EU STRESS TEST FOR KS NPP
-LICENSEE REPORT
(Rev.1c)

Taiwan Power Company

May 2013

EU STRESS TEST FOR KUOSHENG NPP - LICENSEE REPORT

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1. General data of site/plant

1.1 Site characteristics

Kuosheng Nuclear Power Plant (KSNPP), also known as Second Nuclear Power Plant in Taiwan, is located on the northern coast of Taiwan and fronts on the East China Sea. In terms of geographical coordinates, the Kuosheng site lies at latitude 25°12’09”N and longitude 121°39’46”E. The site is situated on a coastal plain at an elevation ranging from 10 to 20 meters above mean sea level. It is close to Keelung City, and Taipei City is about 22 kilometers southwest of the site. It is approximately 12 kilometers southeast of the First (Chinshan) Nuclear Power Plant. There is no naturally occurring watercourse passing through the Kuosheng site (Note: Two small, artificial open channels exist within the plant boundary, intended as drainage creeks to carry runoff water that originate from a ridge behind the plant site: creek A flows along the west side of the plant and creek B flows southeast of the site.) There are three naturally occurring streams, i.e., Huong Creek, Yuantan Creek and Mashu Creek, in the vicinity of the site, all flowing into the East China Sea. The plant is protected from these three streams by sand dunes rising up to several tens of meters above mean sea level.

1.2 Characteristics of units

Two Boiling Water Reactors (BWRs), product line number designated as BWR-6, are installed at KSNPP with the rated core thermal power originally licensed at 2894 MWt for each unit. These two BWR-6s were designed and furnished by General Electric (GE). The Unit 1 reactor reached its initial criticality on February 1, 1981 and the Unit 2 reactor on March 26, 1982, respectively. KSNPP successfully implemented “Measurement Uncertainty Recapture power uprate” (MUR PU) for unit 1 on November 30, 2007 and for unit 2 on July 7, 2007. As a result, the rated core thermal power for each unit has been slightly increased to 2943 MWt.

Unit Design Operation Parameters

Fuel bundles	bundle	624
Control Rods	rod	145
RPV Height (Internal)	in	838
RPV Diameter	in	218 ID
Containment Type	MARK-III	

1.3 Significant differences between units

By design, redundancy is provided for each safety system by two or more separate divisions or trains, designated as Division (or, Train) A, Division (or, Train) B, etc. The term division (or, train) means that all components and support equipment necessary to complete the intended safety function of each system is contained within the division (or, train). The arrangement of the redundant divisions (or, trains) of a system ensures adequate physical separation and electrical isolation between them. By such an arrangement, no single failure or malfunction in components of any division (or, train) will result in a loss of the system function. In addition, any propagating failures, such as threats due to fires or floods, can be avoided from one division (or, train) to other divisions (or, trains). The plant is designed on a twin-unit concept. All major equipment at Unit 2 is essentially a duplicate of its counterpart at Unit 1. Nevertheless, systems and components required for safety are not shared between Units l and 2, except the following:

One 4.16kV/3920kW air-cooled Emergency Diesel Generator (commonly referred to as the 5th EDG) was initially designed as a swing EDG for either Unit 1 or Unit 2. That is, the 5th EDG could be deployed as alternative AC power source for the emergency power demand by either unit 1 or unit 2, but not both, if water-cooled EDGs at either unit should be unavailable. However, after the Fukushima Nuclear Accident, the Station Blackout Procedure 1451 has been revised that under appropriate control and management, the 5th EDG can be deployed to simultaneously supply power to the Essential Buses at both Units 1 and 2. (It has been verified that the power generation capacity of the 5th EDG is sufficient to simultaneously satisfy the power demand for operating one safety division at each unit.)

1.4 Results of probabilistic safety assessments

The first nuclear power plant Probabilistic Risk Assessment (PRA) application in Taiwan was initiated in 1983 by ROCAEC. A base PRA model was established in 1985 using KSNPP as the reference plant. KSNPP completed its Living Probabilistic Safety Assessment (PSA) modeling and analysis in 1995. From then onwards, the parent company, TPC, is committed to revising and updating this Living PSA every three years to reflect plant design changes and operating performance. As of yet, four revisions have been made to the Kuosheng Living PSA. The plant Living PSA program has developed two PSA models, one for full power conditions and the other for the refueling outage mode. Broadly, the full power PSA model analyzes 5 categories of events, namely plant internal events, earthquakes, floods, fires and typhoons. The results of the most recent assessment are summarized as follows:

(1) The total average Core Damage Frequency (CDF) at full power operation is estimated to be 2.549E-5/RY. The total average CDF during a typical refueling outage is estimated to be 9.55E-6/RY.

(2) The total average Large Early Release Frequency (LERF) at full power operation is estimated to be 1.617E-6/RY.

(3) Contributions to the total average CDF at full power operation are: 37.90% (9.659E-6/RY) from plant internal events, 32.29% (8.231E-6/RY) from earthquakes, 12.27% (3.128E-6/RY) from typhoons, 1.23% (3.144E-7/RY) from floods, and 16.30% (4.155E-6/RY) from fires.

(4) Contributions to the total average LERF at full power operation are: 12.42% (2.008E-7/RY) from plant internal events, 76.07% (1.23E-6/RY) from earthquakes, 0.83% (1.345E-8/RY) from typhoons, 0.12% (1.956E-9/RY) from floods, and 10.56% (1.708E-7/RY) from fires.

As for the off-rated condition, there’s no difference between low power and full power operation in system operability assumption for safety assessment. Due to the fact that the reactor contains less heat source in low power operation and the decay heat needed to be removed after scram is relatively low compared to that of full power operation, the result of safety assessment should be non-limiting and can be bounded by that of full power operation.

For the refueling outage mode PSA, the cliff edge effects of fuel buildings and independent buildings have been assessed in the most limiting condition as reactor shutdown with full core discharged, the daily work scope in outage schedule will be evaluated following refueling outage safety assessment in advance, and the shutdown safety meeting will be held daily to ensure the potential risks are within acceptable value. Therefore, the refueling outage safety assessment process is complete and thorough. In regard to the result of PSA, the most limiting CDF value during outage is lower than the value in power operation, so it also can be bounded by full power operation assessment.

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2. Earthquake

2.1 Design basis

2.1.1 Design Basis Earthquake (DBE) of the plant

2.1.1.1 Characteristics of the DBE

The station Design Basis Earthquake (DBE) is classified into two categories as follows:

1. OBE: The Peak Ground Acceleration (PGA) of Operating Basis Earthquake for the station is 0.2g;
2. SSE: The Peak Ground Acceleration (PGA) of Safe Shutdown Earthquake (SSE) for the station is 0.4g.

The above values are selected in accordance with calculations derived from the magnitude 7.3 earthquake on the Richter scale that occurred in 1909. Its intensity was VIII+ on the Modified Mercalli scale. It was evaluated and analyzed in the KSNPP FSAR section 2.5, summarized as below:

According to historical records, the two greatest earthquakes (before 1999) happened in Keelung, northern Taiwan in 1867 and in Taipei, northern Taiwan in 1909 respectively. Therefore, the site relevant design criteria are based on the records of these two earthquakes.

The intensity (Taiwan scale) in Keelung area of the earthquake happened in 1867 north east of Keelung was V, or Modified Mercalli intensity of level VIII. From the damaged conditions in Kinpori in the historical record, it was conservatively inferred that the seismic intensity experienced at the Kuosheng site would have been V on the Taiwan scale. Judging from the report of destroyed houses at Kinpori, which was located about 5 kilometers northwest of the present Kuosheng site, an intensity of V (Taiwan Scale) may conservatively be assigned to the site area for this earthquake.

The earthquake that occurred in 1909 in the Taipei area (epicenter located 20 km south of Taipei at a depth of about 30 km) was assigned a Richter magnitude of 7.3. The intensity (Taiwan scale) felt in Taipei was V. According to the isoseismic map issued at that time, the intensity in the Kuosheng site area was estimated to be III or IV.

In the absence of reliable instrument measurement data, two earthquake events that occurred in 1867 and 1909 which had obvious seismic responses near the Kuosheng site area were estimated to result in intensity V around epicenter nearby area. Under conservative consideration, it is assumed that the bigger one of the two earthquakes occurred in the Kuosheng site. Therefore, the maximum potential earthquake defined in the station's FSAR assumed the earthquake of intensity VIII+ on the Modified Mercalli scale (MM scale) to occur at the Kuosheng site. The design basis of SSE and OBE are determined as below:

SSE: The maximum potential earthquake of Kuosheng site area is assumed the epicenter of the earthquake on the Modified Mercalli scale (MM scale) of intensity VIII+ occurring in the vicinity of the Kuosheng site. Based on this assumption, the corresponding peak ground acceleration in the Kuosheng site is 0.25g ~ 0.35g. Under consideration of safety margin, 0.4 g which is the hypothetical maximum vibratory intensity is selected as the peak ground acceleration the Kuosheng site.

OBE: The maximum historical intensity ever occurring in the station is VII to VIII in Modified Mercali scale which is equal to intensity V on the Taiwan scale. Based on this conclusion, the corresponding peak ground acceleration in the Kuosheng site is 0.2g. It is also the hypothetical intensity basis for the 40 years operation life of the power plant.

Note: According to Appendix A in 10CFR 100, the requirements of SSE and OBE are as follows:

SSE: The Safe Shutdown Earthquake (SSE) is based upon an evaluation of the maximum earthquake potential considering the regional and local geology and seismology and specific characteristics of local subsurface material.

OBE: The operating basis earthquake (OBE) is the reasonably expected intensity during the operation life of the power plant in considering the seismology and geology of the region surrounding the site.

2.1.1.2 Methodology to evaluate the DBE

Two methods used to evaluate the design basis earthquake (safe shutdown) for the Kuosheng plant are noted as follows:

1. Tectonic Province Method

   According to the historical records of the earthquake that occurred in Keelung in 1867, it was estimated that the intensity of this area was VIII (MM scale) judging from local area's damaged condition. According to seismographic graph to the earthquake in April 4, 1909 issued by Mr. Hsu Ming-Tong, it was assumed that the vibratory intensity at the epicenter was V (Taiwan scale) or VIII (MM scale). Geologically, these two earthquakes were not related. For conservative design, the larger of the two earthquakes was postulated to happen at the Kuosheng site with intensity VIII or VIII+ (MM scale). According to Trifunac & Brady proposal, the peak ground acceleration of the second nuclear power plant is approximately 0.25~0.35g. In conservative consideration, 0.4 g is selected as the peak ground acceleration for the Kuosheng site.

2. Geologic Structure Method

   The two major faults closest to the station are Hsinchuang fault and Kanchiao fault. According to investigations, the two faults have not moved during the past million years. Therefore, they were not considered active according to geologic and seismic siting criteria adopted by the United States Nuclear Regulatory Commission. (*According to these criteria, a fault is considered* *active if there has been surface movement at least once within the past 35,000 years or more than once in the past 500,000 years.)* Therefore, it was concluded in the plant FSAR that these faults did not contribute to the seismic risk of the area and need not be considered in the plant seismic design. (For more details, please refer to the description given in FSAR Section 2.5, in particular, paragraph 2.5.2.2, Geologic Structures and Tectonic Activity, page 2.5-33)

It was assumed by Geologic Structure Method that the earthquake occurred near Banqiao on April 15, 1909 with a magnitude of 7.3 on the Richter scale was induced by the Hsinchuang fault inferred to exist 4.8 kilometers northwest of the Kuosheng site. Taking into account of the attenuation relative to distance, the peak ground acceleration at the site was estimated to be 0.4g (SSE). The conclusions of above-mentioned two methods are used to determine the station SSE that 0.4g was used as the station SSE of foundation bedrock under building foundations for the major building design.

