prolonged emergency	■	■		■		
KR-03 - Reinforcing emergency exercise	■	■		■	■	
KR-04 - Mobile power generating equipment				■		
KR-05 - Emergency plan for emergency at multiple units	■	■		■	■	
KR-06 - Response Form - Seismic alarm in MCR	■					
KR-07 - Education and Training	■	■		■		
KR-08 - SAMG revision	■	■		■		
KR-09 - Low power shutdown SAMG	■	■		■		
KR-10 - Improving the emergency response facilities				■		
KR-11 - Assessment of manpower						■
KR-12 - Development of accident coping strategies	■	■		■	■	
KR-13 - Accident Management Program	■	■		■	■	
KR-14 - Mobile Equipment		■		■	■	
KR-15 - MACST Team				■		
SP-01 - Verification and Validation for Emergency Situations		■		■	■	
SP-07 - Stress Management Guide and Posters				■		
SP-08 - Leadership During Emergency Situations				■		
SP-09 - Command and Control in Emergencies Guide		■		■		
SP-02- Communication During Emergencies						■
SP-03 - Magnetic Help Guides for Portable Equipment					■	
SP-04 - Visual Aids for Identifying Emergency Equipment	■				■	
SP-05 - Training for Emergency Equipment Transport				■	■	
SP-06 - Communication System Improvements	■	■	■	■	■	
US-01 - Development and Application of HRA Methods for Use of FLEX Strategies and Equipment	■		■		■	
US-02 - FLEX Diesel Generator Experience					■	
Grand Total	**21**	**23**	**4**	**29**	**20**	**2**

Table 3. Lesson Learnt Applicability to Job Category

	MCR Ops.	EOF	Field Ops.	Other ERO	Maint. Techs	Security	HP-RP Chemist	[other]
CA-01 - Emergency Management Center (EMC)		X		X				
CA-02 - Emergency Mitigating Equipment (EME)	X		X		X			
CA-03 - Incident Management System (ISM)	X	X		X		X		
CA-04 - Public Alerting Systems	X	X	X	X	X	X	X	
CA-05 - Remote Automated Gamma Monitoring System		X		X			X	
CA-06 - Emergency Satellite Communication System (ESCS)	X	X		X		X		
CA-07 - Unified RASCAL Interface		X		X				
CA-08 - Web Emergency Operating Centre (WebEOC)		X		X				
CZ-01 - Provision of Mobile Diesel Generators (MDG)	X		X		X			X
CZ-02 - Enhancement of Communication Equipment	X	X	X	X	X			
CZ-03 – Diverse and Mobile Emergency Response Center		X		X		X	X	X
CZ-04 - Improved Procedures for Diverse and Mobile Equipment & EOPs	X	X	X					X
CZ-05 - New Extensive Damage Mitigation Guidelines (EDMG)	X	X	X	X				X
FR-01 - Implementation of Operations Team Minimum Staffing	X	X	X	X	X	X	X	
KR-01 - Stress Test	X	X	X	X	X			
KR-02 - Preparation for prolonged emergency	X	X		X				
KR-03 - Reinforcing emergency exercise	X	X	X	X				
KR-04 - Mobile power generating equipment				X				
KR-05 - Emergency plan for emergency at multiple units	X		X	X				
KR-06 - Response Form - Seismic alarm in MCR	X							
KR-07 - Education and Training	X	X		X				
KR-08 - SAMG revision	X	X		X				
KR-09 - Low power shutdown SAMG	X	X		X				
KR-10 - Improving the emergency response facilities				X				
KR-11 - Assessment of manpower								X
KR-12 - Development of accident coping strategies	X	X	X	X				
KR-13 - Accident Management Program	X	X	X	X				
KR-14 - Mobile Equipment	X	X	X	X				
KR-15 - MACST Team				X				
SP-01 - Verification and Validation for Emergency Situations	X	X	X	X	X	X	X	
SP-07 - Stress Management Guide and Posters				X				
SP-08 - Leadership During Emergency Situations				X				
SP-09 - Command and Control in Emergencies Guide				X				
SP-02- Communication During Emergencies	X	X	X	X	X	X	X	
SP-03 - Magnetic Help Guides for Portable Equipment			X					
SP-04 - Visual Aids for Identifying Emergency Equipment	X		X					
SP-05 - Training for Emergency Equipment Transport			X		X			
SP-06 - Communication System Improvements	X		X	X				
US-01 - HRA for Use of FLEX Strategies and Equipment	X		X		X	X		
US-02 - FLEX Diesel Generator Experience	X		X		X			
Grand Total	**26**	**23**	**21**	**30**	**11**	**8**	**6**	**5**

Canada

Lesson Learnt: CA-01 – Emergency Management Centre (EMC)

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Emergency Operations Facility
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

In light of the lessons learned from the seismic incident at the Fukushima Daiichi Nuclear Power Plant a Canadian nuclear power plant decided to build on its already substantial emergency response and control structure to better respond to emergencies, especially those as a result of natural disasters. As a result the utility decided to merge its Site Management Center (SMC) and the Corporate Emergency Support Center (CESC) into a new state-of-the art Emergency Management Center (EMC) facility.

The new EMC is located approximately 1 km from the site and its primary purpose is to provide emergency response support to the stations. This includes communication with external agencies and additional support or resources, such that the stations are able to focus solely on plant response.

The EMC maintains a VSAT satellite uplink for phone, fax, and Internet, as well as radio, servers for software operation, electronic dosimetry, external broadcast capability and back-up power to support sustained operations during infrastructure outages. It is set up to maximize communications both within the EMC and with off-site resources.

In addition to the EMC, two alternate command posts were established to provide redundancy should the primary EMC become uninhabitable. The alternate command posts will also be used as evacuation centres for the purpose of staging response resources when dealing with a significant all-hazards event that requires longer-term management and on-going support to relieve on-site responders and station operations.

The nuclear power plant also put in place a mobile EMC to back up the EMC or the Emergency Operations Center (EOC), or to augment command requirements depending on the situation. The mobile EMC is also equipped with back-up power, VSAT capability, and phone, fax and radio capabilities.

Another nuclear power plant approach was to develop a new off-site Emergency Operations Center which is located 23KM from site. This facility serves as the center for all off-site actions during an event and has permanent back-up facilities for each of the on-site Emergency Facilities in the event these locations are no longer habitable.

Another nuclear power plant is reviewing this approach and is in the early stages of looking at consolidating ERO facilities.

Supplemental Files: None

Anticipated Benefits: The EMC coordinates and manages the overall Corporate response to a nuclear emergency and is EMC is the facility that provides the primary contact for communications with the Provincial, regional, and local municipal government centres. It also provides support with the appropriate technical and financial resources, including the support to and oversight of the Main Control Room and Station Emergency Operations Centres.

To test the proof of concept of a central command post which amalgamated the existing SMC and CESC as well as our ability to response to an "all hazards" event, including radiological, the nuclear power plant participated in an exercise lead by Emergency Management Ontario which involved more than 50 participating organizations.

During the exercise the EMC successfully served as the central command and logistic control and coordination point.

The events described in this lesson learnt occurred: Canada from April 2011 to September 2012

Lesson Learnt: CA-02 Emergency Mitigating Equipment (EME)

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Emergency Operations Facility
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

A major lesson learned from the Fukushima Daiichi nuclear event concerns preparedness for loss of core cooling events due to complete loss of on-site and off-site electrical power. To address these types of events, which can be initiated by internal or external hazards, Canadian nuclear power plants have added an additional layer of emergency backup water and electrical power based on portable emergency mitigating equipment (EME). The EME strategy is designed to prevent a beyond design basis accident (BDBA) from progressing to a severe accident.

In parallel, emergency mitigating equipment guidelines (EMEGs) were developed to provide instructions on the operation of EME. The inability to predict actual plant conditions that require the use of EME makes it impossible to provide specific procedural guidance. As such, the EMEGs provide guidance that can be employed for a variety of conditions. Control room staff will transfer from emergency operating procedures (EOP) to the EMEGs upon determination that the loss of heat sink event is due to an extended loss of AC power (ELAP).

Should EME not be deployed in a timely manner or otherwise fail to prevent Severe Accident Management Guidelines (SAMG) entry conditions from being met, the SAMGs may be entered directly from the EMEGs. Under these circumstances, EME may still be available to SAMG for use in mitigation strategies.

Supplemental Files: None

Anticipated Benefits: The safety benefit is the provision of an additional layer of defense whereby the Level 4 from the IAEA defense in depth levels is further subdivided into Level 4a and 4b. Level 4a was introduced as an additional layer of defense with the intent of using additional safety features to provide additional means for preventing a beyond design basis accident, i.e. with limited or no core melt, from progressing to a severe accident.

The EME strategy helps in reducing the risk from some contributors in plant-specific probabilistic safety assessments (PSA) (e.g. station blackout and loss of ultimate heat sink scenarios). EME validation studies indicate that the actions and responses are highly feasible and warrant consideration to reduce the site risk profile when the actions are directed.

The events described in this lesson learnt occurred: Canada from April 2012 to present

Lesson Learnt: CA-03 Incident Management System (IMS)

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Emergency Operations Facility
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

Following the Fukushima event, one Canadian nuclear power plant undertook a review of the organization's emergency response structure. As a result of this review and additional lessons learned from the Fukushima event, the nuclear power plant decided to transition to the Incident Management System (IMS) in an "All Hazards" approach to emergency response at the station site.

The IMS is an internationally recommended standardized approach to emergency management, recommended for managing all incidents. It guides how personnel, facilities, equipment, procedures, and communications may be coordinated during an incident. The IMS was adopted by the province of Ontario and provides standardized organizational structures, functions, processes and terminology for use at all levels of emergency response in Ontario.

The existing nuclear power plants' Emergency Plan was reviewed and amended in accordance with the

move to IMS and an all hazards approach to emergency response and a revised Emergency Response Organisation (ERO) and procedures were produced and included the implementation of an additional 3 shifts to staff the ERO.

In another utility, the formal Incident Command Structure (ICS) is utilized under an All-Hazards approach. The ICS model allows integration between all response partners and ensures common terminology.

Another utility has adopted IMS in the corporate response structure, and is looking at extending to the Nuclear Emergency Response Organization

Supplemental Files: None

Anticipated Benefits: Proof of concept exercises were completed at the nuclear power plant as part of the IMS implementation. ERO personnel viewed the IMS an all hazards approach to emergency management as a significant improvement over the existing recovery model. The personnel found that IMS provided an efficient, flexible and consistent structure to manage events at all levels, allow incidents to be managed in a cohesive manner, facilitating the response to incidents and cooperation between multiple organizations and jurisdictions.

The IMS establishes a clear line of reporting and authorities within the nuclear power plant organization for both radiological and "all hazards" events.

The events described in this lesson learnt occurred: Canada from April 2011 to April 2013

Lesson Learnt: CA-04 Public Alerting Systems

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Emergency Operations Facility
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

As part of the one Canadian nuclear power plant's on-going efforts to enhance emergency preparedness and maintain efficient and effective communications with its residents in the event of any type of emergency, the nuclear power plant collaborated with radio stations in the region to implement an Alert FM™ notification. This system utilizes the sub-carrier system of local FM Radio stations to send a message to a mobile receiver. The receivers sound with an auditory warning and a message is broadcast on the screen to provide detailed response instructions within seconds.

The nuclear power plant provided receivers to all staff whose presence on site is required to meet the utility licensed operational requirements and to support safe operation of the site per applicable Provincial and Federal Regulatory requirements. The nuclear power plant also deployed Alert FM™ technology to local municipality (3000 receiver units) to support public alert efforts, with the capability to send public alert messages within 10 km of the site (primary zone). The system is connected to the National Public Alerting System (Alert Ready) and receives all Threat to Life Alerts distributed through that system.

Another nuclear power plant and associated provincial authority EMO utilizes a mass notification system (Everbridge) this system is used to notify all residents within the 20KM planning zone from the station and is augmented by the National Public Alerting System (Alert Ready). In addition to the notification systems, this province utilizes a Warden Service which consists of actual members supporting 15 zones of the 20 KM planning zones who support door-to-door notifications with provincial agencies during an event.

Another utility has worked with the pilot project for National Public Alerting System, which is also employed by the local Municipality to notify local residents. Sirens are also employed to notify residents within the Automatic Action Zone within 3km of stations.

Supplemental Files: None

Anticipated Benefits: Currently, the Municipality around the nuclear power plant relies on sirens and Rapid Notify to alert the public in the 10-kilometer radius of the nuclear power plant of nuclear emergencies. Rapid Notify is a system that sends out messages to residents using land-line phone technology. The ever-increasing trend of people becoming more reliant on cellular technology and replacing their land-line phones with cell phones presents an area where improvements could be made. The Alert FM™ serves as a public notification enhancement. It will provide Municipal Emergency Officials the ability to broadcast emergency messages directly to residents, businesses and institutions with an audible alert and text message within seconds.

The events described in this lesson learnt occurred: Canada from January 2012 to September 2016

Lesson Learnt: CA-05 Remote Automated Gamma Monitoring System

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Emergency Operations Facility
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

The benefits of an enhanced remote radiological monitoring program were evident after the Fukushima event for modeling purposes, and early detection of plume pathways to assist in response and recovery effort. Along with remote monitoring capability t real-time data is essential to quickly identify the existence of radiological hazards during a major event. This data also plays a critical role in supporting the decision making process related to employee and public safety.

Prior to the events at Fukushima one Canadian nuclear power plant utility relied on manual collection and analysis of remote monitoring data, which did not cover sufficient area, with infrastructure that was not robust enough for large scale disasters. In mid-2012, the utility Emergency Plan Programs initiated several enhancements to its remote monitoring program. The enhanced monitoring system consists of an automated gamma monitoring system with monitors in place within site boundaries as well as various locations within the primary zone (up to 10 km) to monitor radiological releases. The off-site radiological monitoring consists of fixed gamma monitors, deployable gamma monitors and air samplers. Real time information is available to Emergency Response staff and response organizations such as Health Canada, Office of the Fire Marshal and Emergency Management and the Canadian Nuclear Safety Commission (CNSC). Thermoluminescent dosimeters are located inside the site fence and within a 10 km radius of the site.

Primary data transmission is via the cellular network, with back-up satellite capability. Data storage and external data access is provided through a remote off-site third party data storage network with appropriate cloud security and backup power and storage facilities.

Nu-PathNET® (EM), a radiological monitoring database and analytical software application is utilised to consolidate all remote monitoring data and support emergency event response functions.

An additional nuclear power plant developed a Radiation Boundary Monitoring System (RBM) which consists of 16 fixed boundary gamma detectors radially arranged 1KM around the site proper. These detectors transmit via cellular repeaters directly into the MCR and can be viewed remotely by all ERO staff. The RBM devices are solar powered with battery back-up.

Another utility uses automated remote monitoring within the site boundary. Manual monitoring is performed within the remainder of the 10Km Detailed Planning Zone.

Supplemental Files: None

Anticipated Benefits: The enhanced remote monitoring network in conjunction with Nu-PathNET® (EM) analytical software will provide operational improvements and increased efficiency to the utility's emergency response processes. Implementation of the remote monitoring network will reduce personnel exposure in an emergency event, enhance the quality of monitoring data reported, eliminate opportunities for human error and increase speed of data the utility is required to disseminate to government entities and the public. The implementation of automated monitoring equipment and associated software allow response times to be extended and staff resources to be used to respond during emergency events.

The events described in this lesson learnt occurred: Canada from April 2011 to September 2012

Lesson Learnt: CA-06 Emergency Satellite Communication System (ESCS)

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Emergency Operations Facility
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	**Communications Equipment**
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

In 2017, one Canadian nuclear power plant moved forward with efforts to implement enhancements to the utility's on-site and off-site emergency communications capabilities to encompass lessons learned from the events at Fukushima Daiichi and Daiini in 2011. A fixed-site satellite communications system was selected to fulfill this purpose referred to as the Emergency Satellite Communication System (ESCS).

The ESCS provides independent backup capabilities for on-site and off-site communication during station blackout (SBO) and other beyond design basis accidents (BDBA) in support of the nuclear power plant Nuclear Emergency Response Plan

At each required location, ESCS provides data and voice communication capability through

the use of fixed-site satellite phones and deployable/fixed VSAT (Very Small Aperture Terminal) dishes. ESCS acts as one of three methods of emergency communication and provides multiple phone hubs and Internet connectivity to emergency cloud applications for station Emergency Operations Centers (EOC).

Another nuclear power plant has adopted the approach of utilizing fixed satellite systems in the MCR, Security and Off-site Emergency Operations Centers. All other on-site facilities have satellite phones which provide mobile coverage.

Another utility uses portable satellite phones as backup communications method in the main control rooms, Site Management Centres, Corporate Emergency Operations Facilities and Crisis Management and Communication Centre.

This utility has also implemented capability to restore site communication in a BDBE with extended loss of AC Power, but the systems are portable. This system provides a range of functionality: Satellite, radio and 4G data.

Supplemental Files: None

Anticipated Benefits: VSAT technology uses satellite connectivity to support multiple phone hubs and Internet connectivity in both a stationary and mobile setting, allowing for versatility and ease in maintaining uninterrupted connectivity. This approach will allow for continued, uninterrupted information and data transmission to off-site and mobile Emergency Command Centers (EMC) and external agencies in the event of primary communications infrastructure challenges during large-scale events when plant systems and environments could be challenged.

The events described in this lesson learnt occurred: Canada from April 2011 to April 2017

Lesson Learnt: CA-07 - Unified RASCAL (Radiological Assessment System for Consequence Analyses) Interface (URI)

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Emergency Operations Facility
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

Prior to 2015 the software used by utilities and Province of Ontario (Office of the Fire Marshal and Emergency Management) to calculate off-site radiological conditions and inform protective actions as defined in the Provincial Nuclear Emergency Response Plant (PNERP) was designed to address design basis accidents (DBA) and single-unit accidents. The software had limited capabilities for beyond design basis accidents (BDBA) and multi-unit events.