In response to new evidence of the Shanchiao fault, Taipower has commissioned the Institute of Nuclear Energy Research to do the evaluation. Preliminary result has confirmed fault length is 34 km inland and over 40 km offshore after investigation of geological topography. Although the investigation result of the fault length is longer than the promulgation issued by Central Geological Survey, further geological survey will be performed to confirm the total length of the Shanchiao fault, Taipower will take the essential actions depending on the result of survey.

Regarding the Seismic Margin Assessment (SMA), both commissioned consultant companies Bechtel and S&A will focus on essential buildings, foundation of equipment, pipes and supports to do the assessment based on existing PRA. At a later date, it will be re-evaluated according to the result of Seismic Probability Risk Assessment (SPRA) done by the Institute of Nuclear Energy Research. If there is any deficiency, complementary enhancements will be taken.

2.1.1.3 Conclusion on the adequacy of the DBE

According to the US Nuclear Regulatory Commission (NRC) regulations, the seismic design criteria for building in nuclear power plants must base on the geological and seismic conditions within the site sitting scopes of 320km to calculate the potential threats to nuclear power plants by possible active faults (it means that faults had been activated one time during 35,000 years or activated twice during 500,000 years). And then, domestic and overseas experts referred to historical maximum earthquake records to calculate the design basis earthquake in nuclear power plants.

According to the special issue No. 19 (07, 2007) issued by Central Geological Survey, Ministry of Economic Affairs, the Shanchiao Fault which is in North-North-East move toward direction is classified as a normal fault. It can be divided into two sections: The southern section is 13km long extended from Sulin District, New Taipei City to Peitou District, Taipei City. The northern section is 21km long extended from Peitou to Jinshan (a.k.a Chinshan) District, New Taipei City. The latest activated time of the fault is approximately 10,000 years ago. It is temporarily classified into the second active fault.

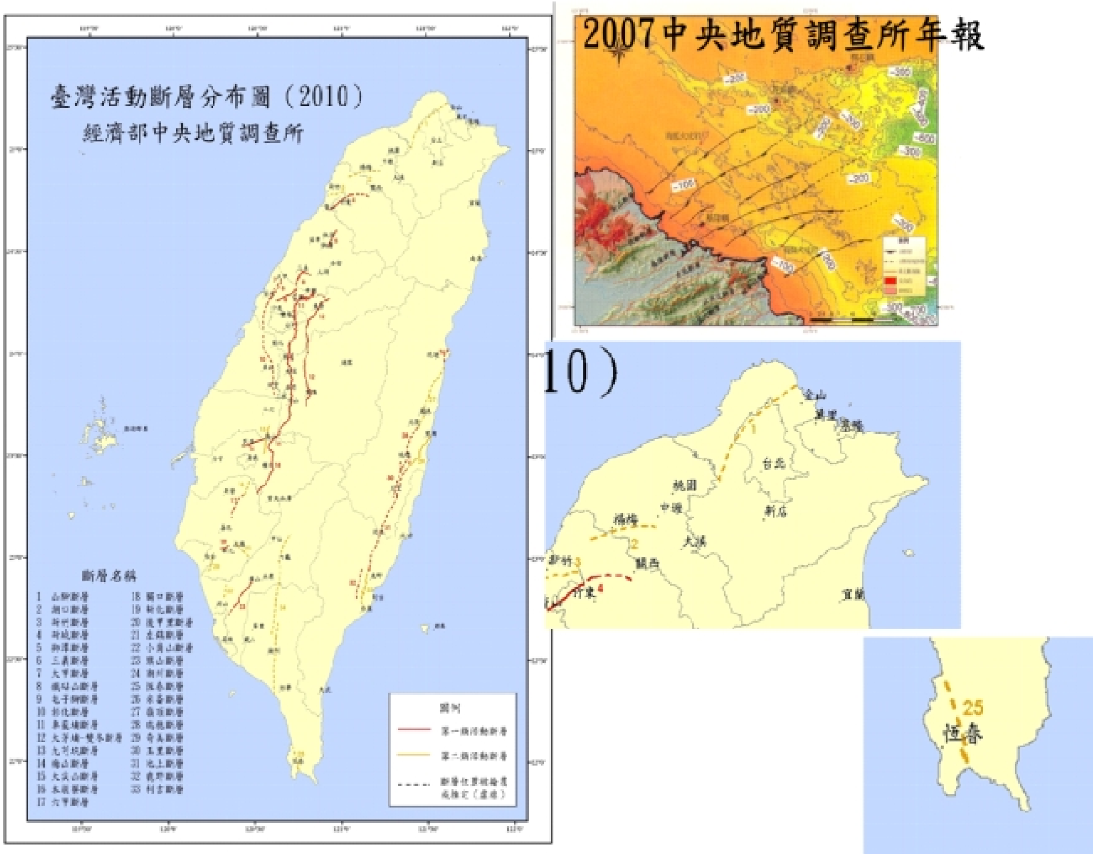


Fig 2-1

According to the data issued by Central Geological Survey, Ministry of Economic Affairs, Taiwan Power Company committed National Central University to conduct “Site Vibratory Characteristic and Seismic Reaction Study for nuclear power plant” (completed in May, 2009). Its preliminary evaluation results are as bellows:

Table 2-1

Fault	Length under the Land	Length under the Sea	Depth of Epicenter	Magnitude (ML)	Calculated ground surface acceleration
Shanchiao Fault	34 km	16.6km	10km	6.8	0.3g

Table 2-2

KSNPP foundation bedrock acceleration value calculated from Shanchiao Fault	0.3g
KSNPP Base foundation bedrock designed acceleration value	0.4g
Ground surface acceleration calculated from foundation bedrock designed acceleration value	0.56g

When the earthquake induced by Shanchiao Fault was propagated to the foundations of KSNPP Reactor Building, its vibratory acceleration value 0.30g is less than that of the station FSAR evaluated and analyzed design basis earthquake value 0.4g (please refer to the description in section 2.1.1.1).

2.1.2 Provisions of the plant to protect against the DBE

2.1.2.1 Key SSC needed to achieve safe shutdown state after the earthquake

The seismic classifications for the station major building structures in Nuclear Island are listed below:

Table 2-3

Equipment \ Relevant Parameters		Elevation(Above sea Level) m	Seismic Category
Power	Off-site power	Startup Transformer: 27m; Emergency Startup Transformer: 12m	II
	Emergency Diesel Generator	12m	I
	The Fifth Diesel	12m	I
	Gas Turbine Generator	22m	II
Water source	Emergency Circulating Water Pump	7.9m	I
Drainage Creek	Creek A (Main Security Gate)	9.5m at Bottom of Creek /13 m at Ground level	II
	Creek B (Heavy Equipment Warehouse)	11.6m at Bottom of Creek /15 m at Ground level	II
RPV Cooling (Flooding)	Emergency Core Cooling System(RHR)	Inside Containment	I
	Fire Water(Raw Water)	90m (bottom of Pool B)	II
	Sea Water(Inject to Reactor)	NA	NA
Reactivity Control	Control Rod	Inside Containment	I
	Standby Liquid Control	Inside Containment	I
	Backup Boron Injection	Inside Containment	I
Containment / Reactor Integrity	Hydrogen Control	Inside Containment	I
	Hydrogen Ignition system	Inside Containment	I
	Containment Exhaust	Inside Containment	I
	Standby Gas Treatment System	Inside Containment	I
Oil Tank	Div. I Emergency Diesel Generator Fuel Oil Tank	7m	I
	Div. II Emergency Diesel Generator Fuel Oil Tank	7m	I
	Div. III(HPCS)Emergency Diesel Generator Fuel Oil Tank	7m	I
	The Fifth Diesel Generator Fuel Oil Tank	12m	I

	Gas Turbine Fuel Oil Tank	22m	Ⅱ
	35000 kiloliter Fuel Oil Tank	101m	Ⅱ

The station important storage tanks are listed below:

Table 2-4 Important Storage Tank in Kuosheng NPP

Storage Tank	Capacity(m^3)	Seismic Category	Elevation	Material Type of Structure
CST(Unit 1)	3029	I	12m Underground Concrete Structure	Closed type Steel-reinforced Concrete Structure
ACST(Unit 1)	1325	Ⅱ	12 m Aboveground Water Tank	Closed type Steel-reinforced Concrete Structure
CST(Unit 2)	3029	I	12m Underground Concrete Structure	Closed Steel-reinforced Concrete Structure
ACST(Unit 2)	1325	Ⅱ	12m Aboveground Water Tank	Closed type Steel-reinforced Concrete Structure
DST(Common)	189	Ⅱ	12m Aboveground Water Tank	Steel-reinforced Structure
ADST(Common)	189	Ⅱ	12m Aboveground Water Tank	Steel-reinforced Structure
Raw Water Reservoir A(Common)	19508	Ⅱ	100m Slope	Opened Steel-reinforced Concrete Water Pool
Raw Water Reservoir B(Common)	23858	Ⅱ	90m Slope	Opened Steel-reinforced Concrete Water Pool
Raw Water Reservoir C(Common)	25000	Ⅱ	9m Underground	Closed Steel Concrete Water Pool
Raw Water Reservoir D(Common)	25000	Ⅱ	9m Underground	Closed Steel-reinforced Concrete Water Pool

The required critical systems, structures and components (SSC) for unit safe shutdown are listed below:

A. Structure:

1. Control Building –Seismic Category I
2 Auxiliary Building - Seismic Category I
3. Diesel Generator Building - Seismic Category I
4. Reactor Building - Seismic Category I
5. Emergency Circulating Water Pump House - Seismic Category I

B. System and its backup systems:

1. Emergency Diesel Generator (Div. Ⅰ/Ⅱ/Ⅲ及 5th) - Seismic Category I
   Fuel Oil Transfer System - Seismic Category I
   Air Starting System - Seismic Category I
   Jacket Water Cooling System- Seismic Category I (5th D/G is air cooled)
2. Emergency Core Cooling system ECCS (RHR A/B/C, HPCS, LPCS) - Seismic Category I
   Power Supply (EDG) - Seismic Category I
   Emergency Cooling Water Sources (ECW) - Seismic Category I
3. Reactor Core Isolation Cooling (RCIC) - Seismic Category I
   Water Source for Condensate Storage Tank - Seismic Category I
   125V DC Power - Seismic Category I
4. Automatic Depressurization System (ADS) - Seismic Category I
   205 PSIG High Pressure Air Storage Tank - Seismic Category I
   125V DC Power - Seismic Category I
5. Emergency Chilled Water System - Seismic Category I
   Emergency Chilled Water Source (ECHW) - Seismic Category I
   Power Supply (EDG) - Seismic Category I
6. Emergency Circulating Water System (ECW) - Seismic Category I
   Power Supply (EDG) - Seismic Category I
   Water Source (Sea water) - Emergency Circulating Water System Intake Structure is Seismic Category I

The structures and equipment required for safe shutdown are all designed as seismic category I, and shall be operable under Design Base Earthquake condition to ensure unit safe shutdown.

2.1.2.2 Main operating provisions to avoid reactor or SFP damage after earthquake

The structures of the station reactor, spent fuel pool and fuel Building are all designed as seismic category I. The main operation provisions to avoid damage of reactor or spent fuel pool after earthquake are respectively described as follows:

1. Reactor building：

   The station procedures already specified necessary actions of each emergency response measures and checkup procedures after earthquake so as to assure equipment integrity. According to the requirement of procedure 575 “Emergency procedure for earthquake,” after earthquake the shift manager shall inform relevant maintenance sections as per 575.1 “Unit detailed checkup procedure after earthquake” to check the important items according to “Essential equipment and structures check list as well as “Equipment and structures check criteria” because systems and equipment may have different mode of failures caused by strong earthquakes. And then, the Station Operation Review Committee (SORC) shall review and evaluate all plant checkup results and test reports.

A. procedure 575 “Emergency procedure for earthquake” ;

Purpose: The guideline is provided for operator to take immediate emergency response actions in case of earthquake.

Short Summary: Please refer to Fig 2-2 “Nuclear Power Plant Emergency Response Flow Chart”

(A) After earthquake, Shift Manager/Shift Supervisor shall judge the damaged condition of unit equipment and decide whether to continue operation or shutdown step by step or manual scram. The determination rule of unit whether to continue operation is as follows:

a. Unit operation can be continued if vibratory intensity < OBE and there is not any severe damage found.

b. Unit shall be shutdown if vibratory intensity < OBE but any following condition:

- Due to equipment severe damage, unit safe operation is impacted .
- Severe radiation release due to earthquake
- Unit must be shutdown as per Technical Specification requirements due to system inoperable.

(B) If vibratory intensity > OBE, verify that an automatic reactor scram initiated by the RPS high seismic intensity trip signal is successful --- in case the automatic seismic scram fails to work as designed, a manual scram shall be initiated. Furthermore, reactor shall be quickly de-pressurized to 35 kg/cm^2 and then the unit shall be rapidly reached to cold shutdown state as per steps “RPV anticipated emergency pressure relief” in procedure 1451 “The Station Ultimate Response guidelines”. Besides, it shall be checked if tsunami will attack the station as per procedure 577.2.

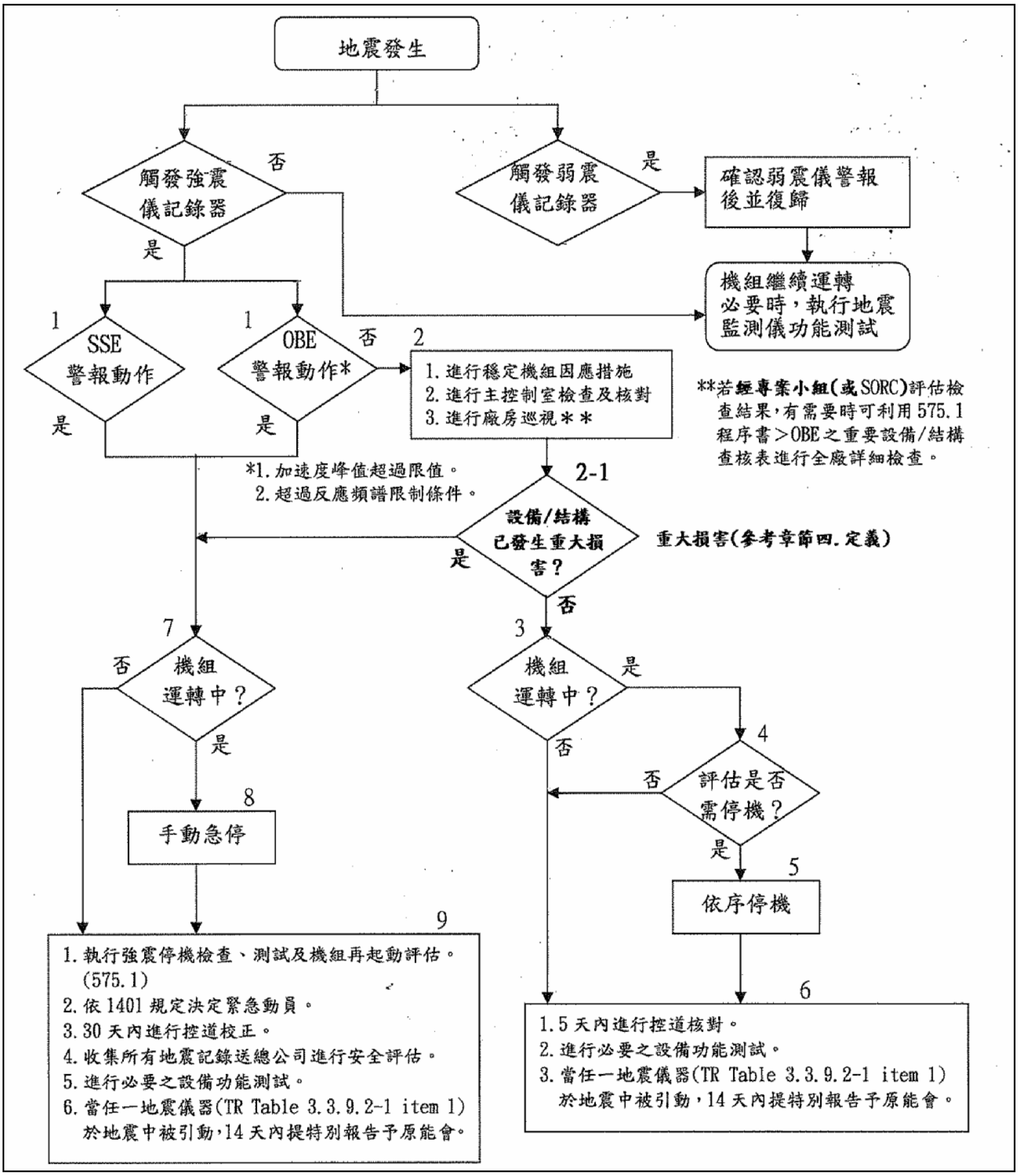


Fig 2-2 Nuclear Power Plant Emergency Response Flow Chart

(C) Unit shall be inspected and checked after earthquake as per the attachments (Control Room inspection and checkup list) and (Buildings Surveillance) in procedure 575 and it shall be completed within 24 hours. The inspection and checkup results shall be submitted to SORC for review if it impacts unit operation function.

(D) Vibratory intensity > OBE and after unit shutdown

The following actions shall be taken:

a. Unit shut down inspection shall be performed after strong earthquake and Unit re-startup shall be evaluated.

b. Emergency mobilization action shall be taken as per procedure 1401.

c. Control channel shall be calibrated within 30 days.

d. All seismic records shall be submitted to Head Office for safety assessment.

e. Special report shall be submitted to ROCAEC 14 days after earthquake if any seismometer (TR Table 3.3.9.2-1 item 1) is actuated.

f. The required functional tests shall be performed.

(E) Vibratory intensity < OBE and after unit shutdown

The following actions shall be taken:

a. Control channel shall be checked within 5 days.

b. The required functional tests shall be performed.

c. Special report shall be submitted to ROCAEC 14 days after earthquake if any seismometer (TR Table 3.3.9.2-1 item 1) is actuated.

B. Procedure 575.1 “Unit detailed checkup procedure after earthquake”:

Purpose: After strong earthquake, it may result in damage and malfunction of any equipment / structures. It shall be observed, inspected, and evaluated to judge whether to continue operation the unit or normal shutdown step by step. When Vibratory intensity reaches > OBE (Operating Basis Earthquake), the station shall conservatively adopt URG to rapidly depressurize the reactor after its automatic or manual scram. However, the essential equipment which used to mitigate accident consequence maybe damaged under synergetic effects of strong earthquake, e.g., equipment damage caused by pipe break flooding or by oil tank or lube oil fire accident may render it unable to perform their intended function. The station shall walk down to clear the possible weak point and to replace the abnormal equipment with the other equipment or to carry out rush repair in order to reduce unit possible risk and to secure unit safety.

Short Summary: In case of Seismic intensity > OBE:

(A). The station overall inspection and checkup shall be performed as per the procedure 575 “Seismic emergency procedure” based on Shift Manager or SORC request. The maintenance personnel including Mechanical Section, Repairs Section, Electrical Section, Instrumentation and Control Section, and Engineering Improvement Section shall perform the overall detailed inspection and checkup as per “The station essential equipment / structures check list” and “Equipment / structures key point inspection criteria” .The inspection personnel shall have maintenance experience and specialty.

(B). Major important items shall be inspected and checked-up based on SORC request. The inspection and checkup results shall be submitted to SORC for review if unit can be continuously operated or shall be shutdown. If unit shutdown is required, the process as shown in figure 2-3 “Strong earthquake shutdown inspection, test, and unit restart-up flow chart”

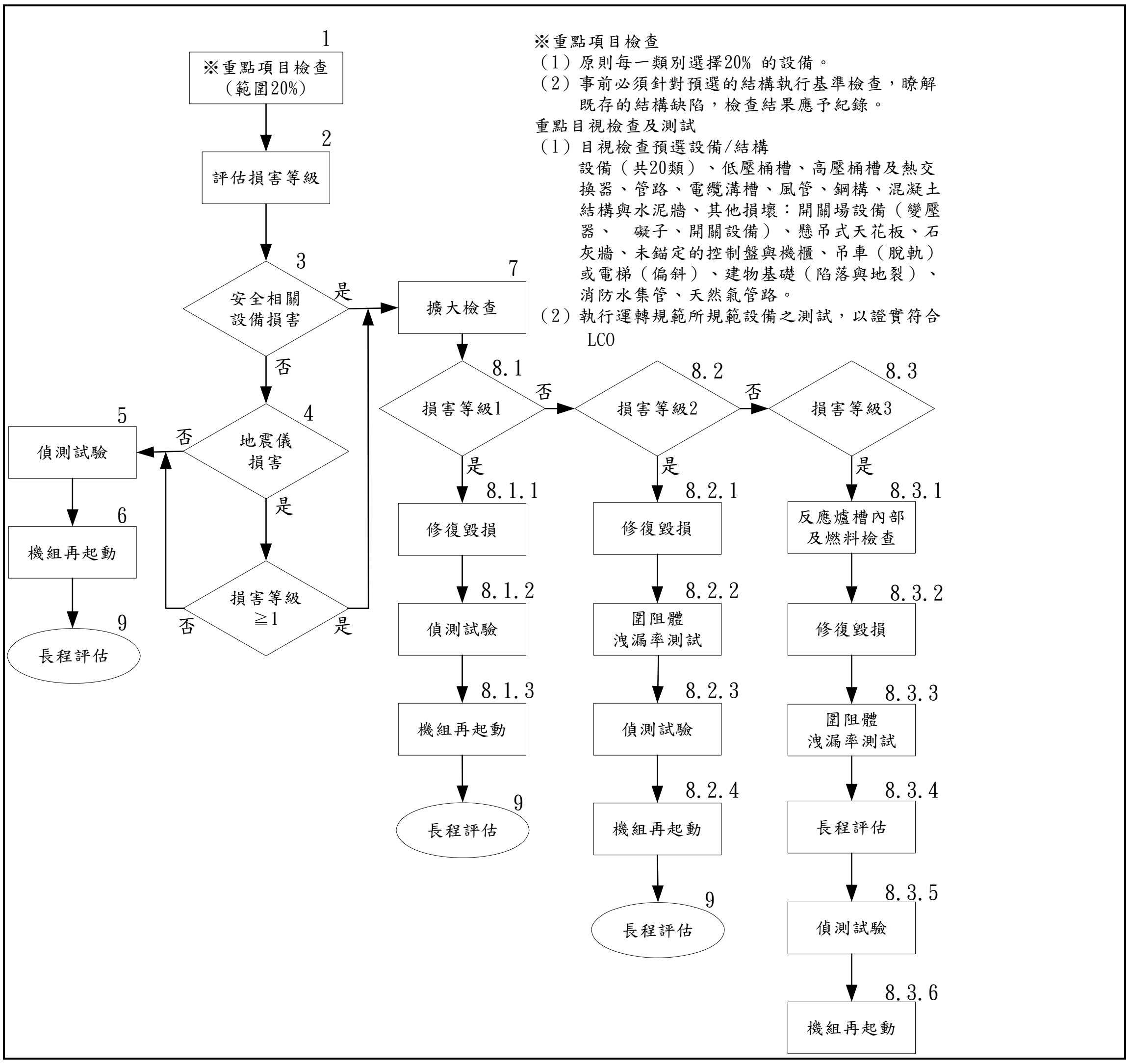


Figure 2-3 “Strong earthquake shutdown inspection, test, and unit restart-up flow chart