Lessons learned from the Fukushima Daiichi Nuclear Power Plant demonstrated the need to provide dose projection capabilities for multi-unit events. In order to enhance the approach to plume dispersion modelling during BDBAs and multi-unit events, the nuclear power plant utilities in Ontario selected the Unified RASCAL Interface (URI) to replace the previous dose projection tool. The URI tool was developed in the United States through a partnership of Entergy and Exelon. The interface provides site-specific overlay of meteorological, dispersion, and dose assessment models.

Supplemental Files: None

Anticipated Benefits: The Unified RASCAL Interface (URI) tool will be used to project doses and support decisions to implement or not implement protective measures of the public after a nuclear event as defined by the Provincial Nuclear Emergency Response Plan. It will provide site-specific overlay of meteorological, dispersion, and dose assessment models and provide multi-unit dose assessment capability allowing the summing of up to five separate releases from separate release points. The tool will allow for source term back calculation, allowing operators to adjust model projections even with limited in-plant data.

The events described in this lesson learnt occurred: Canada from April 2011 to September 2012

Lesson Learnt: CA-08 Web Emergency Operating Centre (WebEOC)

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Emergency Operations Facility
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description

Canadian nuclear power plants' review of post Fukushima lessons learned indicated a need to enhance the organizations ability to effectively communicate information with external agencies, most importantly Ontario's Office of the Fire Marshal and Emergency Management (OFMEM) and Canadian Nuclear Safety Commission (CNSC), during a broader scope of extreme events than had previously been considered. It was determined the following information needed to be included:

- General situation and plant status.
- Necessary unit specific information for units in an emergency state.
- Location and magnitude of any off-site releases should they occur.

In 2012, the nuclear power plants implemented WebEOC, an emergency management software application, as the primary means to effectively manage an emergency response to any or all hazards. The application is used by all Emergency Response Organization Command staff to ensure interoperability and management of strategic objectives, strategies, and tactics. The application also provides a forum for situational awareness through sharing of emergency response information internally between command centers on-site as well as with specific external stakeholders. This system is operated within the nuclear power plant's Emergency Management Center (EMC), which maintains back-up power and communications capabilities at all times to ensure sustained operation when local infrastructure is challenged.

Supplemental Files: None

Anticipated Benefits: During an Exercise at nuclear power plants, WebEOC proved highly effective at allowing information entered at the source to be effectively and easily shared with multiple agencies through Internet access.

The events described in this lesson learnt occurred: Canada from April 2011 to September 2012

Czech Republic

Lesson Learnt: CZ-01 – Provision of Mobile Diesel Generators (MDG)

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Emergency Operations Facility
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	Fire brigade, DELTA team

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description

In case of loss of power supply for 6 kV bus bars of emergency power supply (BV, BW, BX) supplied also from reserve diesel generators - DGs (QV, QW, QX) or emergency station blackout SBO DGs (0QZ, 7QZ) it is necessary to recover power supply for required consumers (valves, Instrumentation and Control (I&C) measurement, Post Accident Monitoring System - PAMS). For this reason, mobile diesel generators KOHLER SDMO were purchased as the last option for power supply of the most important systems and components. Parameters of the mobile DG (MDG) are the following: type D440 SILENT, power 440 kVA / 352 kW STBY, Voltage 3x400 V AC and rated frequency 50 Hz.

Mobile DG 4 x 352 kW (one per unit), voltage 3x400 V AC

The primal goal of the MDG is power supply for I&C systems. 1 MDG per each unit is available at both Czech power plants (Dukovany, Temelin). When needed, the mobile DGs are transported by fire brigade to location of operation (together with cable car), cables are emplaced by DELTA team (Special emergency team dedicated for local actions) between the MDG and bus bars and using these cables MDG is connected to the relevant bus bars by inspection electrician and operational electricians. As a support for nuclear power plant personnel, detailed procedures describing the process of transport, preparation and connection of MDG were developed.

Contribution of the modification to nuclear power plant safety was confirmed by probabilistic safety assessment (PSA) analysis and feasibility of the required actions was proved during regular training.

Supplemental Files: https://www.energygeneratorsales.co.uk/sdmo-generator-sales/product-detail/sdmo-d440-440kva352kw-three-phase-industrial-silent-diesel

Anticipated Benefits: Installation of mobile DGs is one of many provisions implemented as a part of post-Fukushima national action plan. Implementation of this modification contributes to increased redundancy and diversity to ensure the key safety functions. Mobile devices may be considered as another level of defense in depth.

The events described in this lesson learnt occurred: Czech Republic, 2014 - 2019

Note: Text in brackets [ ] added to submittal by Task Group for clarification.

Lesson Learnt: CZ-02 – Enhancement of Communication Equipment

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Emergency Operations Facility
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description

The challenge was to ensure communication between emergency services inside and outside Czech nuclear power plants (Dukovany and Temelin) in case of damage of standard telecommunication infrastructure (e.g. seismic event followed by station blackout).

The possible problem with communication inside the nuclear power plant was solved by purchasing field phones and radio stations including necessary infrastructure. For using field phones, it was necessary to install telephone switchboard inside the shelters located at Czech nuclear power plants (Dukovany and Temelin), to prepare cable lines inside buildings and to install connection points. Furthermore, antenna systems (together with necessary cables) were installed as a part of radio stations.

Communication outside the nuclear power plant was solved by purchasing satellite phones and installation of GSM (Global System for Mobile Communications) repeater in the nuclear power plant's shelters including installation of antenna system. Furthermore, backup charging devices dedicated to charging of satellite phones and radio stations were provided in the shelters as well.

Functionality and contribution of the new devices was proved during regular emergency trainings.

Field phones

Radio stations

Antenna systems

Satellite phones

Charging devices and transmitters

Supplemental Files: None

Anticipated Benefits: Installation of alternative communication means is one of many provisions implemented as a part of post-Fukushima national action plan. Implementation of this modification is in agreement with emergency preparedness conception to enable cooperation and communication between all emergency services taken part in emergency management in case of damage of standard telecommunication infrastructure.

The events described in this lesson learnt occurred: Czech Republic, 2012 - 2013

Note: Text in brackets [ ] added to submittal by Task Group for clarification.

Lesson Learnt: CZ-03 – New Backup (Diverse) and Alternate (Mobile) Emergency Response Center

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Emergency Operations Facility
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	Technical Support Center personnel

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description

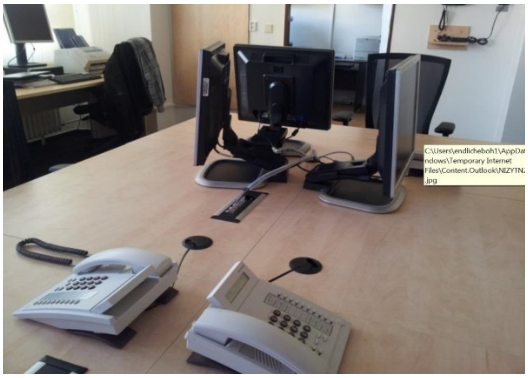
Backup (diverse) and alternate (mobile) emergency response center were established at nuclear power plants in the Czech Republic. The aim, based on the National Action Plan - item 59, was to ensure the functionality of the emergency response organization components even in the case that the „design" ECC (emergency control center at the nuclear power plant) is unavailable or for the members of emergency response organization there is not possible to get onto the site. The aim is to provide an alternative way of managing extraordinary events in case of loss of design basic emergency control center, control center of physical protection and control center of fire protection). At the same time, it is a solution for concealing shift staff and fire brigade personnel and their equipment in case of unavailability of covers, respectively fire brigade buildings, i.e. in site isolation mode for 72 hours.

The backup (diverse) control center of Emergency Response Organization for Temelín Nuclear Power Plant (in 2014) and Dukovany Nuclear Power Plant (in2015) were established in neighboring towns in the buildings in which the dosimetry situation in the nuclear power plant emergency planning zone is monitored.

In case that the both Emergency Response Centers - ERCs (basic and backup) are not available or not excessive from any reason, there is necessary to ensure the full functioning of the Emergency Response Organization (in the event of significant site destruction, when there is bad radiation situation etc.). To perform this task, three inflatable tents with accessories were purchased at Temelín and Dukovany Nuclear Power Plant (including generator, air-conditioning, heating, lighting, fuel supply, protective equipment, radiation protection, satellite phone, food and drink, etc.) This kind of tent is regularly used by army or integrated rescue forces during big disasters (fire, flooding, earthquake, etc.) in the Czech Republic. The air-inflated hall can be layout on proper place with respect the current radiation situation and meteorological conditions. Each tent is stored on a trailer, which can be transported by emergency response organization car or other vehicle to a designated location.

Each tent is equipped with a step by step manual so that the construction and installation of accessories can handle even by the no specialist persons.

Diverse Emergency Control Center (located in Moravsky Krumlov)



Alternative (Mobile) Emergency Control Center

Box Truck – (for transporting a tent)

Supplemental Files: None

Anticipated Benefits: Possibility to provide accident management and emergency response activities when the design bases emergency response center at the site is not available from any reason.

The events described in this lesson learnt occurred: Czech Republic, 2014 - 2017

Note: Text in brackets [ ] added to submittal by Task Group for clarification.

Lesson Learnt: CZ-04 – Improved Procedures for Diverse and Mobile Equipment & Emergency Operating Procedures

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Emergency Operations Facility
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	Fire brigade, DELTA team, TSC members

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description

One of the measures implemented at Czech nuclear power plants after the Fukushima Nuclear Power Plant accident was installation of Diverse and Mobile (DAM) equipment, which is intended to ensure basic safety functions, especially for long-term blackout events, also called Extended Loss of AC Power (ELAP) events, complete Loss of Ultimate Heat Sink (LUHS) events, combination of ELAP and LUHS, as well as multi-unit events. This new DAM equipment dramatically improved the ability of the plants to respond to all events leading to ELAP and LUHS caused by external hazards or other initiators.

Using the new DAM equipment required development of new specific procedures to extend the applicability of emergency procedures taking into account all states resulting from design basis accidents and as well as design extension conditions. The new DAM procedures are:

- DAM-1 Primary system injection
- DAM-3 Injection of feedwater into steam generator
- DAM-5 Initial assessment of nuclear power plant status and dislocation of mobile equipment*

- DAM-6 Emergency makeup of demineralized water tanks
- DAM-7 Loss of key parameters measurement
- DAM-8 Boron makeup into the reactor coolant system
- DAM-10 Hydroaccumulators isolation
- DAM-11 Spent fuel pool makeup
- DAM-12 Containment depressurization
- DAM-13 Switch from mobile equipment to design equipment
- DAM-14 Low pressure primary system injection

* Discussed further in the example below

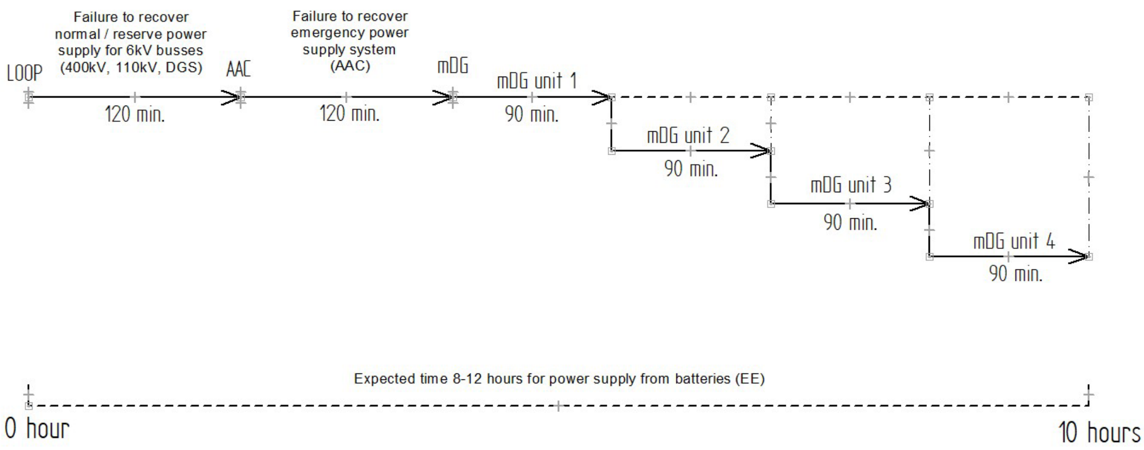
The corresponding links to specific DAM procedures were subsequently incorporated into the original Emergency Operating Procedures (EOPs / ECA-0.0, Blackout), Shutdown procedures (SD / SD-0, Shutdown blackout) and Severe Accident Management Guidelines (SAMG) to provide a comprehensive and interconnected structure of the emergency management documentation. Upgraded documentation to cover the events in the scope of design extension conditions lead to significant safety improvements in the area of accident management program implementation at Czech nuclear power plants.

Subsequently, a safety analysis of recovery of power supply to required electrical loads using mobile diesel generators, one MDG per unit, was performed by UJV (Czech Nuclear Power Engineering Company) using a probabilistic safety assessment (PSA) model. Two variants were considered in the analysis: (1) power supply recovery performed for one unit only and (2) power supply recovery performed sequentially for all four units (with available time 10 hours in total. Four different external hazards were considered in the analysis: (1) earthquake, (2) high winds, (3) extreme snowfall, and (4) extremely low temperatures. Expected time windows of specific manipulations were examined (i.e. measured during regular drill) and discussed with plant personnel. Task allocation, way of communication, and sequence of required actions were discussed with the relevant local operators. The following personnel were required to take a part in the scenario:

- Control room operators (3 per unit)
- Shift electrician (1 per nuclear power plant)
- Inspection electrician* (1 per nuclear power plant)
- Operational electrician (4 per nuclear power plant)
- Fire brigade
- DELTA team (Special emergency team dedicated for local actions, 4 per nuclear power plant)

* Discussed further under Recommendation 1, Staffing

UJV developed the following timeline to illustrate the sequence of the expected failures and required actions:



Failure probability of power supply recovery from MDG was calculated for "normal" conditions as well as for cases caused by external events.

Mobile DG 4 x 352 kW (one per unit), voltage 3x400 V AC

Supplemental Files: None

Anticipated Benefits: Upgrade of documentation to cover the events in the scope of design extension conditions leading to the significant safety improvement in the area of accident management program implementation at Czech nuclear power plants.

Based on the analyses describe above, two recommendations were formulated:

- Staffing

  In the case of a multiunit event, some problems to perform required actions by the inspection electrician in time may be expected, since there is only one inspection electrician per nuclear power plant. UJV recommended an increase in the number of inspection electricians or to share some of the responsibilities of this position with shift electricians, of which there are four per nuclear power plant.

- Procedures

  It was found that some of the required actions (e.g. transport of a heavy spool with cables from the ground floor to the second floor) may require increased number of personnel. It would be beneficial to state such information directly in DAM procedures to avoid any delays during emergencies.

The events described in this lesson learnt occurred: Czech Republic, 2014-2017

Note: Text in brackets [ ] added to submittal by Task Group for clarification.

Lesson Learnt: CZ-05 – New Extensive Damage Mitigation Guidelines (EDMG)

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Emergency Operations Facility
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	Fire brigade, DELTA team, TSC members

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description

Verification of flow paths availability and access under SBO conditions were included into so called "FLEX" approach (use of Diverse and Mobile equipment – "DAM"). Component parts of this approach were (1) justification and verification of selected approach and proposed measures, (2) development of "DAM" support guidelines and procedures and (3) development of Extensive Damage Mitigation Guidelines (EDMG).

Justification and verification of the capability of the newly implemented measures to perform the required functions, the capability of personnel to perform the required functions in the required time, and the adequacy of organizational measures were developed by assessing compliance with the following criteria:

- NEI 12-06, Diverse and Flexible Coping Strategies (FLEX) Implementation Guide
- WENRA Safety reference Levels for Existing Reactors, Issue F – Design extension Conditions.

With an external supplier the following procedures for use of DAM equipment have been developed in 2015 (FLEX and EDMG procedures):

- Guidelines for the use of DAM equipment (P003y): This guideline describes usage all mobile and portable equipment depend on unit parameters to recover long term stable plant status or mitigate emergency plant status – usage of these guidelines was incorporated to the Emergency Operating Procedures and Severe Accident Management Guidelines (SAMGs)
- Local manipulation sheets for the use of DAM equipment - (procedures P331 a P334) include detail description of measures in case of total loos of all means to ensure electric power (SBO – station blackout) or remove decay heat (LUHS - Loss of Ultimate Heat Sink).
- Requirements for operability of DAM equipment - (procedure B155j with the requirements for operability of DAM was implemented to ensure availability of DAM equipment)
- Guidelines for the response to significant damage of the site (EDMG) - (procedure P004y EDMG describes recovery of the plant in case of severe damage of plant infrastructure) There are described most important actions to keep nuclear safety, such as confirm reactor trip, to ensure core cooling, feeding SG, containment tightness and spent fuel pool cooling. Guideline also solves plant organization, leading and control role, setting of communication, and cooperation with secure services, fire brigade, radiological group and medicine care with accordance of Emergency Plan.

All these procedures were subject to the standard process of verification within the process of preparation of the documentation. Validation of the selected procedures has been performed by emergency exercises and drills. The procedures are included in regular training of the staff of the Technical Support Center - TSC, team of emergency director and operating shift

In addition, CEZ developed a more systematic methodology for identification of non-routine flow paths for delivery of coolant or providing power in case of severe plant damage. The results were included into Technical Support Guideline TSG-3, Site Capabilities that was added to SAMG package in frame of SAMG update in 2018 based on PWR OG project.

Supplemental Files: None

Anticipated Benefits: Upgrade of documentation to cover the events in the scope of design extension conditions leading to the significant safety improvement in the area of accident management program implementation at Czech nuclear power plants. New guidelines and upgrade of guidelines and procedures are in accordance with Post Fukushima National Action plan (based on National Report on Stress Tests of nuclear power plants Dukovany and Temelin, December 2011), item 53, 56, 59 and 77

The events described in this lesson learnt occurred: Czech Republic, 2014-2018

Note: Text in brackets [ ] added to submittal by Task Group for clarification.

France

Lesson Learnt: FR– 01 – Implementation of Operations Team Minimum Staffing

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description

The Fukushima accident showed the need to guarantee the autonomy of nuclear power plant staff, especially after extreme natural hazards when the plant can be isolated (e.g. Blayais in 1999 in France as well).

The post-Fukushima regulatory request (ECS35-I) was to ensure that all actions required are feasible despite extreme context and can be performed by qualified staff.

The nuclear operator developed a method focusing on operations (main control room (MCR) and field actors) in interface with national crisis teams, using simulator calculations for defining the timing and deadlines to perform critical actions to prevent loss of control: the goal was to establish the general time and staffing with sufficient margin to control situation. The nuclear operator conducted several exercises in 2014, 2015, 2016 on one or two MCR simulators on loss of coolant (LoC) and loss of electricity (LoE) scenarios that were controlled by the operations team. The nuclear operator assumed that the operation team could have to perform them all without support of local emergency teams for 24 hours. It led to adding one supervisor for the two operators in MCR by 2020; thus, chief and deputy of operation team are in charge of key decisions, safety control, and external interfaces.

To reduce the operations staff workload, some prioritization of operation actions should be introduced by modifying dedicated procedures but the diversity of situations due to unexpected scenarios limits this possibility. Thus, it is potentially leaving an important workload for the operations team in real time. The operations team workload has been adapted by changing roles and responsibilities as proposed by the operator. However, the exercises (mentioned above) highlighted the challenge of accumulating functions by the lead members of the operations team (chief, deputy and supervisor).

The exercises also showed also the multitude of influence factors on human actions in field (e.g. darkness) and the difficulty to translate them into quantitative analyses of time and staffing margins. In this domain, the implementation of post-Fukushima actions revealed that there is a lack of fundamental scientific and evidence-based data on the quantitative impact of influence factors on human actions performance. The conduct of risk analysis in case of extreme events may further show that design measures could be necessary to protect paths and workplaces to ensure that necessary actions could be performed.

Supplemental Files: None

Anticipated Benefits: Validation of staffing and timing margins through the use of realistic beyond-design-basis simulations will improve understanding of the needs that must be met for successful event mitigation and improve confidence in the operations team's capability to meet these demands.

The events described in this lesson learnt occurred: 2014 - 2016

Note: Text in brackets [ ] added to submittal by Task Group for clarification.

Japan

The Federation of Electric Power Companies (FEPC) responded to the Phase 2 information request in narrative format as an alternative to the template format seen elsewhere in this appendix. The following report is the FEPC response to the Phase 2 information request.

1. MITIGATION STRATEGIES (i.e. strategies for maintaining or restoring core cooling, containment, and spent fuel pool cooling capabilities)

Introduction

Until the Fukushima Nuclear Power Plant Accident, Japan's nuclear power plants had not credibly assumed the possibility of a severe accident caused by a beyond- design-basis external event. The Fukushima Nuclear Power Plant Accident made clear that nuclear power plants' chain of command was unclear, materials and equipment were lacking, and information sharing and communication was not swift and reliable in accident response at the time. Based on the lessons learned from the Accident, operators have been sorting out the important points in emergency response and improving emergency response capabilities.

The Fukushima Accident has made it clear that a phased approach is effective in accident response. Specifically, as shown in Diagram 1, resources can be used most effectively if the time since the occurrence of the accident is separated into three phases and accident response is implemented appropriately in each phase.

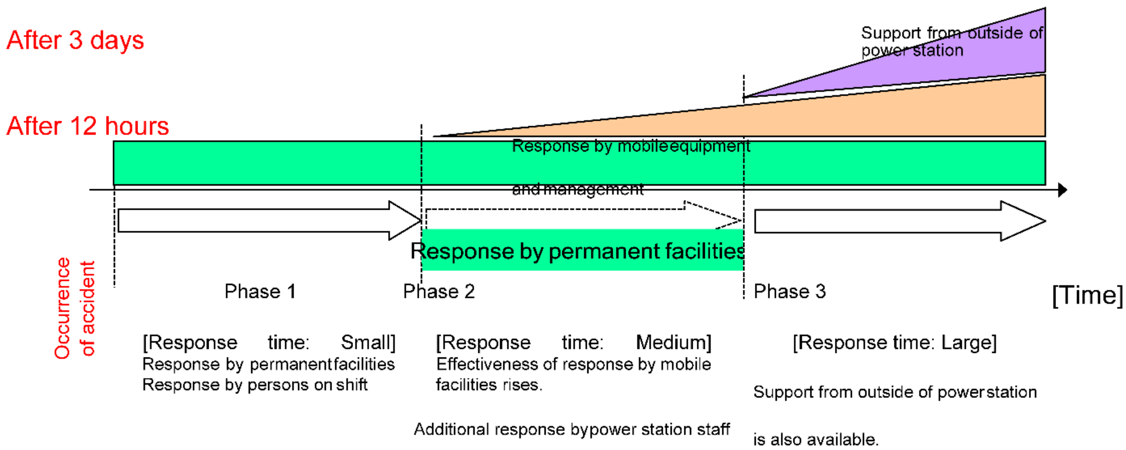
Phase 1 is defined as the time from the occurrence of the accident until 12 hours after the accident based on the experience gained in the Fukushima Accident. Phase 1 relies on response only by shift personnel and permanent facilities. This forms the fundamental requirements for safety facilities.

Phase 2 is defined as the period from 12 hours after the accident to 3 days from the occurrence of the accident. Staff that were at the station at the time of the accident can be expected to perform additional accident response measures in this phase. Additional response may be performed using the mobile equipment installed at the station.

Phase 3 is defined as the period from 3 days after the accident onwards. Offsite support can be relied upon in this phase.

Based on this phased approach, safety improvement measures from both structural and nonstructural viewpoints, including ERO staffing and manuals, are being discussed.

Diagram 1 Conceptual diagram of a phased approach in accident response



The following is an explanation of the equipment that has been strengthened since the Accident.

Core damage prevention measures

The three basic safety functions of commercial reactor facilities are to "stop", "cool" and "contain". There are measures in place to prevent significant damage to the core in case of a loss of function of facilities which is to respond to design basis accidents, regardless of cause. These measures are intended to eliminate unexpected events as a severe accident prevention measure from a defense in depth perspective.

Assuming a scenario in which the control rod does not operate correctly and emergency shut down fails despite these measures, there are other measures in place to bring the reactor to a subcritical state (stop) to prevent significant damage to the core.

Examples of measures are as follows.

- PWR - Install a diversification automatic actuation panel (ATWS mitigation facility) that will automatically actuate the auxiliary feedwater pump to inject a boric acid solution.
- BWR - Suppress reactor output via the recirculation pump trip function that will automatically stop the reactor coolant recirculation pump (RPT). Control reactivity via reactor SCRAM using the alternative rod injection function (ARI) independent of the reactor safety protection system and the independent standby liquid control system (SLC) that operates using a different principle from the reactor shutdown function that uses the control rod.

Regarding the "cooling" function, the highest level of reliability reasonably achievable is required for high pressure core spray pumps and other emergency core cooling facilities that cool the core in an accident. Assuming a scenario in which the emergency core cooling facility does not actuate and core cooling fails despite these measures, there are other measures in place to prevent significant damage to the core even when the cooling function of the design basis accident response facilities of the commercial reactor is lost while the reactor cooling pressure boundary is at high pressure.

Examples of measures are as follows.

- PWR - Even if all AC power is lost, the turbine-driven auxiliary feedwater pump can continue to inject water into the steam generator due to the recently deployed portable storage battery for the turbine-driven auxiliary oil pump. The primary system can be depressurized and cooled sufficiently by removing heat from the secondary cooling system.

- BWR - Install a high-pressure alternate injection system. The high-pressure alternate injection system and the reactor isolation cooling system can be actuated from the field when the high pressure injection system, which is a design basis accident response equipment, cannot be actuated due to the function loss of all AC power source and DC power source system and also the high-pressure alternate injection system cannot be actuated from the main control room.

There are also measures in place to prevent significant damage to the core when the depressurization function of the design basis accident response equipment of the commercial reactor is lost when the reactor cooling pressure boundary is at high pressure.

Examples of response measures are as follows.

- PWR - Deploy nitrogen cylinders and portable storage batteries. These resources can be used to ensure that the pressurizer relief valve can be actuated at all times so that the reactor coolant boundary depressurizing function can be maintained.
- BWR - Establish an alternate depressurization logic (alternate automatic depressurization function) for safety relief valves that will depressurize in response to a different signal than the automatic depressurization function. Deploy high pressure nitrogen gas cylinders and portable storage batteries to allow actuation of the safety relief valve anytime to maintain the reactor coolant boundary depressurization function.

There are also measures in place to prevent significant damage to the core even when the cooling function of the design basis accident response equipment of the commercial reactor is lost when the reactor coolant pressure boundary is at low pressure.

Examples of response measures are as follows.

- PWR - The reactor cooling function can be maintained by ensuring the filling pump can cool itself and establishing methods to inject water into the reactor via a mid-sized pumper truck or pressurized pumper truck.
- BWR - The reactor cooling function can be maintained by installing a portable low pressure alternate injection system and a permanent low-pressure alternate injection system (makeup water pump that does not require cooling of heat generated from equipment) to respond to scenarios in which there is no time before the core is significantly damaged.

As seen above, there are various equipment in place to cool the commercial reactor by reducing the pressure of the reactor coolant pressure boundary from high to low pressure state even when the safety functions of the commercial reactor with design basis accident response equipment are lost.

With regard to the "containment" function, there are equipment such as the containment vessel spray (equipment to reduce pressure and temperature inside of the containment vessel) in place in the containment vessel to secure the containment function. Even the equipment like this has the highest level of reliability that is reasonably achievable. Assuming that the containment spray does not function despite these measures, there are other measures in place to prevent significant damage to the core even when the design basis accident response equipment's cooling function of the primary containment vessel is lost.

Examples of response measures are as follows.

- PWR - The pressure and temperature inside the containment vessel can be reduced by spraying water into the containment vessel from the spray nozzle installed on the upper part of the vessel using the alternate containment vessel spray pump recently installed as an alternative to the containment vessel spray pump.
- BWR - The temperature and pressure inside the primary containment vessel can be reduced by installing an alternate containment vessel spray cooling system and spraying water from an external water source into the primary containment vessel.

There are measures in place to prevent significant damage to the core by preventing heat from accumulating in the core even if the design basis accident response equipment function of transferring heat to the final heatsink is lost.

Examples of response measures are as follows.

- PWR - Heat can be transferred to the final heatsink via natural convection cooling in the containment vessel by supplying seawater to the containment vessel recirculation unit through the reactor component cooling system using the recently deployed mid-sized pumper truck.
- BWR - Heat can be transferred to the final heatsink by installing the primary containment vessel filter vent system which removes the atmospheric gas in the primary containment vessel and releases it out into the atmosphere after reducing the levels of radioactive materials in the gas via the vent filter, and setting the alternate reactor component cooling system (comprised of the heat exchanger unit and the large capacity water truck).

The severe accident response equipment used in the measures described above were designed with different considerations compared to the design basis accident response equipment. Specifically, the permanent severe accident response equipment were designed so that their functions would not be lost at the same time as the safety functions for design basis accident response equipment are lost, aiming to prevent common cause failure. Design considerations are paid for portable severe accident response equipment, which include storing equipment in areas that are at least 100 m away from the reactor building so that they are not impacted by the same event, and deploying at least two sets of equipment, plus another set in case the standby equipment becomes unavailable.

Containment vessel damage prevention measure

There are containment vessel injection equipment and containment vessel cooling measures in place to reduce the pressure, temperature, radioactive material concentration in the containment vessel to prevent containment vessel damage.

Specific examples of countermeasures are shown below.

- PWR - The permanent alternate low pressure injection pump and portable alternate low pressure injection pump were recently deployed as a type of containment vessel injection equipment which sprays water into the containment vessel from the containment vessel spray line. Other recently established containment vessel cooling measures include passing seawater and coolant through the existing containment vessel recirculation unit.
- BWR - An alternate containment vessel spray cooling system (permanent) that uses the condensate transfer pump and an alternate containment vessel spray cooling system (portable) that uses the portable alternate injection pump to spray water into the primary containment vessel from the containment vessel spray header were recently deployed as containment vessel injection equipment. Measures to cool the primary containment vessel while maintaining the primary containment vessel boundary through the alternate circulation cooling system via the condensate transfer pump, and measures to cool the primary containment vessel by releasing the primary containment vessel pressure into the atmosphere were recently established as containment vessel cooling measures.

In addition to these containment vessel damage prevention measures, difference specific measures have been implemented for each of the phenomena that are known to lead to containment vessel damage. Specifically, measures have been developed for ① phenomenon in which the heat of the molten core corrodes the concrete because the molten core falls into the lower part of containment vessel (molten core concrete interaction (MCCI)), ② phenomenon where the temperature and pressure rise rapidly as the containment vessel atmosphere is directly heated by the molten core as a result of the molten core being released when the containment vessel is at high pressure (direct containment heating (DCH)), ③ phenomenon where the hot fuel cladding tube and water reacts each other and leads to a hydrogen explosion.

Examples of specific measures are listed below.

① MCCI countermeasures

- PWR - The permanent alternate low pressure injection pump described above can be used to spray water into the containment vessel and cool the molten core as it falls into the containment vessel, in order to prevent containment vessel damage. Some plants have separately deployed a pump that can directly inject water into the cavity in the lower part of the reactor. As a result, water can be injected directly into the lower part of the containment vessel and the area cooled at an early stage in the event. If the reactor cooling function is lost and there is significant core damage, water can be injected into the core using the permanent alternate low pressure injection pump described above to delay or prevent the molten core from falling into the lower part of the containment vessel.
- BWR - The alternate containment vessel spray cooling system (permanent) or the alternate containment vessel spray cooling system (portable) described above can be used to spray water into the primary containment vessel, cool the molten core that has fallen into the primary containment vessel, in order to prevent containment vessel damage. This will allow water to be injected directly into the lower part of the primary containment vessel and the area cooled at an early stage in the event. The suppression of molten core inflow into the dry well sump in addition to the actuation of the lower primary containment vessel injection equipment should suppress the corrosion of concrete on the bottom of the sump and prevent contact between the molten core and the primary containment vessel boundary (steel liner). To this end, a corium shield composed of heat resistant materials was recently installed. Additionally, if the reactor cooling function is lost and the core sustains significant damage, water will be injected into the core using the low-pressure alternate injection system (permanent) to delay or prevent the molten core from falling into the lower part of the primary containment vessel.

② DCH countermeasures

- PWR - The release of high pressure melt when the reactor pressure vessel is damaged can be prevented by forcefully depressurizing the primary cooling system through the release of the existing pressurizer relief valve. In releasing the pressurizer relief valve, support systems such as the control air are necessary. Even if these support systems are lost, the opening and closing functions can be recovered by using the recently deployed alternate control air supply equipment.
- BWR - The release of high pressure melt when the reactor pressure vessel is damaged can be prevented by rapidly depressurizing the reactor pressure vessel through the release of the existing pressurizer relief valve. In releasing the safety relief valve, support systems such as the accumulator for the relief valve full of nitrogen is necessary. Even if these support systems are lost, the opening and closing functions can be recovered by using the recently deployed high pressure nitrogen gas cylinders.

③ Hydrogen explosion countermeasures

- PWR - A hydrogen combustion device and a passive autocatalytic recombiner (PAR) were recently installed. These can reduce hydrogen concentration and prevents a hydrogen explosion in the containment vessel. To prevent a hydrogen explosion that may impact the soundness of the annulus even if hydrogen leaks from the containment vessel to the annulus, the hydrogen that has leaked into the annulus will be removed via the existing annulus air recirculation equipment. To operate the hydrogen exhaust valve in the annulus, support systems such as the control air are necessary. Even if these support functions are lost, the opening and closing functions can be recovered using the recently deployed nitrogen cylinders. The hydrogen concentration in the containment vessel can also be measured and monitored using the recently installed portable hydrogen concentration measuring instrument.

- BWR - The plant will ensure that the hydrogen and oxygen concentrations will not reach the combustible range by inactivating the atmosphere inside the primary containment vessel when starting up the reactor. Measures were put in place to release the air within the primary containment vessel via the primary containment vessel pressure relief device if the hydrogen concentration and the oxygen concentration in the primary containment vessel rises. A passive autocatalytic recombiner (PAR) was recently installed in the reactor building to prevent a hydrogen explosion that may impact the soundness of the reactor building. The hydrogen concentration and oxygen concentration within the primary containment vessel can be measured and monitored via the recently installed containment vessel hydrogen concentration meter and the primary containment vessel oxygen concentration meter.

The severe accident response equipment used in the measures described above were designed with different considerations compared to the design basis accident response equipment. Specifically, the permanent severe accident response equipment were designed so that their functions would not be lost at the same time as the safety functions for design basis accident response equipment are lost, aiming to prevent common cause failure. Design considerations are paid for portable severe accident response equipment, which include storing equipment in areas that are at least 100 m away from the reactor building so that they are not impacted by the same event, and deploying at least two sets of equipment, plus another set in case the standby equipment becomes unavailable.

Fuel damage prevention measures in the spent fuel storage tank

Equipment to inject water into the spent fuel storage tank and to control the outflow of coolant are in place to maintain the appropriate water level within the spent fuel storage tank, and to cool the fuel bodies and shield radiation from the fuel bodies. Spent fuel storage tank cooling equipment are in place in preparation for the event that sufficient water levels cannot be secured for the spent fuel storage tank.

Examples of specific countermeasures are shown below.

- Common for BWR and PWR

  The portable alternate injection system (pumper truck and hose) has been recently deployed as a spent fuel storage tank injection equipment. The siphon breaker has been recently deployed as a equipment to control the outflow of coolant from the spent fuel storage tank. A portable spray system (pumper truck, hose, spray header) has been recently deployed as a spent fuel storage tank cooling equipment for when sufficient water levels cannot be secured for the spent fuel storage tank.

Fuel damage prevention measures in a shutdown reactor

Reactor injection equipment have been developed to secure reactor water levels in a shutdown plant, to maintain cool fuel bodies and shield radiation from the fuel bodies.

Specific examples of countermeasures are as follows.

- PWR - Multiple reactor injection measures such as the establishment of the self- cooling of the filling pump and deployment of a mid-sized pumper truck and pressurize pumper trucks have been recently established.
- BWR - A portable low pressure alternate injection system has been developed and a permanent low-pressure alternate injection system (a makeup water pump that does not require cooling itself) has been recently installed to respond to scenarios where there is no time before core damage.