(C). After strong earthquake, all accessible areas in the station shall be inspected and checked-up per reactor building check list, auxiliary building check list, turbine building check list, electrical equipment check list, surrounding area equipment check list, radwaste building check list, and switchyard check list. The important inspection items shall include as follows:

a. The leakage condition of piping systems.

b. The damage condition of low pressure tanks.

c. The damage condition of switchyard equipment

d. Actual level of tank level indication.

e. High vibration, high bearing temperature, and noise condition of revolving equipment.

f. The equipment damaged condition resulting from collapse of nearby materials or hit by falling materials

g. Deformation or loose of essential equipment / structural anchor bolts resulted in its reverse or slippage or displacement condition.

h. The damage condition of the addition pipe including flexible tube, short pipe (pipe spool), and conduit.

i. Pipe damage and pipe support displacement condition

j. The deformation condition of electrical cabinets (panels) and inside components.

k. The crack or scale condition of concrete structures

l. The operable condition of important relays, breakers, and other vibration vulnerable electrical components.

m. Unsecured equipment may fall down on the safety related shutdown equipment.

n. To check if equipment damage caused by flooding accident due to pipe break or water spray may render it unable to perform its intended function.

o. To check if equipment damage caused by oil tank or lube oil fire accident may render it unable to perform its intended function.

(D). There is no severe damage on safety related equipment after inspection:

a. The Operation Section shall carry out the following required surveillance tests:

(a) Control rod insert and withdraw test: If necessary, Nuclear Engineering Section and Instrumentation and Control Section shall be informed to dispatch person to join the test. Each control rod shall be moved to confirm if its condition is normal or not as per procedure 612.3.1.1.

(b) The leakage rate of reactor coolant system and the flow rate of drywell sump shall be calculated to confirm if it is normal or not as per procedures 260.2.1 (for unit 1) & 260.2.2 (for unit 2).

(c) Additional testing items decided by SORC

b. Taipower Headquarters shall set up an evaluation team to evaluate and propose the unit’s restart-up evaluation report after earthquake and submit it to ROCAEC for approval. Unit shall not be restarted-up until ROCAEC approved.

c. Taipower Headquarters shall establish a project team to push the long term evaluation.

(E) There is severe damage on safety related equipment after inspection:

a. Each maintenance section shall expand VT inspection scopes:

(a) All the safety related equipment including supports is not included in the major important inspection items.

(b) All the safety related branch systems including supports.

(c) Containment including penetrations.

(d) Main condenser and sea water tunnel.

(e) The interface connection of embedded pipe with building and tank.

b. The following steps shall be performed depending on its damage degree:

(a) The measures for damage degree 1

<a> damaged items shall be repaired.

<b> The following surveillance tests shall be carried out:

- ✓ Control rod insert and withdraw test:
  If necessary, Nuclear Engineering Section and Instrumentation and Control Section shall be informed to dispatch person to join the test. Each control rod shall be moved to confirm if its condition is normal or not as per procedure 612.3.1.1.
- ✓ The leakage rate of reactor coolant system and the flow rate of drywell sump shall be calculated to confirm if it is normal as per procedures 260.2.1 (for unit 1) & 260.2.2 (for unit 2.).
- ✓ Test items are increased depending on SORC decision.

<c>Taipower Headquarters shall set up an evaluation team to evaluate and to propose the unit restart-up evaluation report after earthquake and submit it to ROCAEC for approval. Unit shall not be restarted-up until ROCAEC approval and then long term evaluation shall be continued. The content of unit restart-up evaluation report shall include:

- ✓ After earthquake essential equipment and structures check list
- ✓ The increased inspection scope and its content repot.
- ✓ Equipment and structures damage and repair list and surveillance test report.

(b) The measures for damage degree 2

<a> damaged items shall be repaired.

<b> Containment leakage test shall be carried out:

<c> The following surveillance tests shall be carried out:

- ✓ Control rod insert and withdraw test: If necessary, Nuclear Engineering Section and Instrumentation and Control Section shall be informed to dispatch person to join the test. Each control rod shall be moved to confirm if its condition is normal or not as per procedure 612.3.1.1.
- ✓ The leakage rate of reactor coolant system and the flow rate of drywell sump shall be calculated to confirm if it is normal as per procedures 260.2.1 (for unit 1) & 260.2.2 (for unit 2.).
- ✓ Each test items per technical specification requirements shall be carried out.
- ✓ TSC or Seismic Inspection Team proposed surveillance test items.
- ✓ The surveillance tests for repair items.

<d> Taipower Headquarters shall set up an evaluation team to evaluate and to propose the unit restart-up evaluation report after earthquake and submit it to ROCAEC for approval. Unit shall not be restarted-up until ROCAEC

approval and then long term evaluation shall be continued. The content of unit restart-up evaluation report shall include:

- ✓ After earthquake essential equipment and structures check list
- ✓ The increased inspection scope and its content repot.
- ✓ Equipment and structures damage and repair list and surveillance test report.
- ✓ Containment Integrated Leakage Test (ILRT) report.

(c) The measures for damage degree 3:

<a> Reactor pressure vessel internal and fuel shall be inspected.

<b> Damaged items shall be repaired.

<c> Containment leakage test shall be carried out.

<d> Long term evaluation shall be continued

<e> All periodical surveillance test and overall system tests shall be carried out as per procedure 700.

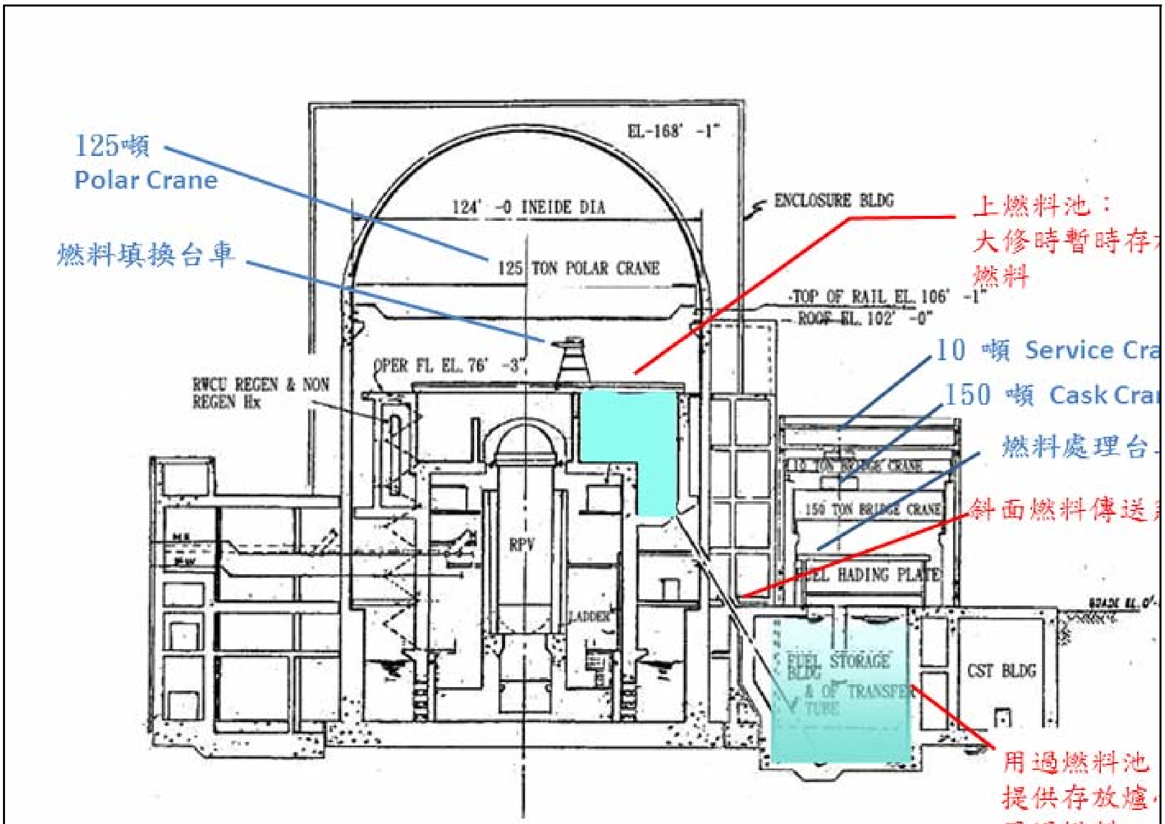
<f> Taipower Headquarters shall set up an evaluation team to evaluate and to propose the unit restart-up evaluation report after earthquake and submit it to ROCAEC for approval. Unit shall not be restarted-up until ROCAEC approval and then long term evaluation shall be continued. The content of unit restart-up evaluation report shall include:

- ✓ After earthquake essential equipment and structures check list
- ✓ The increased inspection scope and its content repot.
- ✓ Equipment and structures damaged and repaired list and surveillance test report.
- ✓ After earthquake equipment and structures seismic capability assessment report.
- ✓ Containment Integrated Leakage Test (ILRT) report.
- ✓ All periodical surveillance test report.

The Site has installed a strong earthquake scram facility in each unit. Four sets of acceleration sensors are installed in 1st floor and 3rd floor of auxiliary building in each unit. When acceleration sensor detects the signal of vibratory intensity reaches its set point, reactor protection system shall be actuated and scram the reactor to assure safety.

2. Fuel pool:

The station fuel pool for each unit is divided into the spent fuel pool in fuel building and upper pool in reactor as shown in Figure 2-4.:



附圖三-1 核二廠燃料池示意圖

Figure 2-4 Spent Fuel Pool Diagram

A. Spent Fuel Pool

Spent Fuel Pool is divided into East Pool, West Pool, and Spent Fuel Transfer Pool. East Pool and West Pool are used for storage of spent fuel and Spent Fuel Transfer Pool is used to transfer the fuel during outage. They are all steel concrete structure and their surfaces are lined by stainless steel plate. The minimum water level during normal operation is maintained in 23 feet above the top of spent fuel rack and fuel rack. The Spent Fuel Pool can maintain the water level 8 feet higher than the storage height of fuel elements in case that Fuel Transfer Gate is damaged and leaked due to earthquake during the period Transfer Pool drains water in order to do maintenance work of piping and valves. Even if all the piping inlets, outlets, and drains leakage, Spent Fuel Pool water level shall not drain lower than the minimum water level 8 feet of fuel element.

The seismic capabilities of relevant equipment which may impact spent fuel pool structural integrity are listed as follows:

a. Fuel Building: Seismic category I

b. Cask Crane and Service Crane supports: Seismic category I.

c. Spent Fuel Pool and its liner: Seismic category I

d. Fuel handling Platform, Cask Crane, and Service Crane: Seismic category I.