Equipment to transfer heat to the final heatsink have been recently deployed in preparation for the loss of design basis accident response equipment function to transfer heat to the final heat sink.

Examples of specific countermeasures are shown below.

- PWR - Developed a new method to transfer heat to the final heatsink via containment vessel natural convection cooling by supplying seawater to the containment vessel recirculation unit via the reactor component cooling system using the mid-sized pumper truck that was recently deployed.
- BWR - Developed a new method to transfer heat to the final heatsink by installing an alternate reactor component cooling system (comprised of a heat exchanger unit and large capacity water truck).

2. OTHER PROCEDURES AND GUIDELINES (to manage other elements of event or emergency response not directly supporting the implementation of mitigation strategies)

1. Development of procedures related to severe accident response equipment

a. Ease of switching - Procedures necessary for swift system reconfiguration are to be developed for equipment that is repurposed as severe accident response equipment in severe accidents. Training is to be conducted to ensure these procedures can be implemented steadily.

b. Secure access routes - Effective operation management is to be conducted so that, should a severe accident occur, the roads and passageways in the station can be secured to transport portable severe accident response equipment or to assess damages done to other equipment.

Specific examples include:

① Secure multiple access routes and their detours to ensure portable severe accident response equipment can be transported and equipment damage assessed, should a severe accident occur

② Store heavy machinery such as wheel loaders capable of removing obstacles on site premises and secure personnel who can operate such heavy machinery

To prepare for the beyond design basis natural disasters in which securing an access route may prove difficult, multiple access routes including detours are secured; depending on the damage, the access route that can be recovered earlier will be chosen from the multiple options.

2. Response related to recovery work

a. Secure spare parts - Appropriate spare parts and tools to replace damaged parts are to be secured for major safety facilities equipment and parts that are replaceable.

Specific examples include:

① Set priorities and conduct recovery work for replaceable equipment and parts in safety critical facilities. Secure necessary spare parts and tools for exchanging parts.

② Secure necessary spare parts and continue to discuss effective recovery measures.

b. Secure storage locations - Spare parts described in a) are to be stored dispersedly in multiple locations that are unlikely to be impacted by external events such as slope failure due to earthquakes, and inundation due to tsunamis.

c. Secure access routes - Effective operation management is to be conducted so that, should severe accidents occur, station roads and passageways that can serve as access routes for recovery work can be secured.

3. Response to support

a. The station policy is to be able to maintain accident containment response measures for at least seven days after the day of the accident using the severe accident response equipment, spare parts, and fuel stored in the station.

b. The station is to formulate a plan for obtaining external support based on discussions and the agreement with relevant parties including plant manufacturers, contractors, fuel supply companies, and other nuclear operators.

c. The station plans to receive assistance from outside within seven days of the event occurring, such as equipment equivalent to on-site severe accident response equipment, spare parts, and fuel, all of which are stored outside the station.

4. Development of procedures, implementation of training, and developing a structure

a. Development of procedures

Procedures are to be developed beforehand, training conducted on personnel, and a structure developed to secure necessary personnel in order to be able to respond to severe accidents flexibly and appropriately.

Specific examples include:

① Gathering information and formulating decision criteria

In severe situations such as station blackout, permanent DC power loss, multiple failures of safety system equipment or instruments, and simultaneous damage incurred to multiple reactors, the state of commercial power generating reactor facilities need to be assessed and decisions made for severe accident response measures to be implemented. To that end, develop procedures including clear decision criteria, types of information necessary and ways to obtain said information so that necessary information can be gathered swiftly.

② Clarifying decision criteria for setting priorities in operations

Develop procedures that clearly stipulate decision criteria for operations such as the use of seawater that should be prioritized to prevent significant damage to the core or the containment vessel failure.

③ Policy of prioritizing safety over protecting property (i.e. facilities)

- The President issues a policy of prioritizing safety over protecting property (i.e. facilities) so that personnel can develop a common base of understanding on safety and behave accordingly.
- Include decision criteria crafted based on the policy of prioritizing safety over protecting property (i.e. facilities) in procedures so that the Deputy Shift Supervisor can issue directions without hesitation.
- The station emergency response headquarters general manager makes decisions following the policy of prioritizing safety over protecting property (i.e. facilities); Develop an emergency response headquarters procedures whose decision-making criteria is based on the policy of prioritizing safety over protecting property (i.e. facilities).

④ Clarify procedure configuration and criteria for transitioning between procedures

- Develop procedures for operators and support organizations to implement specific severe accident response following accident progression.
- Clearly stipulate in the operating procedures about which procedures should be followed in which order according to accident progression, and clarify the criteria for when to transition between procedures.

⑤ Development of procedures related to status monitoring and accident progress prediction

- Select parameters that need to be monitored to respond to severe accidents; list said parameters in operation procedures and emergency response headquarters procedures.
- Organize parameters whose behavior needs to be predicted, items that require impact assessments, and parameters to be monitored in implementing severe accident response measures in the emergency response headquarters procedures.
- Include effective information identified in the effectiveness assessment in the operating procedures used by operators as well as the emergency response headquarters procedures used by emergency response personnel.

⑥ Development of response procedures for early signs

- Review measures to maintain safety functions of facilities and accident prevention measures to see if there are early indications of malfunction that can be identified and if such malfunction could trigger severe accidents
- Develop a structure and procedures that allow for early response when early signs are identified.
- Stipulate in procedures that the reactor should be generally shut down and cooling operations be started if a large tsunami alarm is issued.

b. Conducting training

The following are examples of implementing training.

① Education and training policy

Conduct education and training to increase personnel knowledge of commercial nuclear reactor facilities behavior in severe accidents as a wide variety of severe accident response measures are required depending on the state of the commercial nuclear reactor facility.

② Education to increase knowledge-based understanding and comprehensive exercises

Periodically conduct education to increase knowledge-based understanding of each role assigned to the personnel e.g. education on severe accidents and fundamental response methods.

Plan periodic training for the situation where emergency response personnel working on the field and operators need to cooperate to go through the sequence of response measures, and arrange exercises to comprehensively confirm the effectiveness of supporting organizations.

③ Maintenance training

Have employees conduct maintenance and inspection activities and develop experience exchanging parts to gain more knowledge of the commercial nuclear reactor facility and spare parts.

④ Training assuming high dose conditions

Conduct accident response training assuming high dose conditions, night time and inclement weather.

⑤ Preparations to ensure manuals are readily available

Ensure through maintenance and inspection activities that information and manuals on facilities and equipment are readily available. Conduct accident response training using such information and manuals.

c. Developing a structure

The following are examples of developing a structure.

① Allocation of roles and clarifying the party responsible

- Allocate clear roles to organizations implementing the severe accident response measures and the support organizations providing support to the implementing organizations. Designate the responsible party for each.
- Formulate work teams considering the expertise and experience of each personnel.
- Clarify the chain of command and develop a structure that makes effective implementation of severe accident response measures possible.

② Configuration of the implementing organization

The organization implementing the severe accident response measures will consist of the following teams. Roles will be allocated accordingly and a structure will be developed that allows for the smooth implementation of severe accident response measures.

- Shift (operators) that will implement operations related to accident impact mitigation and escalation prevention. A unit team that will provide information needed to select appropriate response measures to the shift (operators).
- Recovery team that will operate the portable severe accident response equipment related to accident impact mitigation and escalation prevention and recover malfunctioning equipment
- Self-defense fire brigade to conduct fire extinguishing activities

③ Response to situations where multiple reactors are damaged

- The general manager of the station response headquarters will set forth an action policy when severe accidents occur at multiple reactors. The Unit chief designated for each reactor will implement severe accident response measures by providing advice for operations related to accident impact mitigation and escalation prevention for the relevant reactor, overseeing response using portable severe accident response equipment and supervising recovery of malfunctioning equipment.
- Constantly secure station necessary emergency response personnel at the plant and develop a structure that allows the personnel to respond appropriately even when multiple reactors are damaged simultaneously.

④ Configuration of the supporting organization

- Create 1) a engineering support organization that provides technical advice to the implementing organization and 2) an operation support organization that will develop an environment where the implementing organization can concentrate on severe accident response, as support organizations for the station response headquarters.
- The engineering support organization will be comprised of a team that gathers information necessary for accident response, predicts and assesses plant state progression, and a team that measures radiation and radioactivity in and outside the station and controls exposure.
- The operation support organization will be comprised of a team that gathers external response information, a team that serves as a contact point for external relevant organizations, a team that centrally manages procurement and transport, and a team that supports the operation of the station response headquarters.

⑤ Setting up the response headquarters and gathering personnel

- A Plant General Manager (manager of nuclear disaster response) will establish a station response headquarters with an implementing organization and supporting organizations within it.
- Emergency response personnel, operators, and self-defense fire brigade will always be on site premises when the plant is in operation to ensure swift response should a severe accident occur at night time or on weekends (outside of working hours on weekdays).

(For multiple units)

There should be approximately 40 emergency response personnel, approximately 20 operators, and 10 members of the self-defense fire brigade for a total of 80 personnel constantly being at the station. A total of 180 personnel should be able to be gathered within 10 hours of an event occurring. An additional 40 emergency response personnel should be secured within 6 hours of the eventoccurring.

- Conduct periodic communication training based on a predetermined contact structure to ensure necessary personnel can be gathered even at night time and on weekends (outside of working hours on weekdays) in emergencies.

  The emergency response personnel structure should be managed appropriately to prepare for the eventuality that there is a vacancy. If a vacancy cannot be filled, the reactor needs to shift to an operational state where safety can be secured with the existing number of personnel, e.g. stopping a reactor.

⑥ Clarifying the division of roles for each team and the person responsible Clarify the functions of teams mentioned in ⑤ above and appoint team leaders and their proxies as the parties responsible for implementing response measures and for supervising other teams under their control.

⑦ Clarifying the chain of command and proxies

Clarify the chain of command in the station response headquarters ,appoint proxies, and define the order of succession for when the commander is unavailable.

⑧ Preparation of facilities for effective implementation of measures

- Set up an emergency response center equipped with communication facilities (including a TV conferencing system) that allows communication inside and outside the station and connects to the integrated nuclear disaster response network in order for the implementation organization and support organization to implement their assigned roles.
- Equip the emergency response center with mobile communication facilities to coordinate response between the field and the main control room emergency response center.

⑨ Providing information outside and inside the station

Develop a structure whereby the station can provide information widely through a communication system that can connect to the integrated nuclear disaster response network and the satellite phone facilities in order to contact organizations inside and outside the station on the status of reactor facilities and the implementation of severe accident response measures.

⑩ Development of external support structures

- Develop structures such as a head office response headquarters for when a nuclear emergency situation is declared in order to smoothly receive support from outside the station.
- The head office response headquarters will be comprised of a team that will review and formulate station recovery methods, a team that willshare information within the head office response headquarters, a team that will assess the state and progression of the accident, a team that will assess the amount of radioactive materials emitted, a team that will communicate with relevant authorities, a team that will respond to PR inquiries, a team that will provide support to the station in siting region response, a team that will recover communication facilities and secure support, a team that will improve the workplace environment of the station, a team that will support the development of an on-site medical base, a team that will procure and transport materials necessary for station recovery, a team that will establish and operate the nuclear disaster response support base, a team that will request support from authorities, and a team that will coordinate support received

from other nuclear utilities. The head office response headquarters will provide technical and operational support to ensure that the station response headquarters can concentrate on accident response.

- The head office response headquarters will establish a nuclear disaster response support base and develop a structure whereby they can receive engineering support from other nuclear utilities and from the nuclear emergency situation support organization.
- The head office response headquarters will mobilize not only the nuclear division but other divisions so that nuclear emergency response measures can be implemented as a companywide initiative.

⑪ Development of a structure for mid-to long term response after the accident

- To prepare for situations in which mid-to long term response is required after a severe accident, develop a structure to implement appropriate and effective responses in coordination with relevant organizations internal and external.
- Should a severe accident occur, implement measures to reduce radioactivity levels and process contaminated water that includes radioactive materials leveraging the experiences and knowledge gained in the Fukushima Daiichi Nuclear Power Station Accident. Continue to maintain the cooperative relationships with various organizations in normal times so that necessary response measures can be discussed together after an accident to smoothly bring things under control.

3. STAFFING

Necessary personnel structures are to be developed and periodically assessed so that station maintenance activities can be conducted should a severe accident occur or large-scale damage be incurred. Necessary measures are to be implemented following this assessment.

Specific examples of structure development are as follows.

(Same as "2. Other procedures and guidelines, (4) Development of procedures, implementation of training, and developing a structure, c. Developing a structure")

① Allocation of roles and clarifying the party responsible

- Allocate clear roles to organizations implementing the severe accident response measures and the support organizations providing support to the implementing organizations. Designate the responsible party for each.
- Formulate work teams considering the expertise and experience of each personnel.
- Clarify the chain of command and develop a structure that makes effective implementation of severe accident response measures possible.

② Configuration of the implementing organization

The organization implementing the severe accident response measureswill consist of the following teams. Roles will be allocated accordingly and a structure will be developed that allows for the smooth implementation of severe accident response measures.

- Shift (operators) that will implement operations related to accident impact mitigation and escalation prevention. A unit team that will provide information needed to select appropriate response measures to theshift (operators).
- Recovery team that will operate the portable severe accident response equipment related to accident impact mitigation and escalation prevention and recover malfunctioning equipment
- Self-defense fire brigade to conduct fire extinguishing activities

③ Response to situations where multiple reactors are damaged

- The general manager of the station response headquarters will set forth an action policy when severe accidents occur at multiple reactors. The Unit chief designated for each reactor will implement severe accident response measures by providing advice for operations related to accident impact mitigation and escalation prevention for the relevant reactor, overseeing response using portable severe accident response equipment and supervising recovery of malfunctioning equipment.
- Constantly secure station necessary emergency response personnel at the plant and develop a structure that allows the personnel to respond appropriately even when multiple reactors are damagedsimultaneously.

④ Configuration of the supporting organization

- Create 1) a engineering support organization that provides technical advice to the implementing organization and 2) an operation support organization that will develop an environment where the implementing organization can concentrate on severe accident response, as support organizations for the station response headquarters.
- The engineering support organization will be comprised of a team that gathers information necessary for accident response, predicts and assesses plant state progression, and a team that measures radiation and radioactivity in and outside the station and controls exposure.
- The operation support organization will be comprised of a team that gathers external response information, a team that serves as a contact point for external relevant organizations, a team that centrally manages procurement and transport, and a team that supports the operation of the station response headquarters.

⑤ Setting up the response headquarters and gathering personnel

- A Plant General Manager (manager of nuclear disaster response) will establish a station response headquarters with an implementing organization and supporting organizations within it.
- Emergency response personnel, operators, and self-defense fire brigade will always be on site premises when the plant is in operation to ensure swift response should a severe accident occur at night time or on weekends (outside of working hours on weekdays).

  (For multiple units)

  There should be approximately 40 emergency response personnel, approximately 20 operators, and 10 members of the self-defense fire brigade for a total of 80 personnel constantly being at the station. A total of 180 personnel should be able to be gathered within 10 hours of an event occurring. An additional 40 emergency response personnel should be secured within 6 hours of the eventoccurring.
- Conduct periodic communication training based on a predetermined contact structure to ensure necessary personnel can be gathered even at night time and on weekends (outside of working hours on weekdays) in emergencies.

The emergency response personnel structure should be managed appropriately to prepare for the eventuality that there is a vacancy. If a vacancy cannot be filled, the reactor needs to shift to an operational state where safety can be secured with the existing number of personnel, e.g. stopping a reactor.

⑥ Clarifying the division of roles for each team and the person responsible Clarify the functions of teams mentioned in ⑤ above and appoint team leaders and their proxies as the parties responsible for implementing response measures and for supervising other teams under their control.

⑦ Clarifying the chain of command and proxies - Clarify the chain of command in the station response headquarters, appoint proxies, and define the order of succession for when the commander is unavailable.

⑧ Preparation of facilities for effective implementation of measures

- Set up an emergency response center equipped with communication facilities (including a TV conferencing system) that allows communication inside and outside the station and connects to the integrated nuclear disaster response network in order for the implementation organization and support organization to implement their assigned roles.
- Equip the emergency response center with mobile communication facilities to coordinate response between the field and the main control room emergency response center.

⑨ Providing information outside and inside the station

Develop a structure whereby the station can provide information widely through a communication system that can connect to the integrated nuclear disaster response network and the satellite phone facilities in order to contact organizations inside and outside the station on the status of reactor facilities and the implementation of severe accident response measures.

⑩ Development of external support structures

- Develop structures such as a head office response headquarters for when a nuclear emergency situation is declared in order to smoothly receive support from outside the station.
- The head office response headquarters will be comprised of a team that will review and formulate station recovery methods, a team that will share information within the head office response headquarters, a team that will assess the state and progression of the accident, a team that will assess the amount of radioactive materials emitted, a team that will communicate with relevant authorities, a team that will respond to PR inquiries, a team that will provide support to the station in siting region response, a team that will recover communication facilities and secure support, a team that will improve the workplace environment of the station, a team that will support the development of an on-site medical base, a team that will procure and transport materials necessary for station recovery, a team that will establish and operate the nuclear disaster response support base, a team that will request support from authorities, and a team that will coordinate support received from other nuclear utilities. The head office response headquarters will provide technical and operational support to ensure that the station response headquarters can concentrate on accident response.
- The head office response headquarters will establish a nuclear disaster response support base and develop a structure whereby they can receive engineering support from other nuclear utilities and from the nuclear emergency situation support organization.
- The head office response headquarters will mobilize not only the nuclear division but other divisions so that nuclear emergency response measures can be implemented as a companywide initiative.

⑪ Development of a structure for mid-to long term response after the accident

- To prepare for situations in which mid-to long term response is required after a severe accident, develop a structure to implement appropriate and effective responses in coordination with relevant organizations internal and external.
- Should a severe accident occur, implement measures to reduce radioactivity levels and process contaminated water that includes radioactive materials leveraging the experiences and knowledge gained in the Fukushima Daiichi Nuclear Power Station Accident. Continue to maintain the cooperative relationships with various organizations in normal times so that necessary response measures can be discussed together after an accident to smoothly bring things under control.

4. ORGANIZATIONAL STRUCTURES, COMMUNICATION, DECISION MAKING AUTHORITY, AND SAFETY CULTURE

Necessary structures are to be developed and periodically assessed so that station maintenance activities can be conducted should a severe accident occur or large-scale damage be incurred. Necessary measures are to be implemented following this assessment.

Specific examples of structure development are as follows.

（Same as “2. Other procedures and guidelines, (4) Development of procedures, implementation of training, and developing a structure, c. Developing a structure”）

① Allocation of roles and clarifying the party responsible

- Allocate clear roles to organizations implementing the severe accident response measures and the support organizations providing support to the implementing organizations. Designate the responsible party for each.
- Formulate work teams considering the expertise and experience of each personnel.
- Clarify the chain of command and develop a structure that makes effective implementation of severe accident response measures possible.

② Configuration of the implementing organization

The organization implementing the severe accident response measureswill consist of the following teams. Roles will be allocated accordingly and a structure will be developed that allows for the smooth implementation of severe accident response measures.

- Shift (operators) that will implement operations related to accident impact mitigation and escalation prevention. A unit team that will provide information needed to select appropriate response measures to the shift (operators).
- Recovery team that will operate the portable severe accident response equipment related to accident impact mitigation and escalation prevention and recover malfunctioning equipment
- Self-defense fire brigade to conduct fire extinguishing activities

③ Response to situations where multiple reactors are damaged

- The general manager of the station response headquarters will set forth an action policy when severe accidents occur at multiple reactors. The Unit chief designated for each reactor will implement severe accident response measures by providing advice for operations related to accident impact mitigation and escalation prevention for the relevant reactor, overseeing response using portable severe accident response equipment and supervising recovery of malfunctioning equipment.
- Constantly secure station necessary emergency response personnel at the plant and develop a structure that allows the personnel to respond appropriately even when multiple reactors are damaged simultaneously.

④ Configuration of the supporting organization

- Create 1) a engineering support organization that provides technical advice to the implementing organization and 2) an operation support organization that will develop an environment where the implementing organization can concentrate on severe accident response, as support organizations for the station response headquarters.
- The engineering support organization will be comprised of a team that gathers information necessary for accident response, predicts and assesses plant state progression, and a team that measures radiation and radioactivity in and outside the station and controls exposure.

- The operation support organization will be comprised of a team that gathers external response information, a team that serves as a contact point for external relevant organizations, a team that centrally manages procurement and transport, and a team that supports the operation of the station response headquarters.

⑤ Setting up the response headquarters and gathering personnel

- A Plant General Manager (manager of nuclear disaster response) will establish a station response headquarters with an implementing organization and supporting organizations within it.
- Emergency response personnel, operators, and self-defense fire brigade will always be on site premises when the plant is in operation to ensure swift response should a severe accident occur at night time or on weekends (outside of working hours on weekdays).

  (For multiple units)

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- Conduct periodic communication training based on a predetermined contact structure to ensure necessary personnel can be gathered even at night time and on weekends (outside of working hours on weekdays) in emergencies.

The emergency response personnel structure should be managed appropriately to prepare for the eventuality that there is a vacancy. If a vacancy cannot be filled, the reactor needs to shift to an operational state where safety can be secured with the existing number of personnel, e.g. stopping a reactor.

⑥ Clarifying the division of roles for each team and the person responsible Clarify the functions of teams mentioned in ⑤ above and appoint team leaders and their proxies as the parties responsible for implementing response measures and for supervising other teams under their control.

⑦ Clarifying the chain of command and proxies - Clarify the chain of command in the station response headquarters, appoint proxies, and define the order of succession for when the commander is unavailable.

⑧ Preparation of facilities for effective implementation of measures

- Set up an emergency response center equipped with communication facilities (including a TV conferencing system) that allows communication inside and outside the station and connects to the integrated nuclear disaster response network in order for the implementation organization and support organization to implement their assigned roles.
- Equip the emergency response center with mobile communication facilities to coordinate response between the field and the main control room emergency response center.

⑨ Providing information outside and inside the station

Develop a structure whereby the station can provide information widely through a communication system that can connect to the integrated nuclear disaster response network and the satellite phone facilities in order to contact organizations inside and outside the station on the status of reactor facilities and the implementation of severe accident response measures.

⑩ Development of external support structures

Develop structures such as a head office response headquarters for when a nuclear emergency situation is declared in order to smoothly receive support from outside the station.

- The head office response headquarters will be comprised of a team that will review and formulate station recovery methods, a team that will share information within the head office response headquarters, a team that will assess the state and progression of the accident, a team that will assess the amount of radioactive materials emitted, a team that will communicate with relevant authorities, a team that will respond to PR inquiries, a team that will provide support to the station in siting region response, a team that will recover communication facilities and secure support, a team that will improve the workplace environment of the station, a team that will support the development of an on-site medical base, a team that will procure and transport materials necessary for station recovery, a team that will establish and operate the nuclear disaster response support base, a team that will request support from authorities, and a team that will coordinate support received from other nuclear utilities. The head office response headquarters will provide technical and operational support to ensure that the station response headquarters can concentrate on accident response.
- The head office response headquarters will establish a nuclear disaster response support base and develop a structure whereby they can receive engineering support from other nuclear utilities and from the nuclear emergency situation support organization.
- The head office response headquarters will mobilize not only the nuclear division but other divisions so that nuclear emergency response measures can be implemented as a companywide initiative.

⑪ Development of a structure for mid-to long term response after the accident

- To prepare for situations in which mid-to long term response is required after a severe accident, develop a structure to implement appropriate and effective responses in coordination with relevant organizations internal and external.
- Should a severe accident occur, implement measures to reduce radioactivity levels and process contaminated water that includes radioactive materials leveraging the experiences and knowledge gained in the Fukushima Daiichi Nuclear Power Station Accident. Continue to maintain the cooperative relationships with various organizations in normal times so that necessary response measures can be discussed together after an accident to smoothly bring things under control.

With regard to communication, facilities equipped with diversified communication means are established to make sure that necessary instructions are given to station personnel should a design-base accident occur.

Specific examples are as follows;

① Facilities with diversified communication means are established as a communication facilities inside the station.

② A safety parameter display system (SPDS) is installed to transmit data required to understand the status of an accident to the emergency response center located in the reactor building.

③ The above-mentioned facilities are connected to an on-site emergency power source or uninterruptable power source.

In addition, dedicated communication lines with diversified communication means are installed so that the station can make contact with important parties outside the station.

Specific examples are as follows.

① Communication facilities are established to communicate with head office, the government, local authorities, and other related organizations outside the station.

② Communication facilities equipped with data transmission system and an integrated nuclear disaster prevention network are established to transmit necessary data to the emergency response support system (ERSS) and other related parties.

③ Communication facilities are designed to be used constantly without being interrupted by congestion, and are connected to dedicated communication lines equipped with diversified communication means such as wired, radio, or satellite communication lines.

④ All of the aforementioned facilities are designed to connect to on-site emergency power supply sources or uninterruptable power supply sources.

Moreover, there are other necessary facilities and procedures provided so that the station can communicate with important parties inside and outside. [Art.62]

Specific examples are as follows.

① In addition to the function to communicate with necessary parties inside and outside the nuclear power station, various facilities as well as procedures are provided, such as satellite phone equipment, portable power supply system for the emergency response center in the reactor building, and the 1st gas turbine generator, which enables power to be supplied to the communication facilities from an alternative power supply system,

② Facilities and procedures such as satellite phone equipment and radio link system are provided to share important parameters measured with important places inside and outside the station.

Image of enhancement of radio communications

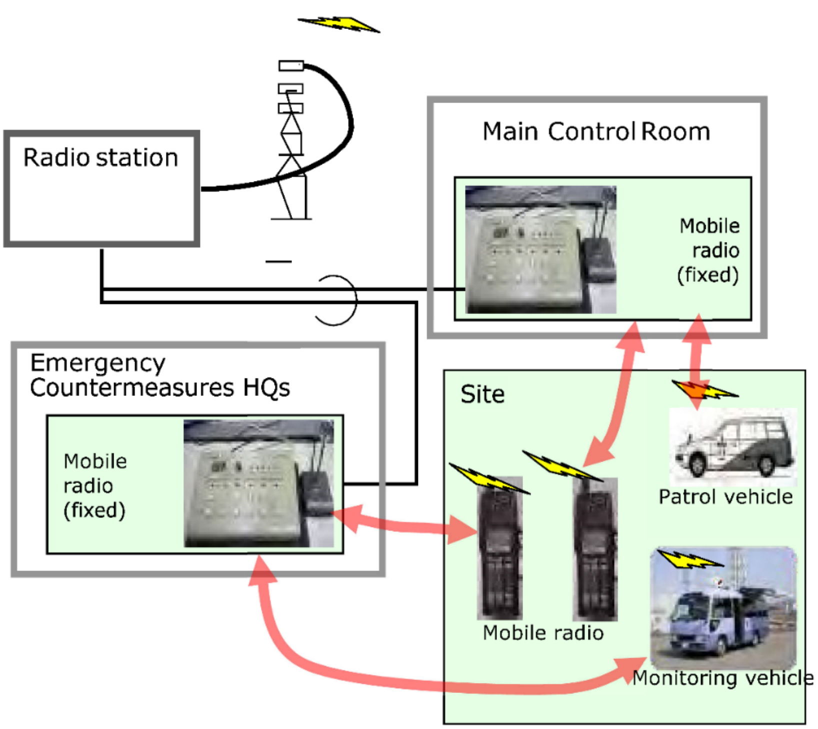
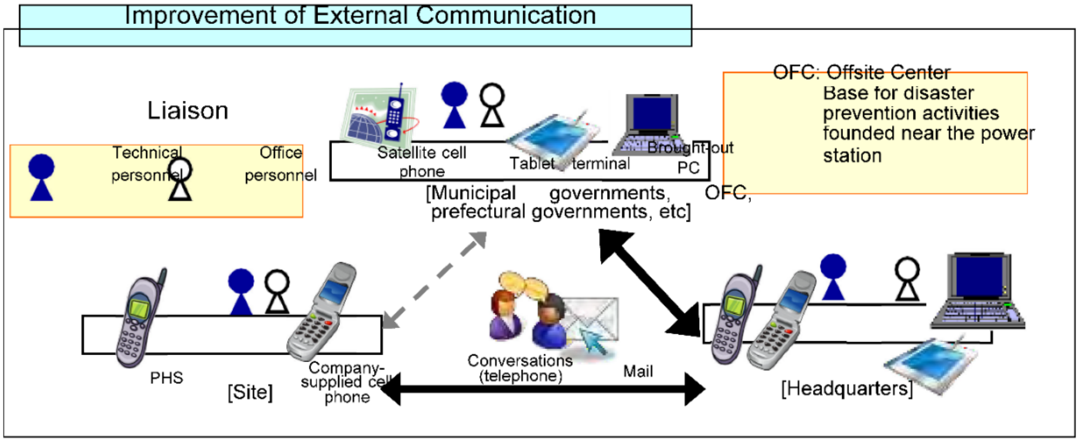


Image of External Communication



With regard to safety culture, a structure is developed to carry out quality assurance activities to implement design & construction and operation & maintenance smoothly and safely. Also, the management assumes a leading role to undertake initiatives such as reform so that safety culture will take root in the entire organization.

Specific examples are as follows.

① The quality assurance plan is formulated based on "Rules of Quality Assurance for Safety of Nuclear Power Plants (JEAC4111-2009)" and "Regulations on the method of quality control of design and construction by licensee of nuclear reactors, and technical standards for the licensee to review quality control, regarding commercial nuclear reactors", in order to construct a quality management system including efforts to raise awareness of station personnel to conform to technical specifications and related ordinances as well as to encourage initiatives to develop safety culture, aiming to achieve, maintain, and improve safety at the nuclear power station.

② The system to document procedures and records is stipulated based on the quality assurance plan for each department of head office, the power station and the internal audit office of head office.

③ The president is to develop a policy based on the quality assurance plan, and disseminate to all employees the importance of nuclear safety. Moreover, under Chief Nuclear Officer (CNO) who is a supervising manager of the implementation party, plant general managers and directors at Head office are to formulate, carry out, evaluate and improve plans related to quality assurance activities implemented at each department, according to the policy.

④ Head of the internal audit office, a supervising manager of the audit party, is to conduct an audit independently from the implementation party.

⑤ While a supervising manager of the implementation party is to conduct a self- evaluation of the status of safety culture, a supervising manager of the audit party is to carry out an independent evaluation of the station's effort to develop safety culture. An evaluation of safety culture conducted by an external organization is also subject to the audit.

⑥ The president receives a report about the quality assurance activities from supervising managers, and conducts a management review about the necessity of further improvement based on the report.

⑦ Moreover, activities common among the implementation party are reviewed by supervising managers at head office, and activities conducted by the station are examined at the plant general manager review. The results of both reviews are to be reflected into each duty aiming to maintain and improve the effectiveness of the quality management system.

5. PERSONNEL QUALIFICATIONS AND TRAINING

Station engineers receive education and training to maintain and improve their expert knowledge and technical skills.

Specific examples include:

1. Conduct fundamental education and training for newly deployed engineers to ensure that they obtain fundamental knowledge regarding nuclear power generation.
2. Engineers that will be involved in design & construction and operation & maintenance will receive desktop education and practical training at external domestic nuclear power-related organizations according to their capabilities, in addition to training at station facilities, to ensure that they gain the necessary expert knowledge and technical skills.
3. Formulate education and training implementation plans that stipulate specific matters such as persons subject to such training, the content, and frequency of training depending on the level of expert knowledge and the technical skill of personnel.
4. Engineers that will respond to natural disasters and severe accidents, personnel in charge of administrative matters, and contractor employees will receive the necessary education and training according to their roles.
5. In addition to the above, a Nuclear Human Resource Development Center has been established to conduct systematic education and training to increase the base level of technical skills, based on the realization that an attitude of formulating countermeasures at one's own initiative and swiftly preparing for future developments was lacking in the TEPCO Fukushima Nuclear Power Station Accident. Initiatives are being undertaken to increase technical capabilities at the Center.

Procedures are developed in advance and training conducted for the station to be able to respond appropriately and flexibly to severe accidents.

Specific examples include:

1. Education and training implementation policy

   Conduct education and training to increase operator's knowledge of generating nuclear reactor facility behavior in severe accidents, as a wide variety of countermeasures are necessary for severe accident depending on the state of the reactor.

2. Conduct education and comprehensive exercises to increase knowledge-based understanding

   ① Conduct periodic education for personnel to improve knowledge-based understanding of severe accidents and basic response methods according to their roles.

   ② Periodically plan exercises to comprehensively confirm the effectiveness of the implementing organization and supporting organization, and training given to the emergency response personnel on the field and the operators to learn how to cooperate in carrying out a series of response measures.

3. Maintenance training

   Have employees conduct maintenance and inspection activities and develop experience exchanging parts to gain more knowledge of the commercial nuclear reactor facility and spare parts.

4. Training assuming high dose conditions

   Conduct accident response training assuming high dose conditions, night time and inclement weather.

5. Preparations to ensure manuals are readily available

Ensure through maintenance and inspection activities that information on facilities and equipment and manuals are readily available. Conduct accident response training using such information and manuals.

Conduct education and training assuming large-scale damage, in addition to those related to severe accident response, for operators, emergency response personnel and self-defense fire brigade (including contractor employees) designated to respond to large-scale damage.

Conduct individual training and education for the Nuclear Emergency Preparedness Manager and their proxy, assuming that normal chains of command may not be functioning in large scale disasters.

Enhance education and training so that operators and emergency response personnel can execute response measures beyond their assigned roles, by ensuring that they acquire capabilities to respond flexibly to the situation.

6. PLANT INSTRUMENTATION, CONTROLS, HUMAN-SYSTEM INTERFACES, AND COMMUNICATIONS EQUIPMENT

The station has facilities and procedures necessary in assessing data for estimating parameters, should parameters that need to be monitored to respond to severe accidents become difficult to measure due to instrument failure.

Specific examples include:

1. Should the state of the station exceed the station's capabilities to grasp the situation (e.g. exceed maximum measurable temperature), estimate parameters to assess the state of the generating nuclear reactor facility and set priorities for the parameters to be estimated. To this end, select important monitoring parameters, designate instruments that measure alternative parameters as severe accident response equipment, and deploy portable measuring equipment as severe accident response equipment.
2. Provide power should power for instrumentation be lost. To that end, deploy portable instruments, permanent alternate AC power sources and power supply trucks as severe accident response equipment.
3. Record parameters in severe accidents. To that end, deploy SPDS display devices as part of a safety parameter display system, and a data transmission device and an emergency response support system transmission device as severe accident response equipment.
4. Estimate and monitor parameters using other channels to assess the state of the generating nuclear reactor facility, should instruments to measure those parameters necessary for severe accident response fail. Designate important instruments and important alternative instruments of the other channel as severe accident response equipment.

The station has developed facilities and procedures necessary to communicate with locations inside and outside the station as necessary.

Specific examples include:

1. Communicate with locations inside and outside the generating nuclear reactor facility as necessary and receiving power from alternative power supply sources. To that end, deploy satellite telephone equipment, wireless communication equipment, mobile telephone equipment, communication equipment that uses the integrated nuclear power emergency preparedness network, safety parameter display system (SPDS), portable power sources for the emergency response center, and gas turbine generators as severe accident response equipment.

   The satellite telephone equipment, wireless communication equipment, mobile telephone equipment, communication equipment that uses the integrated nuclear power emergency preparedness network, and safety parameter display system (SPDS) will receive power from the alternative power sources to ensure power source diversity.

2. Share important parameters measured with relevant organizations. To that end, deploy satellite telephone equipment, wireless communication equipment, mobile telephone equipment, and communication equipment that uses the integrated nuclear power emergency preparedness network as severe accident response equipment.

   The satellite telephone equipment, wireless communication equipment, mobile telephone equipment, communication equipment that uses the integrated nuclear power emergency preparedness network, and safety parameter display system (SPDS) are designed to use different communication methods.