According to the station's calculation and evaluation for the impact to the Spent Fuel Pool structural integrity due to heavy materials falling down: the weight of Cask Crane is 244,000lbs, 30'-4" height above the floor; the weight of Service Crane is far lighter than that of Cask Crane; the height of Fuel Handling Platform above the floor is very low. Therefore, the impact force of the crash of Cask Crane with Cask and its hangers (The total weight of Cask Crane with Cask and its hangers is 220,000lbs) is the maximum. Its average crash impact force to RC wall is 14.82 N/mm2 far smaller than RC concrete crack intensity of 23.8 N/mm2 so that RC wall shall not be damaged and the Spent Fuel Pool structural integrity can be maintained.

Note: This evaluation is based on the weight of Fuel Cask and its hanger 220,000lbs but the actual weight of Fuel Cask and its hanger depending on its supplier's design.

Cask Crane rail is designed to carry equipment and components only in the outside area of East Pool so as not to damage the fuel in Spent Fuel Pool in case of material falling down. Service Crane is usually parked in the east of East Pool where is far away from Spent Fuel Pool so as not to damage the fuel in Spent Fuel Pool in case of material falling down.

The surface of steel concrete in Spent Fuel Pool is lined by stainless steel plate in order to avoid contaminated water leaks to surrounding areas along the crack in case that steel concrete cracks. There is installed a connect-through drain pipe under the stainless steel plate lining to lead contaminated water drainage to Fuel Building Drainage Sump in case that the stainless steel plate in Spent Fuel Pool occurs cracks due to external force. There is installed a leakage detector on the connect-through drain path and its flow signal is transmitted to Control Room Annunciator Panel in case it detects of water flowing through the connect-through drain pipe. The station can take the necessary actions as per the station's procedure if there is abnormal condition.

Although the spent fuel pool cooling system is not designed as seismic category I, its necessary cooling can still proceed via seismic category I RHR spent fuel pool cooling mode in case that it is damaged due to earthquake so as not to result in loss its cooling function.

B. Upper Pool

Upper pool is divided into Fuel Storage Pool and Fuel Transfer Pool and pool are lined with stainless steel plate. Stainless steel fuel racks in the Fuel Storage Pool are used for temporary storage of fuel elements during outage. Fuel Transfer Pool is used to transfer fuels during outage. Fuel Storage Pool is separated from Fuel Transfer Pool with a wall and a gate to secure that sufficient water to cover with fuel in case there is massive leakage in Fuel Storage Pool or Fuel Transfer Pool.

The seismic resistant capability of relevant equipment which impact upper pool structural integrity is listed as follows:

A. Reactor Building: Seismic category I

B. Polar crane and its supports: Seismic category I.

C. Reactor Building Upper Pool & Liner: Seismic category I

D. Refueling Platform: Seismic category I.

E. 360-Degree Work Platform: Seismic category I.

According to the station calculation and evaluation for the impact to the Upper Pool structural integrity due to heavy materials fall down: the weight of Polar Crane is 583,930lbs, 26’-1 1/2”in height above the floor; the height of Refueling Platform above the floor is very low. Therefore, the impact force of Polar Crane with RPV Top Guide and its hangers (The total weight of Polar Crane with RPV Top Guide and its hangers is 165,000lbs) of heavy materials falling down above 7 floor is the biggest. Its average impact force to RC wall is 7.14 N/mm^2 far smaller than RC concrete crack intensity of 29.8 N/mm^2 so that RC wall shall not be damaged and the Upper Pool structural integrity can be maintained.

Polar Crane is usually parked far away from the Upper Pool in order to avoid falling to damage the Upper Pool. The 360-Degree Work Platform above Reactor Cavity shall not be moved to above the Upper Pool during outage so that there is no safety potential to the fuel.

2.1.2.3 Indirect effects of the earthquake taken into account

1. Seismic resistant capability of safety related system associated equipment:
   As stated in section 2.1.2.1, the structures, systems and components required for unit safe shutdown are all designed as seismic category I so as to be able to withstand Design Basis Earthquake to maintain its’ integrity.

2. Internal Flooding:
   Internal flooding impact had been evaluated by Taipower Nuclear Engineering Department and its evaluation scope includes Reactor Building, Auxiliary Building, Fuel Building, Diesel Building, Control Building, Radwaste Building, and Turbine building. It is found from the analysis result that the flooding height of the other buildings are all less than 6” or the flooding of the other buildings will not happen except that several safety related compartments (HPCS, LPCS, RCIC, and RHR etc) may have 0.78~1.71 feet flooding potential and may impact the Leg Pump operation. The equipment compartments of the above-mentioned potential flooding buildings are all installed with water-proof doors and its flooding alarm will be alerted in case that flooding accident happens so that they will not impact other areas and their equipment surrounding the equipment compartments and the operability of the other divisions. The safety related systems in the other divisions will not be impacted. The station essential equipment compartments are all installed with water-proof doors and floor sump pumps. During normal operation the Main

Control Room can supervise the floor sump water level any time and sump pump shall be automatically started to pump floor sump water if there is abnormal water level condition so that it can meet the adaptable response need for abnormal water level condition.

The station already started surveillance test of the relevant pumps and its test result meets specification requirement. Moreover, the relevant water drain operating procedures in each building were reviewed and procedure 577.1 “Emergency water drain in each building operating procedure” is added to immediately dispatch person to check if sump pump is normal operated or not in case of each building flooding event. Besides, the drain flow source is traced as per procedure 566.4 and properly isolated. In case of station blackout, drainage water is directly drained to the programmed collection place by means of sump pump which its power is temporarily supplied by mobile diesel generator or gasoline engine pump.

If sump water level in any essential equipment room is more than “maximum safe operation level”, unit shall be downloaded and maintained in safe shutdown condition as per emergency operating procedure EOP-500.6. Moreover, if each building ground water became serious flooding, unit shall be shutdown and maintained in safe shutdown condition as per new added process “Attachment 1: Site area and management process” in procedure 577 “Extra raining or flooding emergency operating procedure” (Attachment 2-1) and depending on the different guideline judging from the flooding height and its impact serious extent on each building.

The station radwaste on-shift engineers who concurrently serve as water pump staff shall manage the building flooding event at any time. Control room engineer shall follow the above-mentioned process and take necessary action to rapidly shutdown the unit in safe shutdown condition as per the above-mentioned management process depending on flooding impact serious extent so as to mitigate its impact to unit safety to the minimum.

3. Loss of off-site power

The station off-site power may be lost in case of DBE strong earthquake because it is designed as seismic category II. In this condition, each unit is designed to equip with two sets of seismic category I emergency diesel generators to provide the power which is needed to safely shutdown the reactor. Moreover, the station is also designed to equip with one set of seismic category I the fifth air-cooled emergency diesel generator which is common to both units as the backup of any of above-mentioned EDG at any time in case that any of above-mentioned EDG lost its intended function.

Furthermore, DCR-K1-2855/K2-2856 were issued according to the proposal in “Improvement Measure Effectiveness Assessment Report for KSNPP’s Response to Loss of Off-site Power Under Power Operation” issued by Institute of Nuclear Energy Research to upgrade the power capacity of safety related battery sets A, B, C, & D from 8 hours to 24hours. Its relevant operation process for isolation of non-essential loads is also incorporated in the station procedure 500.15

and the clear tag is also hanged on DC power distribution panels in order to remind operator to follow.

The station already completed the review of power allocation response measures in case of beyond design basis earthquake. Its relevant contents please refer to chapter 5 "Loss of power and loss of ultimate heat sink" and is summarized as follows:

A. The fifth air-cooled diesel generator and two sets of gas turbine generators can provide essential power in case that station blackout happens and cooling seawater is completely lost. And also, the fifth air-cooled diesel generator provides power to both units' essential bus was already programmed and its relevant process was incorporated in the station procedure 1451.

B. 4.16 kV emergency power directly supplied to switchbox bus was programmed in case of non-segregated phase bus duct (NPBD) failure and its relevant process was incorporated in the station procedure 1451.

C. DCR-K1-2855/K2-2856 were issued to install an additional disconnect switch on the rear side of switchbox bus 1(2)A2 in order to directly supply power to switchbox bus 1(2)A4 via the cable by means of black start diesel generator or 1500kW mobile power truck in case of emergency.

Other response and enhancement measures for off-site power loss including the improvement measures of emergency diesel generator building and emergency circulating water pump house water-proof, the extension measure of emergency diesel generator operation time, and additional procurement of each kind of diversity power supply are prepared to maintain the station long term accident response capability so as to assure that reactor core is long term covered with water and fuel integrity is maintained.

4. The required manpower and facilities are delayed to arrive at the site by off-site road blockage due to earthquake:

   The accident occurrence time can be divided into normal work time period and unusual work time period which are respectively described as follows:

   <u>A. Accident happens duringoffice hours:</u>

   a. If operation shift personnel can not arrive at the site for take-over, the training manpower in simulator center and mobile support group can take over and support unit operation.
   b. The maintenance manpower including on-site maintenance manpower and long term on-site contracting manpower which have total one hundred persons can satisfy with the emergency maintenance requirement in case of emergency condition.
   c. The on-site fire station manpower has 8 persons on the second shift (day shift). Duringoffice hours, the emergency fire brigade manpower can be augmented to 48 persons to support fire fighting according to emergency response organization,.
   d. The station can establish in no time the emergency mobilization organization to support

rush repair and operation.

B. Accident happens during off-office hours:

a. Emergency mobilization shall be initiated in no time according to the procedure 1407 “TSC Mobilization and Response process”, and the procedure 1409 “HPC Mobilization and Response process”. If off-site road can’t be accessed due to earthquake, plant will immediately report it to Nuclear Emergency Preparedness Execution Committee (NEPEC) requesting for support. NEPEC will co-ordinate manpower and resources of whole company, then make a request to Nuclear Incident Response Headquarter led by the central government for support of sending engineering soldiers to repair offsite roads and bring the plant staff, workers, equipment, and goods to and out of the site by helicopters. Injured staff and workers can also be airlifted to hospitals. In response to plant request for backup, Central Hazards Response Center functions as follows：

   1. Heavy mechanical equipment can be used to rule out the roadblock.
   2. The station Minguan Jetty can be used for carrying the rescue personnel and the hang type rescue equipment via sea transportation.
   3. Helicopter which can use the playground of Dapeng elementary school 1km away the station or the station vacant space for landing shall be used for carrying the rescue personnel and the hang type rescue equipment.

b. There are 24 maintenance personnel who live in the single standby-duty dormitory on-site will be mobilized for rush repair of the damage equipment. Besides, the maintenance personnel total 23 persons who live in Jinshan and Wanli District shall be advised to enter the site for assistance of emergency response management. Moreover, there are around 100 technical personnel who live in Jinshan and Wanli District will be requested for support according to emergency rush repair terms in the maintenance contract in case of emergency condition.

c. At present the on-site fire station manpower which adopts the way of contract out is maintained 8 persons in site. The on-site fire station contracted manpower who all come from Jinshan District can emergently enter the station in case of emergency condition.

5. The capability of Fire Protection and Fire Fighting facilities:

Each safety related system used to mitigate the accident consequence is designed as seismic category I depending on its importance in accordance with the station design criteria manual. Plant arrangement also adopts separate rule (for instance, in different room). Non-safety related system equipment is designed in different seismic class depending on its importance and its location if could impact safety related equipment or not. In case that earthquake vibratory intensity exceeds its design basis, it could only impact its availability but will not impact other operable equipment. For the equipment in different safety divisions, they are separated from different fire compartments and fire barriers so that the equipment in different divisions will not be simultaneously burn out due to fire protection facilities failure.

For the seismic resistant capability of fire protection piping, The station shall enhance the walkdown and maintenance works for source equipment and piping which is not seismic category I, and already installed a water supply pipe and its relevant valves from fire water reservoir to 14" main fire water circulating pipe valve. In case that the existing fire water supply pipe is broken, its isolation valve can be manual closed and then fire water can be supplied to the 14" main circulating pipe by way of this new addition pipe. Furthermore, the DCR was issued to change the 12" fire water pipe and raw water pipe in protection area from cast iron underground pipe to carbon steel exposed pipe and its seismic class is designed as category I so as not to impact fire water supply in case of earthquake.