7. PORTABLE EQUIPMENT/TOOLS, PROTECTIVE GEAR, AND WORK ENVIRONMENTS

Portable equipment to be used in large-scale damages and severe accidents are designed as follows.

1. Capacity

   The portable severe accident response equipment will have the necessary capacity according to the objective of the system, taking into account assumed severe accident and the accident progression. The station will also secure enough portable severe accident response equipment, including spare equipment, and consider the function and reliability of the equipment so that the station will not only have the minimum necessary capacity but capacity with additional margins.

2. Secure connection

   When connecting portable severe accident response equipment to permanent equipment, use bolts or screws to connect cables to ensure connection is easy and secure. Use flanges to connect large diameter pipes or in high pressure environments, and simpler connecting methods for low small diameter pipes and in low pressure environments, according to the diameter of pipes or the pressure of inner fluids. To ensure that portable severe accident response equipment can be used interchangeably within the site, the station will endeavor to use thesame connection methods across multiple systems, e.g. the same shapes will be used for multiple units within the site, same diameter pipe used to connect the same pumps.

3. Multiple connection ports

   Connecting ports that connect permanent equipment with portable severe accident response equipment to supply water or power from outside the reactor building will be installed in multiple isolated locations indoors or outdoors on different sides of the building to prevent them from becoming unusable due to common cause such as intentional crashing of a large airplane or other acts of terrorism.

4. Working environment on the field

   Areas that are assumed to have low radiation levels in a severe accident will be selected as portable severe accident response equipment installation sites and shielding installed on the location so that portable equipment can be installed or connected with permanent equipment safely even if severe accidents occur.

5. Storage location

   Portable severe accident response equipment will be stored in multiple locations at least 100 m or more away from the reactor building, turbine building andwaste processing building, and also 100m away from outdoor design basis facilitiesand permanent severe accident response equipment whose functions the portable severe accident response equipment will be replacing, considering the impact of natural disasters such as earthquakes and tsunamis, acts of terrorism such as the intentional crashing of a large airplane, the location of design basis accident response facilities and permanent severe accident response equipment, and other conditions.

6. Securing access routes

   The station will ensure that station roads and passageways will be able to be secured in a severe accident to transport portable severe accident response equipment and to grasp the damages done to other equipment.

   The station will secure multiple routes to transport the portable severe accident response equipment from the storage place to its installation location or connecting location indoors or outdoors, other access routes to assess the damages done to other facilities, and their detours in the event that natural disasters, external man-induced events, inundation, and fires occur.

   Wheel loaders that can remove obstacles will be stored and used as necessary to secure an access route that can be recovered the quickest among multiple access routes in the event earthquakes and other natural disasters impact outdoor access routes.

7. Design basis accident response equipment and permanent severe accident prevention equipment, and their diversity

   Portable severe accident response equipment is designed considering diversity, independence, geographical decentralization to ensure that common causes such as environmental conditions, earthquakes, tsunamis, and other natural disasters, external man-induced events, inundation, fires and support system failures do not cause function loss of the portable severe accident response equipment, design basis accident response equipment, and permanent severe accident prevention equipment simultaneously.

The reactor control room has facilities and procedures necessary for operators to remain at their positions even in a severe accident.

Specific examples include:

1. Secure livability of the main control room and protect operators from radioactive materials emitted into the environment in severe accidents by installing shielding in the main control room, shielding in the waiting room for the main control room, portable positive pressure air conditioner, and the positive pressurizer. To that end, deploy shielding of the waiting room for the main control room, portable positive pressure air conditioner, and a positive pressurizer as severe accident response equipment and designate the shielding of the main control room as a severe accident response equipment. Develop procedures to have operators wear full face masks and a develop a structure for shift turnover to ensure that operator effective exposure dose does not exceed 100mSv over seven days in any accident sequence.
2. Reduce operator exposure from the radioactive materials emitted into the environment or the secondary containment facility in a severe accident using the emergency gas processing system. The emergency gas processing system is designated as a severe accident response equipment.
3. Check the concentration of gasses in the main control room using an oxygen content meter and carbon dioxide content meter. To that end, deploy an oxygen content meter and carbon dioxide content meter as severe accident response equipment.
4. Secure lighting in the main control room via portable lighting with a built-in battery. Deploy portable lighting with a built-in battery as a severe accident response equipment.
5. Set up a changing area to prevent contamination from entering the main control area.

8. WORK PLANNING, TECHNICAL SUPPORT, AND EMERGENCY RESPONSE FACILITIES

1. Engineering support

The station is to establish supporting organizations to be able to respond appropriately and flexibly to severe accidents. Supporting organizations consist of a engineering support organization that will provide technical advice to the implementing organization and an operational support organization that will provide an environment in which the implementing organization can concentrate on safety or accident response.

The supporting organization policy is to communicate the state of the generating nuclear reactor and severe accident response implementation measures to organizations inside and outside the station and to develop a structure in which it can provide information widely.

Specific examples include:

① Configuration of supporting organizations

- An engineering support organization that provides technical advice to the implementing organization and an operational support organization that will develop an environment in which the implementing organization can concentrate on severe accident response will be established in the station response headquarters as supporting organizations.
- The engineering support organization will consist of a team that gathers information necessary for accident response, predicts and assesses accident progression and a team that measures radiation and the status of radioactivity inside and outside the station and conducts exposure management.
- The operational support organization will consist of a team that will gather external response information, a team that will communicate with external related organizations, a team that will centrally manage procurement and transport, and a team that will conduct station response headquarters operational support.

② Development of a support structure for receiving external support

- Establish necessary structures, e.g. a head office response headquarters to smoothly receive support from outside the station if a nuclear emergency situation is declared.
- The head office response headquarters will be comprised of a team that will review and formulate station recovery methods, a team that will share information within the head office response headquarters, a team that will assess the state and progression of the accident, a team that will assess the amount of radioactive materials emitted, a team that will communicate with relevant authorities, a team that will respond to PR inquiries, a team that will provide support to the station responding to the plant siting region, a team that will recover communication facilities and secure support, a team that will improve the workplace environment of the station, a team that will support the development of an on-site medical base, a team that will procure and transport materials necessary for station recovery, a team that will establish and operate the nuclear disaster response support base, a team that will request support from authorities, and a team that will coordinate support received from other nuclear utilities. The head office response headquarters will provide engineering and operational support to ensure that the station response headquarters can concentrate on accident response.
- The head office response headquarters will establish a nuclear site disaster response support base and build a structure to receive engineering support from other nuclear operators and nuclear emergency situation support organizations.
- The head office response headquarters will conduct nuclear disaster response activities as a company-wide initiative.

2. Emergency response center

Facilities and procedures to implement appropriate severe accident response measures, should a severe accident occur, are deployed to emergency response centers.

The emergency response center will be set up to prepare for the establishment of the emergency response headquarters.

① Response and facilities

A response headquarters to provide necessary severe accident response instructions and communicate with organizations inside and outside the station, and waiting area to accommodate personnel, will be established inside the emergency response center.

Specific examples include:

- Receive power from alternative power sources. Deploy portable power supply equipment and tanker trucks for the response headquarters and for the waiting area as severe accident response facilities, and designate light oil tanks as severe accident response facilities.
- Secure the livability of the emergency response center. In the emergency response center (response headquarters), install an airtight chamber, inner shielding, portable positive pressure air conditioner, positive pressurizer (air tanks), carbon dioxide absorption device, portable outside air intake blower, oxide content meter, carbon dioxide content meter, portable area monitor, portable monitoring post, and a differential pressure gauge as severe accident response facilities.
- Be able to accommodate enough personnel at the response headquarters to be able to respond appropriately to severe accidents. Deploy emergency response personnel gear (dosimeter and masks), materials necessary to examine severe accident response, enough water and food to live on for a week without external support, and equipment/materials for the changing area for the response headquarters and the waiting area.
- Gather information necessary to issue instructions to respond to the severe accident. Deploy the SPDS display devices that constitute the safety parameter display system (SPDS), data transmission devices, and emergency response support system transmission device as severe accident response facilities.
- Deploy satellite phones, wireless communication facilities, and communication facilities that connect to the integrated nuclear disaster response network as severe accident response facilities in the response headquarters so that the response headquarters will be able to contact organizations inside and outside the reactor facilities as needed. Deploy outdoor emergency contact inner phones and mobile radios as severe accident response facilities to communicate with the area outside the first floor of the reactor building, the response headquarters, the waiting area, and the main control room.

② Design policy for severe accident response facilities

Examples of design policies adopted for severe accident response facilities indicated in ① include:

- The facility is designed so as not to lose function in seismic forces due to design basis ground motions and is installed in a location that will not be affected by design basis tsunamis.
- The facility will be in an area far apart from the main control room to ensure geographical decentralization to account for risk.
- Backups for portable power supply equipment will be stored in the emergency response center to protect against failure and to ensure redundancy.

To secure livability and ensure that emergency response personnel, self- defense fire brigade personnel and operators can stay at the emergency response center, the emergency response center will be airtight and will be designed to have shielding and ventilation equipment so that the effective exposure dose of emergency response personnel staying at the emergency response center will not exceed 100mSv in the seven days after the accident.

③ Procedures

The station has established procedures using the equipment given in ① above. Specific examples include:

- Procedures for supplying power from alternative power supply equipment
  - Start on procedures for providing power from the emergency response center portable power supply equipment when establishing an emergency response center.
- Procedures for securing livability
  - Start on procedures for operating the emergency response center portable positive pressure air conditioner when establishing the emergency response center.
  - When making the decision to conduct containment vessel venting after core damage, start on procedures to increase pressure in the emergency response center via the emergency response center positive pressurizer (air tanks) and stop the emergency response center portable positive pressure air conditioner.
  - If a reduction in the radioactive materials in the surrounding environment is confirmed via the portable monitoring post or the monitoring post, start on procedures to start up the portable positive pressure air conditioner and shut down the emergency response center positive pressurizer (air tanks).
  - If portable or stationary monitoring posts show that the radioactive materials in the surrounding environment are sufficiently reduced but the atmospheric dose inside the building is higher than the dose outdoors, start on procedures to ventilate the corridors that serves as an air supply area for the emergency response center portable positive pressurizer air conditioner.
  - When a radioactive plume is passing over the area, emergency response
  - personnel who will be issuing severe accident response instructions or will be working to reduce the scattering of radioactive materials outside the station due to damages done to the containment vessel are required to reside in the command center or the waiting area.
- Procedures related to accommodating necessary numbers of personnel
  - If a severe accident occurs and containment vessel atmospheric radiation level monitors show that core damage has been sustained, start on procedures related to the operation of the changing area including covering the walls and floors, and installation of air tents and various equipment.
  - Deploy to the response center emergency response personnel gear (dosimeter and masks) and store at least one week's worth of supplies such as water and food, necessary to accommodate emergency response personnel without outside support for at least a week. Maintain and manage such supplies.
- Procedures related to assessing information necessary for responding to severe accidents and communication
  - One emergency response personnel will operate the safety parameter display system (SPDS) when establishing the emergency response center.
  - Deploy to the response center materials expected to be required in discussions following severe accidents. Maintain and manage such materials to ensure they are up to date.

9. EMERGENCY RESPONSE PLANS

10. EXTENDED (LONGER-TERM) RESPONSE

Based on the Act on Special Measures Concerning Nuclear Emergency Preparedness, operators have created a nuclear operator disaster response work plan with the aim of smoothly and appropriately implementing nuclear disaster countermeasures. This plan covers, for each nuclear power plant, work necessary in preventing the occurrence and spread of a nuclear disaster and recovering from a nuclear disaster.

The following are examples of the items listed in the nuclear operator disaster response work plan.

【Examples listed in the nuclear operator disaster response work plan】

1. Implementation of nuclear disaster prevention measures
   - Disaster prevention framework
   - Operation of the nuclear disaster prevention organization
   - Preparation of radiation measuring equipment and nuclear disaster prevention materials
   - Preparation of materials to be used in nuclear disaster response activities
   - Development and inspection of equipment and facilities to be used in nuclear disaster response activities
   - Implementation of disaster response education
   - Implementation of training
   - Coordination with related organizations
   - Public relations activities targeting residents around the station in ordinary times
2. Response in alert-level events
   - Reporting and communication
   - Implementation of emergency measures
3. Implementation of emergency response measures
   - Reporting and communication
   - Implementation of emergency measures
   - Emergency response measures
4. Nuclear disaster ex-post measures
   - Station measures
   - Sending nuclear disaster response personnel
5. Others
   - Cooperating with other nuclear operators

Korea

Lesson Learnt: KR-01 – Stress Test

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

* Objective of Stress test in Korea's nuclear power plants.

To evaluate plant response to extreme natural hazards exceeding design basis as a way to reassess the safety of operating nuclear power plants and to find the safety improvement items.

* Scope of Stress test

- SSCs' integrity against BDBA extreme natural hazards evaluation
- Coping capabilities to loss of safety functions
- Severe accident management capability evaluation
- Emergency preparedness and accident management capability evaluation

Supplemental Files: Stress Test summary report (Only Hanul unit 3 report is available in English)

Anticipated Benefits: Identification of nuclear power plants' capability to cope with extreme natural hazards exceeding design basis Identification of nuclear power plants' safety improvement items

The events described in this lesson learnt occurred: Korea from 2013 to 2019

Lesson Learnt: KR-02 – Preparation for prolonged emergency

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

- Securing additional equipment to prepare for a prolonged emergency

Before the Fukushima Daiichi Accident, pursuant to the radiological emergency plan, the KHNP kept approximately 350 units of seven different types of radiation (radioactivity) instruments including high-level beta-gamma dose rate meters, 8,600 pieces of radiation production equipment including protective clothing, 166,000 tablets (130g) of thyroid protection medicine. In response to a prolonged emergency like the nuclear accident in Fukushima, the KHNP has additionally secured 440 units of radiation (radioactivity) instruments and 20,000 radiation protection gears to increase inventory 200% of the previous level.

Supplemental Files: None

Anticipated Benefits: Improvement of radiological emergency plan

The events described in this lesson learnt occurred: Korea, 2013

Lesson Learnt: KR-03 – Reinforcing emergency exercise

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

- Reinforcing radiation emergency exercise

The KHNP has conducted an unannounced radiation emergency exercise at each nuclear power site once a year. Unannounced means the personnel participating in the exercise must not be advised in advance, of the exact date, time and scenario of the exercise. Therefore, it is believed that the unannounced exercise contributes to strengthening emergency response capabilities of radiological emergency staff. Furthermore, research was conducted to develop exercise scenarios based on earthquake and tsunami. The newly developed scenarios have already been applied in the unified emergency exercise.

Photo example of emergency exercise

Supplemental Files: None

Anticipated Benefits: Improvement of capability to cope with emergency situation

The events described in this lesson learnt occurred: Korea, 2013

Lesson Learnt: KR-04 – Mobile power generating equipment

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

- Devising a means for securing necessary information in case of a prolonged loss of electrical power

The power supply to emergency response facilities as well as the main computer is essential for acquisition of key plant parameters in case of a prolonged loss of power. The EDG together with the UPS is secured to prepare for the loss of power to emergency response facilities, however the UPS alone is not sufficient in case of a long-term loss of power. To resolve the issue, the licensee completed additional deployment of mobile power generating equipment to ensure continued power supply to the main computer in 2015.

Supplemental Files: None

Anticipated Benefits: Improvement of emergency response facilities

The events described in this lesson learnt occurred: Korea, 2015

Lesson Learnt: KR-05 – Emergency plan for emergency at multiple units

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

- Amending the radiological emergency plan to include such events as the simultaneous declaring of an emergency at multiple units

The radiological emergency organizations were structured to cope with a radiological emergency at a single unit. Now, the radiological emergency organizations are restructured based on three scenarios: first, a radiological emergency at single unit, second, simultaneous emergencies at two units on the same site, and third, simultaneous emergencies at all units on the same site, and the revision of the radiological emergency plan to incorporate the plan for establishing a radiation emergency organization based on three scenarios has been already completed in December 2011.

In the revised radiological emergency plan, the magnitude of tsunami is added to the criteria for declaring an emergency with respect to a natural disaster. In addition, the revised radiological emergency plan defines the target time for emergency response: issuing a radiation emergency alert within 15 minutes after detection, initiating radiation emergency organizations within one hour after the declaration of a radiation emergency and putting the emergency organizations into operation within two hours.

Supplemental Files: None

Anticipated Benefits: Improvement of capability to cope with emergency situation of multiple units

The events described in this lesson learnt occurred: Korea, 2011

Lesson Learnt: KR-06 – Response Form - Seismic alarm in MCR

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

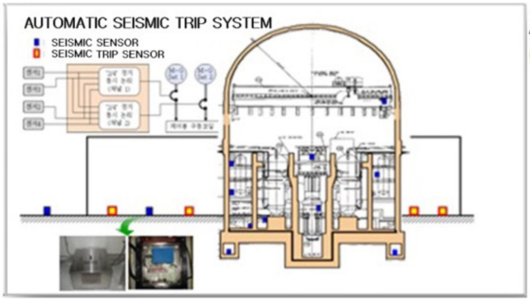
- Improvement of seismic capacity of the seismic alarm window in the main control room

Seismic capacity of the safety-related systems necessary to achieve and maintain safe shutdown, the SSCs necessary to maintain the integrity of spent fuel pool, and the SSCs necessary to maintain containment function under a beyond design basis earthquake will be improved up to the seismic design level of newly constructed nuclear power plants (0.3g).

The seismic performance evaluation is currently conducted using EPRI NP-6041, seismic probabilistic safety assessment (S-PSA) or seismic margin analysis (SMA). Nuclear systems which are deficient in seismic capacity should be reinforced. If necessary, the seismic capacity of such system was strengthened.

Installation of seismically qualified seismic alarm equipment and drop prevention measures to protect MCR operators such as applying seismic design to ceilings and lighting and improving lighting facilities were completed.