For fire protection capability, the station is equipped with the fire brigade total 34 persons who in turn 24 hours three shift on duty in the duty room no matter if it is national holiday in order to assure rapid mobilization for fire fighting. Moreover, the station is equipped with the emergency fire brigade total 48 persons. Operation Support Center (OSC) shall call the emergency fire brigade to support the fire brigade for fire fighting as per the station's procedure when Technical Support Center (TSC) is established. Moreover, the station already signed the "mutual support for fire fighting and first aid agreement "with New Taipei City Fire Bureau the Sixth Brigade. The station will immediately request supports such as manpower, vehicle, machine tools, and materials etc via a hot line telephone if the station is exposed to threats from accidents such as fire, typhoon, flood, earthquake, explosion, compound disaster, and other emergency accidents etc.

For fire fighting facilities, the station is allocated with large scale trolley type powder, CO^2, and Halon fire extinguishers; fire water tanker; and chemical fire truck. They can support to put out the fire in case that the raw water reservoir piping on the hill ruptures due to earthquake. The station inventory for lube oil was already evaluated and programmed its storage area and its amount as per "Fire load limitation for fire compartment catch fire countermeasures" in order to prevent fire expanding to the other fire compartment.

Besides, the station storage tanks depending on its different area and type are designed with overflow dike or fire protection wall to retard the fire intensity extend in order to prevent it to damage the nearby equipment in case fire accident happens.

6. Seismic capability of non-safety related equipment adjacent to safety related equipment safety related equipment such as polar crane in reactor building, service crane in fuel building, bridge crane in dry-well, service monorails in ECCS pump room, chain blocks in main steam tunnel, etc. are all seismic category Ⅰ. Adjacent non-safety related ladders and working platforms are designed as seismic category Ⅰ to avoid affecting safety related equipment.

2.1.3 Compliance of the plant with its current licensing basis (CLB)

2.1.3.1 Licensee's organization / processes to ensure compliance

1. The surveillance test interval of the systems and equipment meet the requirements of KSNPP Technical Specification. The test steps and its acceptance criteria of systems and equipment is listed in detail in 600 series procedures “Surveillance Test Procedures” and its test cycle shall be prepared in accordance with the test requirements of KSNPP Technical Specification.

2. The maintenance method and inspection period of the system and components are described in detail in 700 series procedures “Maintenance Procedures” which include maintenance and inspection contents such as disassembly, inspection, lubrication, replacement of consumed components (such as seal or gasket), installation and torque etc. The inspection of systems and equipment shall be carried out in every outage in accordance with the station’s 10 year Long Term Maintenance program.

3. The inspection and maintenance method of structure is specified in procedure 173.7 “Maintenance rule of structural inspection and monitor”. The inspection results are classified and following measures shall be prepared in accordance with the implementation and record requirements for periodical inspection of civil / structure and passive components. The more important safety related structures shall be inspected every five years. The other safety related structures shall be inspected every ten years. The inspection items are listed as below:

Table 2-5

Item	Structural Code	Structural Name	Safety relevant	Inspection frequency
1	RB	Reactor Building	high	5 year
2	AB	Aux Building (including Enclosure Building)	High	5 year
3	TB	Turbine Building	High	5 year
4	CB	Control Building	high	5 year
5	RWB	Radwaste Building	low	10 year
6	FB	Fuel Building (including CST)	high	5 year
7	CO^2R	CO^2 Storage Room	low	10 year
8	DST	Demineralized water Storage Tank (DST)	low	10 year
9	EDGT	Emergency Diesel Fuel Oil Storage Tank	high	5 year
10	EDGB	Emergency Diesel Generator Building	high	5 year
11	TrF	Transformers	high	5 year
12	5DGB	The Fifth Diesel Generator Building	high	5 year

Item	Structural Code	Structural Name	Safety relevant	Inspection frequency
13	EPH	Emergency Circulating Water Pump House	high	5 year
14	345TT	345kVTransmission Tower	high	5 year
15	SYCR	Switchyard Control Room	high	5 year
16	SY	345kV Switchyard	high	5 year
17	69GISB	69kVSwithgear Room	high	5 year
18	GTB	Gas Turbine Building	high	5 year
19	SBODGB	Gas Turbine Black Start Diesel Generator Room	low	10 year
20	GTDT	600 Kilo liter Day Tank	low	10 year
21	GTFST	35000 Kilo liter Fuel Oil Storage Tank	low	10 year
22	RWR	Raw Water Reservoirs A&B	low	10 year
23	WPS	Yuantan Creek Pump house	low	10 year
24	CWO	Outlet including Jetty	low	10 year
25	ECWI	Emergency Intake	high	5 year
26	CWPH	Circulating Water Pump House	low	10 year
27	CWI	Intake including Jetty	low	10 year
28	VSB	Fuel Building Traffic Access	high	5 year
29	ADST	Aux Demineralized water Storage Tank	low	10 year
30	MUDB	Water Treatment Plant	low	10 year
31	CWT	Circulating water tunnel	low	10 year

2.1.3.2 Licensee's organization for mobile equipment and supplies

The required critical structures, systems, and components including reactor core, and spent fuel pool for unit safe shutdown are documented in the station current licensing basis (CLB) are not damaged under designed basis earthquake and have adequacy capability to shut down the unit in a safe shutdown. The station existing general first aid facilities and spare parts are listed as follows:

Table 2-6 KSNPP existing emergency responding apparatus/equipment

Apparatus/Equipment	Capacity / Quantity	Logistic Location	Inspection Period	Responsible Section

Apparatus/Equipment	Capacity / Quantity	Logistic Location	Inspection Period	Responsible Section
Truck-mounted Mobile Crane	10 tons, 1 set	Heavy Duty Mechanical Shop	3mon	Mechanical Section
Truck-mounted Mobile Crane	13.5 tons, 1 set	Heavy Duty Mechanical Shop	3mon	Mechanical Section
Truck-mounted Mobile Crane	20 tons, 1 set	Heavy Duty Mechanical Shop	3mon	Mechanical Section
Truck-mounted Mobile Crane	32 tons, 1 set	Heavy Duty Mechanical Shop	3mon	Mechanical Section
Truck-mounted Mobile Crane	72 tons, 1 set	Heavy Duty Mechanical Shop	3mon	Mechanical Section
Gasoline-driven Pump	500 l/m, head 28m, 2.7 HP, 2 sets	Heavy Duty Mechanical Shop	3mon	Mechanical Section
Gasoline-driven pump	1000 l/m, head (lift)32m, 6 sets	Heavy Duty Mechanical Shop	3mon	Mechanical Section
Gasoline-powered Generator	110 V, 0.9 kVA, 1 set	Heavy Duty Mechanical Shop	3mon	Mechanical Section
Floodlight (for intense illumination)	AC 110V, 3 kVA, 1 set	Heavy Duty Mechanical Shop	3mon	Mechanical Section
Aerial Lift Truck	5.9 m, 2 sets; 8..1 m 1 set	Heavy Duty Mechanical Shop	3mon	Mechanical Section
Motor-driven Pump	220V 240 l/m lift 10 m 3 sets	Heavy Duty Mechanical Shop	3mon	Mechanical Section
Motor-driven Pump	110V 120 l/m lift 8 m 3 sets	Heavy Duty Mechanical Shop	3mon	Mechanical Section
Large Mobile Water Pump	65ps 1500 L/min, 10 kg/cm2, 3 sets	On-site Fire Station	3mon	Industrial Safety Section
Small Mobile Water Pump	1200 L/min, lift 70m, water lift 90m, 3 sets	On-site Fire Station	3mon	Industrial Safety Section
Mobile Generator	110V/220V, 2.5 kW, 5 sets	On-site Fire Station	3mon	Industrial Safety Section
Fire Truck	10 M3, 12 kg/cm^2, 1 set	On-site Fire Station	3mon	Industrial Safety Section
Chemical Fire Truck	2 M3, 8 kg/cm^2, form capacity 120 kl, 1 set	On-site Fire Station	3mon	Industrial Safety Section
Self-contained Breathing Apparatus	6 kl, 4400 psi & standby bottle 55 pieces, 146 sets	On-site Fire Station	3mon	Industrial Safety Section
Sand Bag (for stopping flood)	20kg per pack, 260 packs	On-site Fire Station	6mon	Industrial Safety Section
Oil Absorbent Boom	10 FT*8FT, MOP un-weaved cotton, 10 pieces	On-site Fire Station	6mon	Industrial Safety Section
Apparatus/Equipment	Specified capacity / quantity	Arrangement place	ISI/ Inspection Period	Responsible Section

Apparatus/Equipment	Capacity / Quantity	Logistic Location	Inspection Period	Responsible Section
Forklift Truck	3/5/6.5/7/12 metric tons, 11 sets	Machine shop	3mon	Mechanical Section
Powder Fire Extinguisher	1520 sets	Each building	3mon	Industrial Safety Section
Flexible Fire Hose	3 in/ 300 m	Machine shop	6mon	Mechanical Section
Emergency Lighting	18 sets	Each building	3mon	Industrial Safety Section
Exhaust Ventilator	45000 CFM, 8 sets	Each building	3mon	Industrial Safety Section
hand-operated Oil Extractor Pump	I piece	On-site Fire station	3mon	Industrial Safety Section
Magic Sorb® (for cleanup of oil/ solvent spill)	50kg	On-site Fire station	6mon	Industrial Safety Section
Oil Dispersant	Non-ionic Surfactant	On-site Fire station	6mon	Industrial Safety Section
Oil Absorbent Pad	200 pieces	On-site Fire station	6mon	Industrial Safety Section
Soft Belt	2 in/ 500 m	Machine shop	6mon	Mechanical Section
Lead Blanket	Lead Content 3mm, 700 pieces	Health Physics Section	6mon	H.P. Section
Lead Clothing	Lead Content 0.5mm, 100 pieces	Health Physics Section	6mon	H.P. Section
Disposable Overshoes	14000 pieces	Health Physics Container	6mon	H.P. Section
Disposable Protection Clothing	13000 pieces	Health Physics	6mon	H.P. Section
Flatbed Truck Trailer	20 metric tons, 1 set	Machine shop	6mon	Radwaste Management Section
Mobile Crane	32 metric tons, 1 set	Machine shop	3mon	Mechanical Section
Forklift truck	12 metric tons, 1 set	Machine shop	3mon	Mechanical Section

2.1.3.3 Deviations from CLB and remedial actions in progress

Taipower nuclear power plants have already established a complete quality assurance program comply with US NRC 10CFR50 Appendix B. All working processes in nuclear power plants such as organization, design, procurement, fabrication, installation, operation, and maintenance etc shall be controlled and supervised by following the quality assurance program in order to assure that each kind of structures, systems, and components (SSCs) can perform its intended functions. Any deviation can also be found in time and is evaluated if there is necessary to take the required corrective actions in order to diminish or to eliminate its impact on unit safety.

The safety associated with seismic design of the plant does not deviate from the commitment of FSAR. If there is any deviation of SSC from the commitment, the plant will conduct safety evaluation and corrective measures according to the following procedure.