Photo of automatic seismic trip system and alarm in MCR



Automatic Seismic Trip System
(Activated at 90% of SSE)

Reinforced Seismic Alarm

Supplemental Files: None

Anticipated Benefits: Improvement of seismic capacity of nuclear power plants

The events described in this lesson learnt occurred: Korea, 2014

Lesson Learnt: KR-07 – Education and Training

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

- Reinforcing education and training on severe accident

Actions to strengthen training and education on severe accident were taken to ensure the operator's prompt response to a severe accident. The refresher training course for operators was revised to incorporate more training time, increased from 8 hours in every two years to 10 hours every year, and the severe accident training will also be provided to the essential staff of Technical Support Center in connection with the operator refresher training. In addition, severe accident scenarios were developed to improve severe accident theories and computer code practice so as to nurture severe accident experts. They will also be used to identify the characteristics of progress of severe accidents for each initiating event and those when operators' action was taken in accordance with SAMG.

Supplemental Files: None

Anticipated Benefits: Operators and staffs will identify and understand the characteristics of progress of severe accidents and SAMG.

The events described in this lesson learnt occurred: Korea, 2013

Lesson Learnt: KR-08 – SAMG revision

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

- Revision of the Severe Accident Management Guidelines to enhance effectiveness

A detailed evaluation methodology for the possibility of core melt cooling by filling the reactor cavity with water was be determined. The possibility of filling the reactor cavity with water was reviewed in parallel with plant walkdown. In addition, the availability and cooling capacity in terms of filling water flow, filling time and the maximum filling water level were evaluated. At the same time, a temporary EOP was developed to ensure review and implementation of effective filling water flow path. Furthermore, the feasibility of external reactor vessel cooling and the likelihood of side effects resulting from filling the reactor cavity with water including steam explosion were also evaluated.

Supplemental Files: None

Anticipated Benefits: Identification of the effectiveness of SAMG

The events described in this lesson learnt occurred: Korea, 2015

Lesson Learnt: KR-09 – Low power shutdown SAMG

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

- Development of Low-Power Shutdown SAMG

Low-Power Shutdown SAMG was developed to improve severe accident response capabilities during low-power shutdown operation like the Fukushima accident. Generic Low-Power Shutdown SAMG had been developed in the late 2012 and based on that, specific Low-Power Shutdown SAMG was developed, and then the full power SAMG and the "Low-Power Shutdown SAMG" were integrated by the late 2015.

Supplemental Files: None

Anticipated Benefits: Improvement of the SAMG

The events described in this lesson learnt occurred: Korea from 2012 to 2015

Lesson Learnt: KR-10 – Improving the emergency response facilities

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

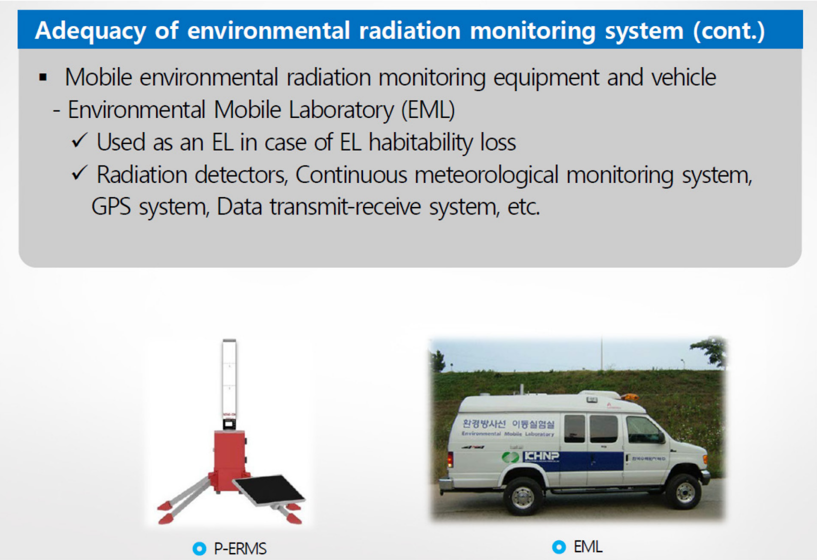
This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

- Improving the emergency response facilities

A plan to improve the habitability and the size of emergency response facilities including Technical Support Center (TSC) and Operation Support Center (OSC) and to prevent inundation of emergency facilities due to a large tsunami was development in the late 2015. In addition, Mobile Radiation Monitors were deployed to transmit radiation monitoring data using mobile communication.



Supplemental Files: None

Anticipated Benefits: Improvement of emergency response facilities

The events described in this lesson learnt occurred: Korea, 2015

Lesson Learnt: KR-11 – Assessment of manpower

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other] Staffing

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other] Staffing

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

- Assessment of adequacy of operating manpower

For the diagnosis of safe operating capacity of nuclear power plants conducted in 2011, task analysis was performed for organizations of nuclear power plant in operation or at each stage of pre-startup operation. Based upon the results, areas for improvement concerning the proper staffing level and human resource planning for nuclear power plants were identified and improvements were made in the standard job classification system, the calculation of proper manpower, and the establishment of human resource planning for nuclear power plants. Additionally, a 'Power Generation Personnel Management' system was constructed to prevent the dilution of expertise and knowledge of the staff due to the growing number of new and inexperienced employees at the plants and to provide quantitative criteria to determine the proper ratio of experienced personnel for each power plant. The system helps the KHNP to determine the adequacy of manpower and to assign personnel to each nuclear power plant.

Supplemental Files: None

Anticipated Benefits: Assessment of adequacy of operating manpower

The events described in this lesson learnt occurred: Korea from 2011 to 2013

Lesson Learnt: KR-12 – Development of accident coping strategies

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

Extreme natural hazards can affect other sites and off-site organization, making it difficult to provide support to nuclear power plants. Even in that case, as described previously, nuclear power plants have protective equipment sufficient enough to protect on site personnel. In response to an extreme natural hazard, KHNP has established MACST (Multi-Barrier Accident Coping Strategy) through which emergency response up to 72 hours after the onset of an extreme natural hazard event is made using onsite equipment. It has been assessed that 72 hours is sufficient to secure an access route for off-site personnel and equipment.

In order to cope with extreme external events, 3-phases of coping strategies are developed with MACST equipment.

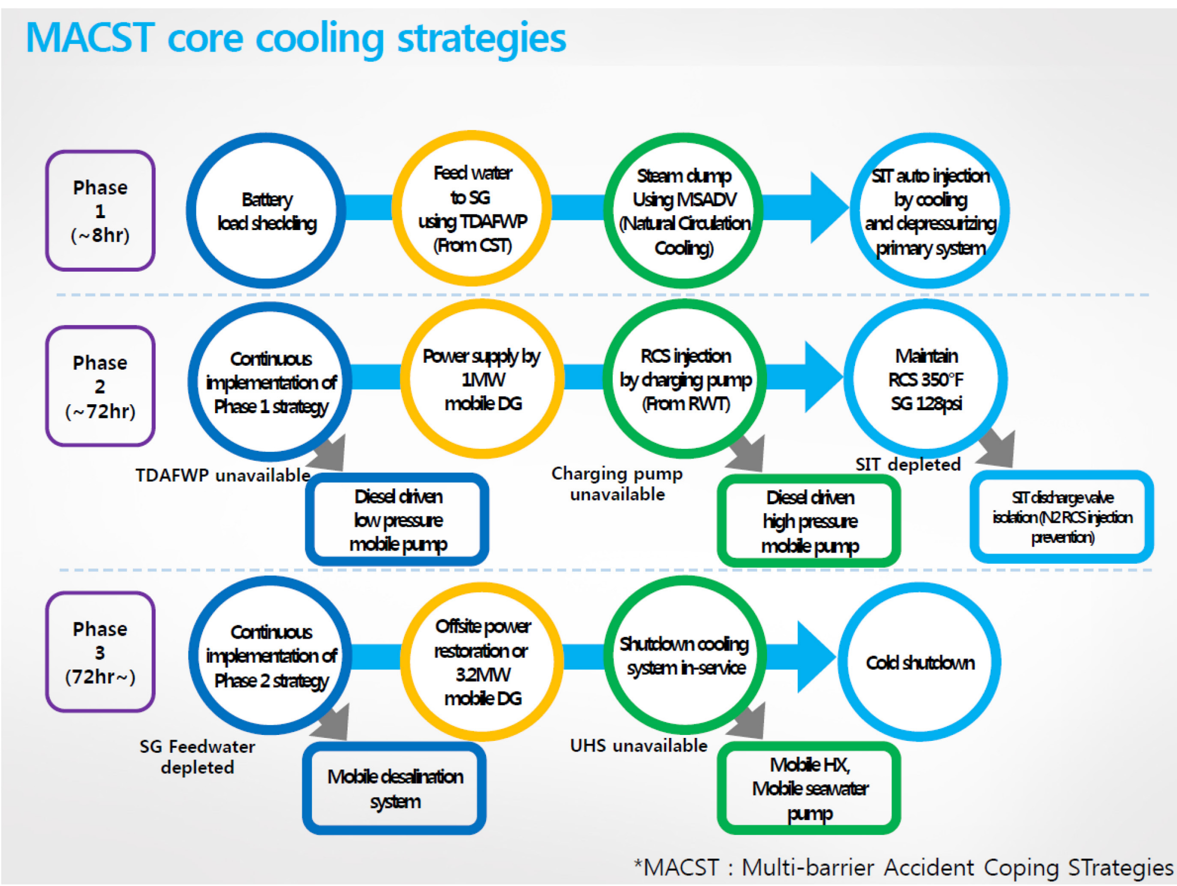
Phase 1: Initially cope with equipment in a plant such as tank, piping, battery, pump, etc. within 8 hours of the accident.

Phase 2: Cope with equipment in a site such as mobile generator, mobile pump, etc. between 8~72 hours after accident.

Phase 3: Cope with every available equipment in a plant, in/out a site after 72 hours after accident.

For the coping strategy, MACST Operating Guides (MOGs) are prepared and Table shows the purpose of each MOGs.

1. Diagram of MACST core cooling strategies



2. Table of MACST procedures

MOG No.	Purpose
1	Long-term RCS Inventory Control
2	Alternative AFW Water Supply
3	Alternative Low Pressure Injection
4	Battery Load Shedding after ELAP
5	Site Survey and MACST Equipment Deployment
6	CST Makeup
7	Electrical Loss of Essential Instrument
8	Alternative Borated Water Injection
9	Temperature Control at Low Decay Heat
10	SIT Isolation
11	Alternative SFP Makeup and Cooling
12	Alternative Containment Building Cooling
13	MACST Equipment Termination (Turnover)
14	RCS makeup during Shutdown

Supplemental Files: None

Anticipated Benefits: Improvement of capability to cope with extreme natural hazards

The events described in this lesson learnt occurred: Korea, 2016

Lesson Learnt: KR-13 – Accident Management Program

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

To cope with BDBA (Beyond Design Basis Accident) and to improve capability of accident management, KHNP developed AMP (Accident Management Program).

Before AMP, some of safety measures for BDBA were pushed forward in accordance with post-Fukushima action and stress test. After AMP, every scope of BDBA will be managed by integrated AMP.

Supplemental Files: PPT material for Accident Management Program

Anticipated Benefits: Improvement of capability to cope with BDBA

The events described in this lesson learnt occurred: Korea, 2019

Lesson Learnt: KR-14 – Mobile Equipment

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

- MACST (Multi-barrier Accident Coping STrategy) equipment

MACST equipment for Phase-1(~8 hr) are stored inside each unit to use as soon as possible. Except the pre-staged equipment, other mobile equipment for Phase 2(~72 hr) & 3 (72 hr~) are stored in the seismic designed integrated storage building which is constructed for each site. Besides the MACST equipment for essential safety functions, subsidiary equipment is also stored in the integrated storage building such as multi-purpose communication unit, emergency lighting, tractor, wheel loader, etc. The integrated storage building has main transportation rout along with an alternate one.

* Pre-staged Middle Generator

The capacity is 400 kW enough to supply electrical power for the battery charger, SIT isolation valves, mobile air compressor, temporary fans, etc. Even though the permanent battery has capability to supply DC power more than 8 hours by load shedding, the early charging of battery increases the credibility of coping capability. Therefore, the generator is pre-staged in the vicinity of Auxiliary Building to remove the uncertainty of transportation and supplies electrical power within 2 hours. 2 operators are supposed to start the generator and supply the electrical power. One middle generator per unit is pre-staged and anchored on the seismic designed pedestal considering external flooding.

* Mobile Air Compressor

The capacity is 11.6 scfm with 90 psig enough to supply compressed air for the air operating valves needed for essential safety function. For the minimization of size and weight, it supplies compressed air to the target header line by isolating other non-essential air consuming headers. For the easy and fast use, it is equipped with wheels to move by one operator. One compressor is stored for each unit required in the vicinity of target header line inside the building. Considering fire and exhaust fumes, it uses electrical power supplied by non-permanent generators such as pre-staged generator.

* High Pressure Mobile Pump

The high-pressure mobile pump has the capacity of 44 gpm with 1,500 psig in order to inject coolant into primary side to compensate for the leakage from RCPs and the coolant shrinkage during cool down. The pressure decrease in primary side and permanent piping design conditions are considered for the pump discharge pressure. Before the external injection operation, SITs makeup the RCP leak and coolant shrinkage passively for more than 8 hours (almost 30 hours). One high pressure mobile pump per unit is stored in the integrated storage building. It will be moved from the building to the pre-determined place. 1 driver and 4 operators are supposed to move and connect the mobile pump.

* 1.0 MW Mobile Generator

The mobile generator has the capacity of 1.0 MW to supply electrical power for the safety-related A or B bus at the ELAP accident. It has enough capacity for the battery charging, MCR HVAC, etc. It will be operated during 8 to 72 hours after the accident. One 1.0 MW mobile generator per unit is stored in the integrated storage building. 1 driver and 17 workers are supposed to move and connect the mobile generator.

* 3.2 MW Mobile Generator

The mobile generator has the capacity of 3.2 MW to supply electrical power for the safety-related A or B bus at the ELAP accident. It has enough capacity for all essential equipment of cooling pumps, motor operated valves, HVAC, etc. The duty is to cool down the plant to the cold shutdown status after 72 hours of accident. However, like the pre-staged middle generator, pre-staged and pre-wired electrical lines of 3.2 MW generator can reduce the coping time drastically and remove the uncertainty of transportation. A few (2 or 3 operators can start the generator and supply the electrical power instead of 18 workers. Two 3.2 MW mobile generators are placed for each site. They are pre-staged with pre-installed cables even though they have still movability. Unlike the pre-staged middle generator, the 3.2 MW mobile generators are staged on the remote area more than 100 meters from the unit and they use the long pre-installed cables. The remote area has dedicated fuel tank with a protection dike. The 3.2 MW mobile generators are commercial grade and non-seismic, but the pre-staged foundation, fuel tank, and dike are seismic designed.

* High Capacity Mobile Pump (for CCWHX)

The mobile pump has the capacity of 5,000 gpm to supply cooling water for the CCW heat exchanger. The actual capacity can be modulated depending on each plant's decay heat. The duty is to cool down the plant to the cold shutdown status after 72 hours of accident. One high capacity mobile pump per unit is stored in the integrated storage building and 1 driver and a dozen workers are supposed to move and connect the pump.

* Mobile Heat Exchanger

The stress test shows that the CCW heat exchangers have enough HCLF value considering 10,000 years return period of seismic events and the earthquake induced tsunami will not inundate the ground level of plants. Even though, there is extremely low possibility to break or block CCW heat exchangers, each site prepares the mobile heat exchangers. The heat exchanger capacity of 4.0 MBtu/hr°F is sufficient to remove decay heat from the reactor after 72 hours of accident. One mobile heat exchanger per unit is stored in the integrated storage building. For the use of mobile heat exchanger, the high capacity mobile pump should be accompanied. Therefore, several drivers and a dozen workers are required to move them and connect mobile hoses.

Supplemental Files: PPT material to introduce MACST equipment

Anticipated Benefits: Improvement of capability to cope with BDBA

The events described in this lesson learnt occurred: Korea, until 2024

Lesson Learnt: KR-15 – MACST Team

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

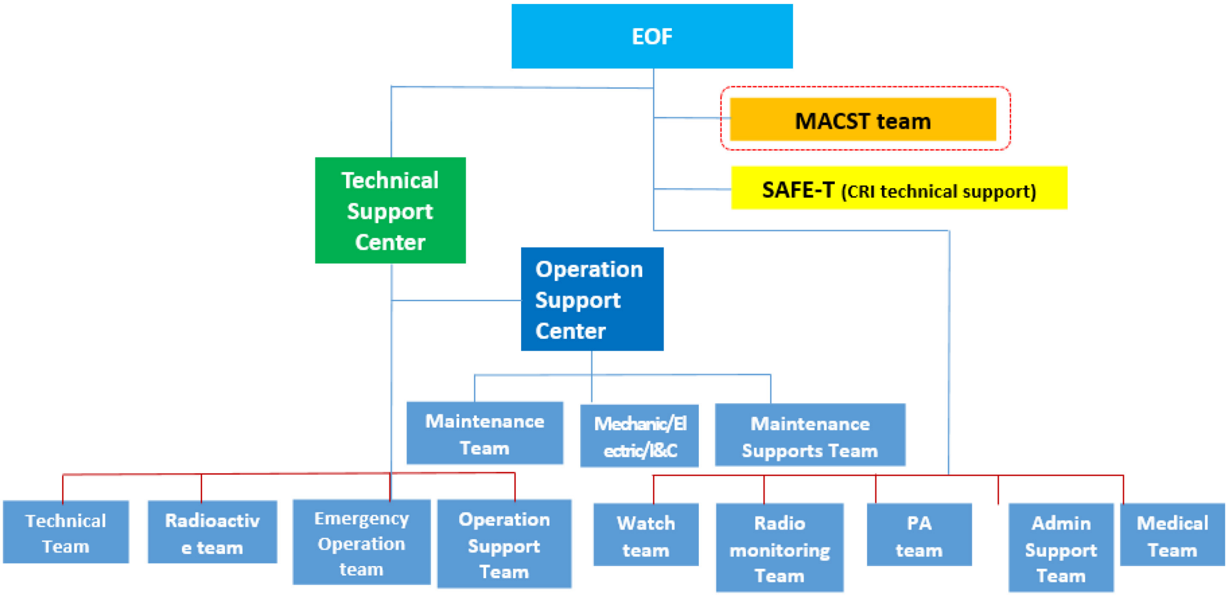
Description:

- Setup of MACST(Multi-barrier Accident Coping STrategy) Team

MACST team will be set up to be responsible for MACST equipment operation of Warehouse under head of nuclear site.