The relevant procedures and its control programs are described as follows:

1. The station personnel shall issue the repair request form and submit it to the relevant sections for repair as per procedure 1102.01- "Equipment maintenance work control procedure" in case those equipment is found to have deviation. Meanwhile, shift engineer shall judge if the deviation will impact unit safety or not as per Technical Specification or technical manual. If yes, operator shall take corresponding actions to operate the unit in Limiting Condition for Operation (LCO). The station shall report to ROCAEC as per station procedure 113.1 "Abnormal event Prompt report process procedure" if the deviation to the unit operation impact already reached the ROCAEC report requirements requested by ROCAEC's "Nuclear reactor facilities abnormal event report and prompt report process". And then the station shall follow procedure 113.2 "Abnormal event report process" to continue the evaluation of the deviation condition to impact the unit operation and propose the improvement measures.

2. Each section of the plant and Independent Safety Evaluation Group of the Department of Nuclear Safety will issue NCD quality nonconformance notice as per procedure 1115.01- "Nonconformance Disposition control process" in case those nonconformance items of SSCs are found. The station shall report Head Office and ROCAEC in case that the NCD involves 10 CFR 21.

3. The following procedures will be followed in regards to the need for repair request and NCD etc. corrective actions:
   Procedure 112 "Evaluation and review process for the repair works of Potential and Critical Components & environment which may result in unit trips." shall be followed in case that the repair work may have the unit trip potential of critical components & environment.
   - Procedure 112.1 "Evaluation and review process for the Potential Dangerous works." shall be followed in case that the repair work may result in operation or maintenance problem or job safety, radiation safety, flooding, and fire etc. accidents.
   - Procedure 1114.03 "The control process for *Danger: Do Not Operate* tags" shall be followed to complete the clearance ("*tag-out*") order before the repair work starts.
   - Procedure 1110.01 "OC engineer's review process for the site work hold point" shall be followed.
   - Procedure 1119.09 "Code repair and replacement control" shall be followed to do the repair

work.

- Procedure 1119.08 “Non-Code repair control” shall be followed to do the repair work.
- Procedure 1103.01 “Nuclear plant design change request control” shall be followed to do the design change request (DCR) control.
- Procedure 1103.04 “Nuclear plant spare parts and component replacement Control” shall be followed to do the replacement work.
- Procedure 1102.02 “Instrument and electrical equipment set point change Control” shall be followed to do the set point change control.
- Procedure 1102.03 “Temporary equipment change Control (Set point temporary change & temporary pipe or wiring dismantle or jump connection)” shall be followed to do the temporary dismantle or jump connection control.
- Procedure 1103.05 “Procedure for Dedication of Commercial Grad Items in Nuclear Safety-Related Applications” shall be followed.

2.1.3.4 Specific compliance check already initiated by the licensee

1. The following enhancements and implemented in response to Fukushima accident:
   - DCR-K0-3886- “Raw water pipe is changed from underground to be exposed”:

     Because the designed capacity of the station Raw Water Pool A & B on the hill is about 37,000 metric tons. It can makeup water to reactor and fuel pool via gravity by way of its storage position which is 90 meters high above ground level and no electrical power is needed to makeup water using raw water which is be the important first aid facility during the accident period of the station.

     This DCR is to rapidly confirm the damaged pipe segments after the earthquake and also to replace it as soon as possible so as to restore the system operable.
   - DCR-K0-4057- “To enhance the local elasticity of raw water pipe”:

     The local elasticity of raw water pipe is enhanced to absorb its displacement caused by seismic dislocation so as not so easy to be damaged.
   - DCR-K1-4074/K2-4075- “Installation of additional RHR backup injection pipe”:

     This DCR can provide an additional water injection path of RHR system which can take the water source from irrigation ditch, domestic water reservoir, or the station nearby water source via mobile pump or fire truck to provide emergency makeup water to reactor in case that the piping from raw water reservoirs A & B to RHR system is broken.
   - DCR-K1-4043/ K2-4044- “Installation of additional shutoff valve and quick adaptor in the pipe in ECW tunnel”;

     This DCR can provide an additional water injection path of RHR system which can take the water source by means of mobile pump and fire hose to provide RHR system cooling water source in case of loss of ultimate heat sink.
   - MMR-K0-257- “Installation of additional flood gates in channels of Creeks A & B”:

This MMR can provide the enclosure function of Creeks A & B to store the water from upstream ridges and the outlet where the water can be pumped by means of mobile pump so as to provide the station each kind of emergency cooling and makeup water source after earthquake

- MMR-K0-259- "Installation of additional fixed transportation pipe from the bridge near sea to the station entrance":

This MMR can transfer the sea water from outlet to the station entrance by means of mobile pump so as to provide the station each kind of emergency cooling and makeup water source after earthquake

2. In response to new evidence found about the Shanchiao fault, Taiwan Power Company has accelerated the geological investigation and evaluation of the seismic resistance capacity of nuclear power plant. Working flow chart is planned in Attachment 2-1 of this chapter. The work contents and its schedule are programmed as follows:

   (1) Planning phase

   The "Geological stability and seismic hazard reevaluation project of nuclear power plant site." program was awarded to Institute of Nuclear Energy Research on December 30, 1999 to conduct the geological survey of the land and the sea surrounding the site and also program the specialist group for review the survey report.

   (2) Investigating phase

   "The supplementary program of geological investigation during operation period in nuclear power plants" was awarded to Sinotech Engineering Consultant Company on November 10, 2010 to conduct the work including geophysical survey of the land and the sea surrounding the site, geophysics survey, topographic survey and each kind of tests. The program is completed in December, 2012.

   (3) Evaluating phase

   a. The original design company-Sinotech Engineering Consultant Company is hired to conduct the "Seismic Margin Assessment (SMA)" program to evaluate the seismic margin of the capability of building structures and equipment components whether can remain unit safe shutdown and can provide residual heat removal function under the beyond design basis accident.

   b. It is scheduled to complete the 'Seismic Probability Risk Assessment (SPRA)" by June, 2013, in accordance with ASME code 2009 version.

3. Except for the Seismic Margin Assessment (SMA) as per US codes, Taipower will carry out seismic enhancement in advance in order for response to the new evidence about the Shanchiao Fault.

   (1) The station already selected two trains of safety water injection paths and the seismic resistant capability of the piping and equipment on these paths are promoted to the greatest seismic degree which can withstand Shanchiao Fault in order to assure unit safe shut down.

(2) Except for emergency power, water injection, and cooling system are all designed seismic category I, a seismic enhancement program for fixed first aid backup equipment and facilities such as raw water reservoirs, raw water piping, gas turbine building structures and equipment etc. has been proposed to increase the seismic resistant capability of such equipment to assure the capability of sufficient backup power and water sources.

4. Except that the review of the report “Geological stability and seismic hazard reevaluation project of nuclear power plant site” is arranged, Taipower planned to negotiate with the National Seismic Center to discuss the following programs:
   (1) The evaluation experiment as well as its value analysis for Nuclear power station primary containment crack and damage and air tightness after earthquake.
   (2) The seismic assessment and enhancement for nuclear power station seismic category II structures.
   (3) Comparison and assessment of nuclear power station seismic design specification.
   (4) It is assessed to install two sets of seismometer in both units reactor building each floor for nuclear power station seismic monitor and application.
   (5) Each station is setup to connect with Central Meteorological Bureau Seismic and Tsunami warning System. Its alarm system and maintenance system were already setup. At present Taipower is continuously collecting the transmitting data for the reference to relevant enhancement in corporation with Central Meteorological Bureau Seismic Forecast Center in future.
   (6) Taipower has made arrangement with Seismological Center of Central Weather Bureau to install an additional seismometer in the site area to monitor seismic scale and to perform the following assessment. The installation plane is scheduled to complete by the end of 2013.

5. After review and evaluation of each issue for necessary materials and apparatus for responding to compound disaster accidents in the light of the Fukushima accident, a list for procuring such materials and apparatus to enhance the plant’s first-response capability is compiled as illustrated in table 2-7 “Procurement of emergency rescue materials and apparatus envisaged as necessary for responding to compound disaster accident.” There are all safe elevation for arrangement of the relevant materials and facilities lay-down areas by the characteristic of spare part s or disperse layout method so as to assure that their stored position is accessible and is not impacted by typhoon and tsunami.

Table 2-7 Procurement of emergency rescue materials and apparatus envisaged as necessary for responding to compound disaster accident

Equipment Name	Spec Capacity / Quantity	Logistic Location	Time Schedule	Inspection Period	Responsible Section
Fire Tanker	10 metric tons, outlet diameter 2 1/2 in, spray pressure 10kg/cm^2, 1set1500L/min,	On-site Fire Station	Completed	3mon	Industrial Safety Section

Equipment Name	Spec Capacity / Quantity	Logistic Location	Time Schedule	Inspection Period	Responsible Section
	10kgf/cm2, 9 sets				
Fire Hose	1000 m	On-site Fire Station	Completed	12mon	Industrial Safety Section
Large Mobile Fire Pump	65ps, outlet diameter 2.5in, 1500L/min, 10kgf/cm2, 9 sets	# 29 Warehouse	Completed	3mon	Industrial Safety Section
Gasoline-powered Generator	AC 100V / 220V 2.4 kVA, 3 sets	# 29 Warehouse	Completed	3mon	Heavy Machinery Subsection
Diesel Engine Generator	AC 100V / 220V 4.5 kVA, 3 sets	# 29 Warehouse	Completed	3mon	Heavy Machinery Subsection
480V 200kW Mobile Diesel Generator	480V 200kW, 4 sets	# 29 Warehouse	Completed	3mon	Electrical Section
ECW Pump Spare Motors	2 sets	G/T Building Roof	Completed	3mon	Electrical Section
120V mobile generators	120V, 1 set	Control Building Roof	Completed	3mon	Electrical Section
120V mobile generators	120V, 2 sets	Electrical Section	Completed	3mon	Electrical Section
120V mobile generators	120V, 2 sets	Control Room	Completed	3mon	Electrical Section
Boric Acid	B-10 Concentration 19.8%, 46.5 Tons	# 30 Warehouse	Completed	3mon	Chemistry Section
Borax	B-10 Concentration 19.8%, 46.5 Tons	# 30 Warehouse	Completed	3mon	Chemistry Section
Soft Belt	3/2 inch, 300m	# 29 Warehouse	Completed	3mon	Heavy Machinery Subsection
Bucket Loader	44.4kW, 1set	Machine shop	Completed	3mon	Heavy Machinery Subsection
Foam Tender Fire Truck	2metric tons, outlet pipe diameter 1 1/2”, spray pressure 8kg/ cm^2	On-site Fire Station	Completed	3mon	Industrial Safety Section
Sand Bag	18 kg/bag-20 kg/bag, 850 bags	On-site Fire Station	Completed	3mon	Industrial Safety Section
Mobile Diesel Air compressor	3*2*2m, 2 sets	# 29 Warehouse	Completed	3mon	Reactor Auxiliaries Subsection
Disposable Overshoes	14,000 pieces	HP Main Control Station	Completed	3mon	H. P. Section
Disposable Protection Clothing	13,500 pieces	HP Main Control Station	Completed	3mon	H. P. Section
Motor Operated Air compressor	110V, 2HP, 1 set	# 29 Warehouse	Completed	3mon	Reactor Auxiliaries Subsection
Motor Operated	110V, 2HP,	# 29 Warehouse	Completed	3mon	Reactor