In case of nuclear accident, Radioactive Emergency Response organization is formed under head of EOF. And MACST team supports emergency response following the order of EOF head.

Diagram of organization chart for MACST team



Supplemental Files: None

Anticipated Benefits: Improvement of capability to cope with BDBA

The events described in this lesson learnt occurred: Korea, until 2020

Spain

Lesson Learnt: SP-01 – Verification and Validation for Emergency Situations

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

During validations involving Emergency equipment and systems, the verification and validation [V&V] have to be done with the most conservatives scenarios expected. Even when Procedures cannot take into account every single possible situation, Human Performance specialist need to go further and raise up those situations to evaluate responses from plant personnel.

For this reason, during Containment building venting system V&V, difficult personal situations (happening out of the plant as happened in Fukushima) were raised to Operators in the field, to analyze their response. The principal lesson learned was that this kind of situations need to be "trained" to be prepared to them.

This practice supposed the review of the Guidance for V&V relating, overall, HU aspects as well as taking into account other aspects such as Doses, events taking place at the same time, unexpected situations, etc.

Supplemental Files: None

Anticipated Benefits: Preparedness for an emergency situation. Review of the V&V guidance in the nuclear power plant.

The events described in this lesson learnt occurred: 2016

Note: Text in brackets [ ] added to submittal by Task Group for clarification.

Lesson Learnt: SP–02– Communication During Emergencies

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	In the nuclear power plant case, corporate response facilities

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

When analyzing the Fukushima event, in the nuclear power plant a need to keep the relatives of personnel informed (As well as to keep workers informed of how their relatives are), a telephone line to do so was established, and a card with the telephone number was given to all "on duty" workers to give to their relatives.

Supplemental Files: None

Anticipated Benefits: This aspect could help managing the incoming calls to the plant in case of emergency. It also would allow workers to focus on the emergency and forgetting about having to contact their relatives.

The events described in this lesson learnt occurred: 2015

Note: Text in brackets [ ] added to submittal by Task Group for clarification.

Lesson Learnt: SP–03 – Magnetic Help Guides for Portable Equipment

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	**Drill / Exercise**
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

During the realization of the emergency portable equipment surveillance tests, it was required to start up the portable equipment in the field. Magnetic help guides for each portable equipment were developed helping the field operator to quickly start up the portable equipment, and also minimize any possible human error that could prevent from the start up the equipment the first time.

Also, during an emergency situation [it] could take time to find out the procedure for using the portable equipment and the procedure takes time to be followed by the field operator. And when the procedure is followed, the field operator needs one hand to hold the procedure, so he cannot use both hands to work with.

Supplemental Files:

Anticipated Benefits: The Magnetic help guides for each portable equipment help the field operator to quickly start up the portable equipment, and also avoid any possible human error that could prevent from the startup of the equipment the first time. The Magnetic help guides are placed in each portable equipment, so the Field operator do not have to spend time to find out the procedure for using the portable equipment. These magnetic helps could be moved and placed next to the area where the devices (switches, valves, etc.) are manipulated, so the field operator do not have to move to look at it and also has free hands to work with. These magnetic helps also include pictures, so they are clear and easy to be followed so it minimizes the human errors.

The events described in this lesson learnt occurred: June 2016

Note: Text in brackets [ ] added to submittal by Task Group for clarification.

Lesson Learnt: SP–04 – Visual Aids for Identifying Emergency Equipment

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

During the realization of a Plant Drill, where the Emergency Procedure requires to identify and manipulate emergency related equipment (valves, cabinets, Control Room Switches, etc.) in Station Black Out situation, refractive [fluorescent] metal identification plates were developed and refractive [fluorescent] tape was used in Control Room switches to help the field operator and the Control Room staff to identify and manipulate emergency related equipment (valves, cabinets, Control Room Switches, etc.) in SBO situation.

Supplemental Files:

Valve refractive [fluorescent] metal identification plate

Orange refractive [fluorescent] tape used to mark cabinets

Anticipated Benefits: The refractive [fluorescent] metal identification plates help the field operator to quickly identify and manipulate the emergency valves involved in the emergency procedures.

The refractive [fluorescent] tape used to mark cabinets in the field plates help the field operator to quickly identify and manipulate this equipment involved in the emergency procedures.

The refractive [fluorescent] tape used to mark Control Room switches help the field operator to quickly identify and manipulate the emergency control room switches involved in the emergency procedures.

All of this help the Control Room Staff and the Field Operators to execute the emergency procedures, minimizing human errors and improving performance times.

The events described in this lesson learnt occurred: April 2016

Note: Text in brackets [ ] added to submittal by Task Group for clarification.

Lesson Learnt: SP–05 – Training for Emergency Equipment Transport

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

Theoretical and practical training in transport means management for transfer of equipment related to PEI [internal emergency plan] in the event of extensive damage, to the personnel of the electrical maintenance, instrumentation and mechanic, services section, supply management and chemistry.

Supplemental Files: None

Anticipated Benefits: This training will guarantee a minimum of people with skills and knowledge to handle the emergency teams and following a defined planning try to minimize human errors.

The events described in this lesson learnt occurred: February – June 2015

Note: Text in brackets [ ] added to submittal by Task Group for clarification.

Lesson Learnt: SP–06 – Communication System Improvements

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

The improvements associated with communication systems in emergency, including those of reinforcement in situations of loss prolonged power supply

Supplemental Files: None

Anticipated Benefits: The improvement of the media ensures that there is communication at all times including situations of major emergencies

The events described in this lesson learnt occurred: June 2014

Note: Text in brackets [ ] added to submittal by Task Group for clarification.

Lesson Learnt: SP-07 – Stress Management Guide and Posters

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

As a result of the analysis of the lessons learned from the Fukushima accident, was identified the importance of stress management for Emergency response staff. (They continued working on a tense environment for a long period without leaving the plant, even when some of the members of his family were suffering due to disaster.)

In order to improve the response of the members of the emergency it has been elaborated a document available on the Alternative Emergency Management Centre focused on stress and anxiety management techniques. Four posters showing the behavior patterns with relaxing images, has been placed on the bedrooms and on the rest room of the Alternative Emergency Management Centre too.

Supplemental Files:

*Cuando intervenimos en una situación de Emergencia de manera prolongada, nos vemos expuestos a emociones negativas. Son situaciones altamente estresantes que pueden influir en nuestro **bienestar personal, emocional y en nuestro rendimiento**.*
En cualquier situación de emergencia, TODOS nos vemos de alguna manera afectados.

El estrés es la respuesta natural de un organismo a presiones externas o internas y tiene repercusión a nivel físico, emocional y mental.

Existen técnicas que te ayudarán a manejar esta respuesta de tu cuerpo y de tu mente, intentamos resumírtelas en esta pequeña guía.

EFECTOS DEL ESTRÉS MANTENIDO

*Las reacciones ante el estrés son numerosas y diferentes en cada una de las personas, pueden ser físicas, relacionadas con el comportamiento, sociales o cognitivas. Si te sientes **confuso, demasiado irritable o muy triste**, tal vez sea el momento de hacer una pausa.*

RUMIACIÓN DE PENSAMIENTOS NEGATIVOS

*Cuando los pensamientos negativos ocupan tu pensamiento, apareciendo en tu mente de forma insistente, estás "**rumiando pensamientos**".*

Esta situación puede ocurrir cuando intentas conciliar el sueño, si es así:

*1- **Identifica** claramente en tu mente el pensamiento a bloquear*
*2- Dibuja una imagen mental en la que tiras a la **papelera** ese pensamiento*
*3- **Ocupa tu mente** con operaciones matemáticas complicadas o algo que te requiera atención para resolver*

Esto ayudará a que caigas dormido en el proceso

¿CÓMO MINIMIZAR LOS EFECTOS DURANTE LOS DESCANSOS?

1. **CHARLA CON TUS COMPAÑEROS DURANTE LOS PERIODOS DE DESCANSO**

Es bueno que expreses tus sentimientos. Aunque te resulte extraño, acepta el hecho de sentirte diferente a lo habitual.

2. **ESCUCHA ...**

...lo que piensan y dicen los demás compañeros. La emergencia también les ha afectado a ellos.

3. **CUÍDATE**

Trata de alimentarte bien, descansa, bebe suficiente agua, intenta relajarte. En los momentos de descanso trata de no "rumiar pensamientos".

4. **ASEGÚRATE DE DESCANSAR Y DESCONECTAR**

Si tienes posibilidad, a la hora de dormir escucha música tranquila, haz respiraciones abdominales y profundas, aleja los pensamientos relacionados con la emergencia. Intenta dejar tu mente en blanco, si no puedes, imagina una imagen placentera para ti, te ayudará a conciliar un sueño más reparador y tranquilo.

Anticipated Benefits: In case of situation of stress maintained by an emergency, this guide and stress management techniques can help workers to relax and rest, minimizing errors in management and communication from stress and fatigue.

The events described in this lesson learnt occurred: 2018

Note: Text in brackets [ ] added to submittal by Task Group for clarification.

Lesson Learnt: SP-08 – Leadership During Emergency Situations

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

One of the lessons learned from the accident was the different treatment given to the crisis situation at the Fukushima Daini and Onagawa plants, in relation to the adequate leadership during the emergency situation.

With the objective of reinforcing this aspect, has been included in the training of Emergency response staff aid tools related to emergency leadership. Two posters have been placed on

Alternative Emergency Management Centre (CAGE) and on the Technical Support Centre (CAT), summarizing appropriate communication practices related to this topic.

Supplemental Files:

Anticipated Benefits: Improvement leadership of emergency response staff during emergency management.

An adequate leadership impacts not only on the decision making process, but also on the environment and proper management of the emergency, so these issues will be improved through training

The events described in this lesson learnt occurred: 2018

Note: Text in brackets [ ] added to submittal by Task Group for clarification.

Lesson Learnt: SP-09 – Command and Control in Emergencies Guide

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	[other]

Description:

In 2014, after analyzing the results obtained from several internal and external observations, and following the process of continuous improvement within the organization, an area for improvement in the field of emergency command and control was identified, specifically in the management of accidents in the Technical Support Center (CAT in Spanish).

To this end, we developed a guide which includes the systematization of a series of processes that, thanks to its simplicity, enable a fast application and facilitates the exercise of the emergency team duties.

The guide consists of seven (7) sections, and a summary, which develop those aspects to be considered in the event an emergency arose. These aspects are:

- Priorities: any type of decision making during an emergency must take into account the following priorities: the General Public, the staff, the Plant, the Environment and Safety.
- Principles of Command and Control: the following principles are defined and established as a reminder at the Technical Support Center:
  - Anticipation: the team must anticipate possible scenarios and be prepared for what may come.

   - Communication: accurate information must be shared through the best available channel, and the understanding of the information must be confirmed.
   - Delegation: the chief of the emergency services must delegate those activities that might prevent him from having a global vision of the situation, and must have the most appropriate equipment for each function.
   - Concurrent Activities: in order to optimize the timings, different actions must be run in parallel while maintaining control of the scenario.
   - Flexibility: in an emergency situation, flexibility, common sense and skipping the rules are required if it is necessary in order to solve the emergency.
   - Leadership: to maintain the situation and the decision making drive under control until the emergency is over.

- Decision making process: this process can be summarized in the following stages: information gathering and sharing; achievement of an even situational mindset within the team; to reach a joint decision making and finally, to perform accordingly. This cycle will repeat until the emergency situation is over.
- Chain of command: the establishment of a chain of command helps to reduce steps, connects managers and defines their responsibilities.
- Resource management: by answering a series of questions, it helps to reflect on the available and necessary resources allocated to tackle and emergency in the most realistic and effective possible way.
- "Blackboard management": this tool ensures an intuitive emergency monitoring and helps to establish recovery strategies as well as the actions to be taken in each phase.
- Briefing format: the emergency manager periodically reviews the situation; the strategies defined; the progress and status of the actions taken, and also receives a quick feedback from the team in order to ensure everything is properly understood.

Supplemental Files: Text of "Command and Control in Emergencies Guide" is provided on the following pages.

Anticipated Benefits: The immediate benefits from the implementation of the "Command and control in emergency situations" guide have resulted into a simple and, at the same time, strong system which, in the event an emergency should arise, enables to establish priorities in the decision making process; to have emergency related command and control basic and shared fundamentals; to have a tool to properly manage the available resources; to improve the monitoring of strategies to follow according to the emergency status and to improve the preparation and coordination of the Emergency team.

The events described in this lesson learnt occurred: February 2014 - 2018

Note: Text in brackets [ ] added to submittal by Task Group for clarification.

Command and Control in Emergencies Guide in pdf file:

Adobe Acrobat
PDFXML Document

United States

Lesson Learnt: US-01 – Human Reliability Analysis Methods for Use of FLEX Strategies and Equipment

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Emergency Operations Facility
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	Guidance Development

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	Human Reliability Analysis

Description:

Both the U.S. NRC and industry are beginning to modify PRA models to represent the implementation of the flexible coping strategies (FLEX) and associated equipment/capabilities that have been put in place at U.S. nuclear power plants following the accident at Fukushima Daiichi. Some of the NRC's Standardized Plant Analysis Risk (SPAR) models have been updated to include FLEX strategies and some utilities have expanded their PRA models to include the use of FLEX equipment. Also, some utilities have requested licensing changes that involve using FLEX strategies or equipment for non-FLEX contexts (e.g., provide additional diesel generator redundancy in loss of offsite power scenarios).

The NRC has published a two-volume report that illustrates the NRC's effort to appropriately credit human actions within FLEX strategies using a systematic, qualitative approach to produce human error probability (HEP) estimates. Volume 1 of this report, "Utilization of Expert Judgment to Support Human Reliability Analysis of Flexible Coping Strategies (FLEX)," was completed in 2018 as an assessment of FLEX action feasibility using data collected by the NRC staff. This information was used to inform the development of the NRC's Integrated Human Event Analysis System for Event and Condition Assessment (IDHEAS-ECA). IDHEAS-ECA is a human reliability analysis (HRA) method that can be used for FLEX and Non-FLEX actions. Upon completion of the method, in 2019, the NRC and industry further explored the feasibility of FLEX actions using IDHEAS-ECA. This work is documented in Volume 2 of the report, "Flexible Coping Strategies (FLEX) HRA Using IDHEAS-ECA." The two reports demonstrate how the teams of experts were used and describe how each project was introduced into the NRC's framework for FLEX. Both projects capture the state of knowledge and uncertainties of the technical issues within FLEX and non-FLEX scenarios.

Supplemental Files: None

Anticipated Benefits: Both projects described in the report serve as a bases to explore the data and knowledge of FLEX within HRA. They demonstrate a cohesive effort to address the challenges identified in existing HRA methods and create solutions to bridge the gaps of understanding. Previous methods used by the NRC assumed that FLEX actions were not feasible. However, these two-projects provide evidence of feasibility. Both efforts increased the understanding of operator actions using FLEX equipment and developed estimates of their feasibility to inform and improve analysis, methodologies, and quantification tools

The events described in this lesson learnt occurred: From 2018 – 2019.

Note: Text in brackets [ ] added to submittal by Task Group for clarification.

Lesson Learnt: US-02 – FLEX Diesel Generator Experience

Applicability

Type of Response

On-site Response (Mitigating Event)	Off-site Response (Protective Actions for Public)

Plant Locations

Main Control Room	Technical Support Center
Remote Shutdown Panel / Facility	Emergency Operations Facility
Other Local Control Station / Field Activity	[other]

Job categories

Control Room Operators	Technical Support Center
Field Operators	Other Emergency Response Organization Personnel
Maintenance Technicians	Security
Health Physicists/Radiation Protection/Chemistry	[other]

Time / Method of Identification

Initial Analysis / Development of the Action	Drill / Exercise
Validation	Audit / Self-Assessment
Training	[other]

This Lesson Learnt Concerns

Mitigation Strategies	Plant Instrumentation/Controls
Other Procedures and Guidelines	Human-system Interfaces
Staffing	Communications Equipment
Organizational Structures	Work Planning
Communication	Technical Support
Decision-making authorities	Emergency Response Facilities
Safety Culture	Emergency Response Plans
Personnel Qualifications	Extended Longer-term Response
Training	Equipment design, maintenance and testing

Description:

NRC licensees use diverse and flexible coping strategies (FLEX) equipment at nuclear power plants to implement long-term core cooling, spent fuel cooling, and containment integrity in beyond-design-basis event scenarios.

On September 26, 2019 and again on April 1, 2020, the licensee for the River Bend nuclear power station conducted periodic testing of their FLEX diesel generators. In both instances, multiple FLEX diesel generators failed to operate. On July 11, 2019, the licensee for Clinton Power Station (Clinton) discovered that the electrical phase rotation of the "A" FLEX diesel generator was opposite to that of the load center for its in-plant loads. If the facility had used the "A" FLEX diesel generator to power any in-plant equipment, it would have caused phase-dependent loads to rotate backwards, potentially damaging in-plant safety-related equipment.

On September 15, 2020, the U.S. Nuclear Regulatory Commission issued Information Notice 2020-02, Flex Diesel Generator Operational Challenges. The information notice (IN) informed addressees of these recent operational challenges involving FLEX diesel generators and described the deficiencies in licensee design, testing, and maintenance practices that contributed to the failures. These deficiencies included failure to provide adequate oversight of vendor provided maintenance and failure to test under the loading conditions that would actually be present during a beyond-design-basis external event.

Supplemental Files: None

Anticipated Benefits: The anticipated benefit of the information notice is increased awareness of conditions that could contribute to operational challenges with FLEX diesel generators at other nuclear facilities. The information can be evaluated for applicability at other facilities and provide the basis for corrective action, if warranted, that can reduce the potential for similar failures. FLEX diesel generator reliability is important to successful implementation of mitigation strategies for beyond-design-basis external events, mitigating the risk related to taking safety-related systems out of service, and to reducing a plant's overall risk profile.

The events described in this lesson learnt occurred: September 2019 – July 2020

Note: Text in brackets [ ] added to submittal by Task Group for clarification.