Equipment Name	Spec Capacity / Quantity	Logistic Location	Time Schedule	Inspection Period	Responsible Section
Air compressor	1 set				Auxiliaries Subsection
Motor Operated Air compressor	110V, 2HP, 1 set	# 29 Warehouse	Completed	3mon	Reactor Auxiliaries Subsection
Gasoline Engine Pump	10kg/ 400GAL, 1 set	Water Plant	Completed	3mon	Liquid Waste Subsection
Gasoline Engine Pump	10kg/ 400GAL, 1 set	Water Plant	Completed	3mon	Liquid Waste Subsection
Radwaste Drum	55 GAL, 1000 pieces	# 1 Waste Warehouse	Completed	3mon	Solid Waste Subsection
Premium Motor Gasoline #95	800L	Oil Warehouse	Completed	3mon	Industrial Safety Section
Combustible Gas Detector	0-100%LVL, 6 sets	Industrial Safety Section Office	Completed	3mon	Industrial Safety Section
Oxygen	6M3/pc, 10 pieces	Supply Section Warehouse	Completed	3mon	Supply Section
Acetylene	3kg/pc, 10 pieces	Supply Section Warehouse	Completed	3mon	Supply Section
Nitrogen	6M3/pc, 10 pieces	Supply Section Warehouse	Completed	3mon	Supply Section
Argon	6M3/pc, 10 pieces	Supply Section Warehouse	Completed	3mon	Supply Section
ECWP Traveling Screen Pump Motor	1HP, 2 sets	G/T Building	Completed	3mon	Electrical Section
ECWP Traveling Screen Wash Pump Motor	15HP, 2 sets	G/T Building	Completed	3mon	Electrical Section
Gasoline Engine Pump	1000L/min, 3.5HP, 6 sets	# 29 Warehouse	Completed	3mon	Heavy Machinery Subsection
Diesel Generator Power truck	4.16kV/1500kW, 1 set	G/T Building	Received in April, 2012	3mon	Electrical Section
Disposable Protection Clothing	13500 pieces	HP Main Control Station	Completed	3mon	HP Section
Motor Operated Air compressor	110V, 2HP, 1 set	# 29 Warehouse	Completed	3mon	Reactor Auxiliaries Subsection
Motor Operated Air compressor	110V, 2HP, 1 set	# 29 Warehouse	Completed	3mon	Reactor Auxiliaries Subsection
Motor Operated Air compressor	110V, 2HP, 1 set	# 29 Warehouse	Completed	3mon	Electrical Section

KSNPP have incorporated all the supply sources of off-site mobile equipment/ backup supplies into procedure 113.3 “Accident (incident) emergency handling procedure”, and performing check, maintenance and test periodically. All the fixed protection equipment installed by DCR will perform maintenance, check and surveillance in accordance with a series of procedure 600/700 to ensure the reliability.

6. Besides, the supply sources for off-site mobile equipment/ backup supplies are provided by Chinshan Nuclear Power Station based on the precondition of mutual support and compatibility.

2.2 Evaluation of margins

2.2.1 Range of earthquake leading to severe fuel damage

2.2.1.1 Weak points and cliff edge effects

The purpose of this assessment is to find out the minimum withstanding value for the required equipment and facilities which can maintain unit safe shutdown via probability risk assessment (PRA) event tree methodology and evaluation of equipment and facilities seismic withstanding extent when earthquake happens. It means that once seismic degree reaches the extent that all the above-mentioned equipment and facilities which is unable to withstand the seismic degree are assumed to lose their intended function and further to impact of unit safe shutdown. The PRA event tree methodology applied to find out the required first aid equipment and facilities of the minimum vibratory withstanding value for the successful first aid path is the cliff-edge defined in this section.

Taipower judges that safety related structures and equipment in each station may be damaged due to earthquake according to the analysis data documented in each NPP’s Living PSA report. (Please refer to the 1995 KSNPP Living PSA Report). The impact to safety related equipment during earthquake is calculated by adopt of seismic hazardous curve and vibratory intensity analysis results and the possible accident sequences discussed between the analyzer and the station SRO. However, Taipower can’t carry out the failure mode and its effectiveness analysis for all equipment and structures because there are too many equipment and structures and the station’s material resources and manpower are limited so that the selection rules are drew up as follows:

The seismic median value of equipment or structures is equal or less than 3.0g (This rule is based on that the opportunity of seismic hazard bigger than 3.0g is very few).

Table 2-8 vibratory -proof Intensity Order List for KSNPP Essential Structures / Equipment

ID No.	Structure / Equipment	Failure Mode	Seismic-proof Intensity
S_{01}	Ceramic insulator	Support failure	0.3
S_{19}	Gas Turbine	Anchor bolt failure	0.61
S_{02}	Lube oil sump tank (Main D/G)	Support failure	0.9
S_{03}	4.16 kV switchgear (T/B Bldg)	Relay chatter	0.91

S_{04}	480V MCC (D/G and Aux. Bldg)	Relay chatter	1.05
S_{05}	4.16 kV switchgear (Aux. building)	Relay chatter	1.19
S_{18}	5th D/G	Support failure	1.20
S_{06}	Top guide	Grid beam deflection	1.28
S_{08}	Reactor recirculation pump	Support failure	1.42
S_{10}	SBLC test tank	Support failure	1.51
S_{11}	LPCS pump room cooling unit	Support failure	1.53
S_{12}	HPCS D/G Aux. equipment (fuel oil transfer pump)	Support failure	1.60
S_{13}	ADS accumulator	Support failure	1.61
S_{14}	Fuel oil storage tank (all D/Gs)	Support failure	1.80
S_{15}	ECW sluice gate	Support failure	1.87
S_{16}	ECW traveling screen	Support failure	1.87
S_{17}	Emergency pump house	Structure failure	1.90

Note: These data are obtained from the 1985 KSNPP PRA report, where S19 & S18 are the seismic-proof analysis data of Gas Turbine and 5th D/G. S7 item (ECHW Pump) was deleted as per Taipower Nuclear Technology 7606-0549 letter "Improvement Items Executive Report after KSNPP Safety Evaluation Report" because its seismic resistant intensity bigger than 3.0g. Besides, S9 item of Main Control Room Emergency Cooling Unit Support failure was deleted as per as the reason stated in the original report table C-3-1.

The station referred to the seismic median value of above table to assess the seismic PRA. The event tree analysis process and result is shown as figure 1 of this chapter's attachment 2-2. The sequences of seismic event tree are shown in table 1 of attachment 2-2. Its success paths and cliff-edge are all reviewed except for the last item of table 1 which can't be produced new success path because cliff-edge resulting from large-break LOC is very low.

From the seismic event tree, two successful reactor shutdown cooling paths (or cases) are observed and as follows:

(1) In the case that off-site power is lost due to earthquake, reactor scram and long term reactor water makeup (including containment cooling) are all successful.

(2) In the case that off-site power is lost and reactor is scrammed but long term reactor water makeup is failed, long term alternative reactor water makeup is successful.

The safety margin and associated cliff-edge of each success path is described as follows:

(1) The cliff edge of a success path is the minimum seismic resistance capability in the event tree

and safety margin is the minimum seismic resistance capability in the event tree minus seismic resistance capability of initiating event.

(2) For success path 1, the cliff edge is 0.77g and the safety margin is 0.16g (0.77g-0.61g).

(3) For success path 2, cliff-edge is expected to be <0.77g (seismic resistance capability of alternative core water makeup to be further verified).

The cliff-edge of this scenario (lost of off-site power) is the maximum seismic resistance capability of successful cooling paths, i.e., success path 1, cliff edge = 0.77g and safety margin = 0.16g.

2.2.1.2 Measures which can be envisaged to increase robustness of the plant

1. According to the initiating events of seismic event trees, the median value for the intensity of an earthquake to induce a loss of off-site power event is 0.61g. The critical component which is Skid Anchor Bolt of Gas Turbine will be incorporated in the Gas Turbine vibration-proof enhancement program which is contracted by Taipower Construction Department.

2. According to one of reactor shutdown cooling success paths as per seismic event tree analysis, the DC power for steam-driven RCIC system or its instrumentation control power as well as the DC power for HPCS pump driven by HPCS Diesel Generator or its instrumentation control power is the reason of cliff-edge effect (0.77g). The station already prepared its enhancement measures including that for response to the new evidence of mountain foot fault and RCIC system (including I&C and control power) is selected to enhance its overall seismic capability. Moreover, the operation process for manual startup of RCIC in case of loss of RCIC control power was included in “URG” and it is demonstrated to be feasible.Cliff Edge will be upgraded from 0.77g to 1.119g after above-mentioned relevant enhancement measures put into practice.

3. According to seismic event tree analysis, one of the reactor shutdown cooling success paths is mobile water injection via RHR B system by raw water pump, fire water pump, or fire truck. Its relevant water injection path and water source was already programmed in Overall Checkup Program Item 4 “Review of Ultimate Heat Sink” and its relevant operation process was also incorporated in unit URG procedure. Moreover, except for seismic-proof enhancement of raw water reservoirs as well as raw water pipe to be exposed, the seismic-proof enhancement of RCIC and RHR B injection paths are evaluated in connection with the new evidence of mountain foot fault.

4. The station already procured 3 sets of mobile type 2HP 10 Kg/ cm2 air compressors to provide air operated valve emergency operation in order to assure that the compressed air supply can be available for AOV operation. In the addition, two sets of mobile diesel driven air compressors and two sets of high pressure boosters are procured to provide the required compressed air for SRV emergency operation. Besides, DCR- K1-4034/K2-4035 was issued to install emergency nitrogen

fill piping and its adapter outside the building in order to standby provide the required compressed air for SRV emergency use. DCR- K1-4034/K2-4035 was completed in April, 2012.

2.2.2 Range of earthquake leading to loss of containment integrity

The station major enclosure structures are Primary Containment, Reactor Pedestal, and Containment Drywell. According to the station 1984 English version Seismic PRA volume III Appendix C2 “Seismic Fragility Analysis” Table 5-4, it is estimated that earthquake result in containment lost its enclosure capability is very low because its vibration-proof surface acceleration median value of above-mentioned structures as listed below is very high. Moreover, the containment isolation valves will close automatically in design after loss-off-site power.

Structure	Surface acceleration median value
Primary Containment	3.5g
Reactor Pedestal	5.0g
Drywell	4.3g

2.2.3 Earthquake exceeding the DBE and consequent flooding exceeding DBF

2.2.3.1 Physically possible situations and potential impacts on the safety of the plant

The consequent flooding exceeding DBF induced by earthquakes is tsunami. The details are described in the chapter 3 “Flooding including tsunami”.

The Kuosheng site is located on the northern coast of Taiwan and fronts on the East China Sea at longitude 121°39’46”East and latitude 25°12’09”North. The site covers a land area of 220 hectares at an elevation of 12 meters (or higher) above mean sea level. The reactor buildings are at a distance of approximately 500 meters from the sea shore.

There is no stream across the site area but there are two streams nearby the site. One of them which is separated a hill from the station is Yuantan Creek 1.75 kilo meters from western site area and it flows to sea in north by west direction. The other one which is also separated a hill from the station is Mashu Creek 4.5km from eastern site area and it flows to sea in north by east direction. Both of them are not the root cause of site area flooding. According to “Water and Soil Conservation Bureau of Agriculture Council” Information Notice in May 2011, the station nearby streams never happen debris flows and landslides incidents and the station major building and structures are all beyond the impact scope of debris flows and landslides potential streams.

Besides, whether there is excavation and backfill earth may impact the safety of site area. The station engineering contract had clearly stipulated that the contractor shall dispose the waste earth after excavation and incorporate it to calculate its engineering cost. There is not any request in the station procedure for the waste earth that it shall be placed in the specific place so that the contractor shall decide itself to transport it to outside the plant for disposal. The excavation earth for Raw Water Reservoirs A and B during its construction period shall follow the construction program and it should have the specific waste earth place to accommodate amount of the construction waste earth. There is not found as per the existing records that the excavation backfill earth may have the doubts to impact the safety of site area in case of earthquake.

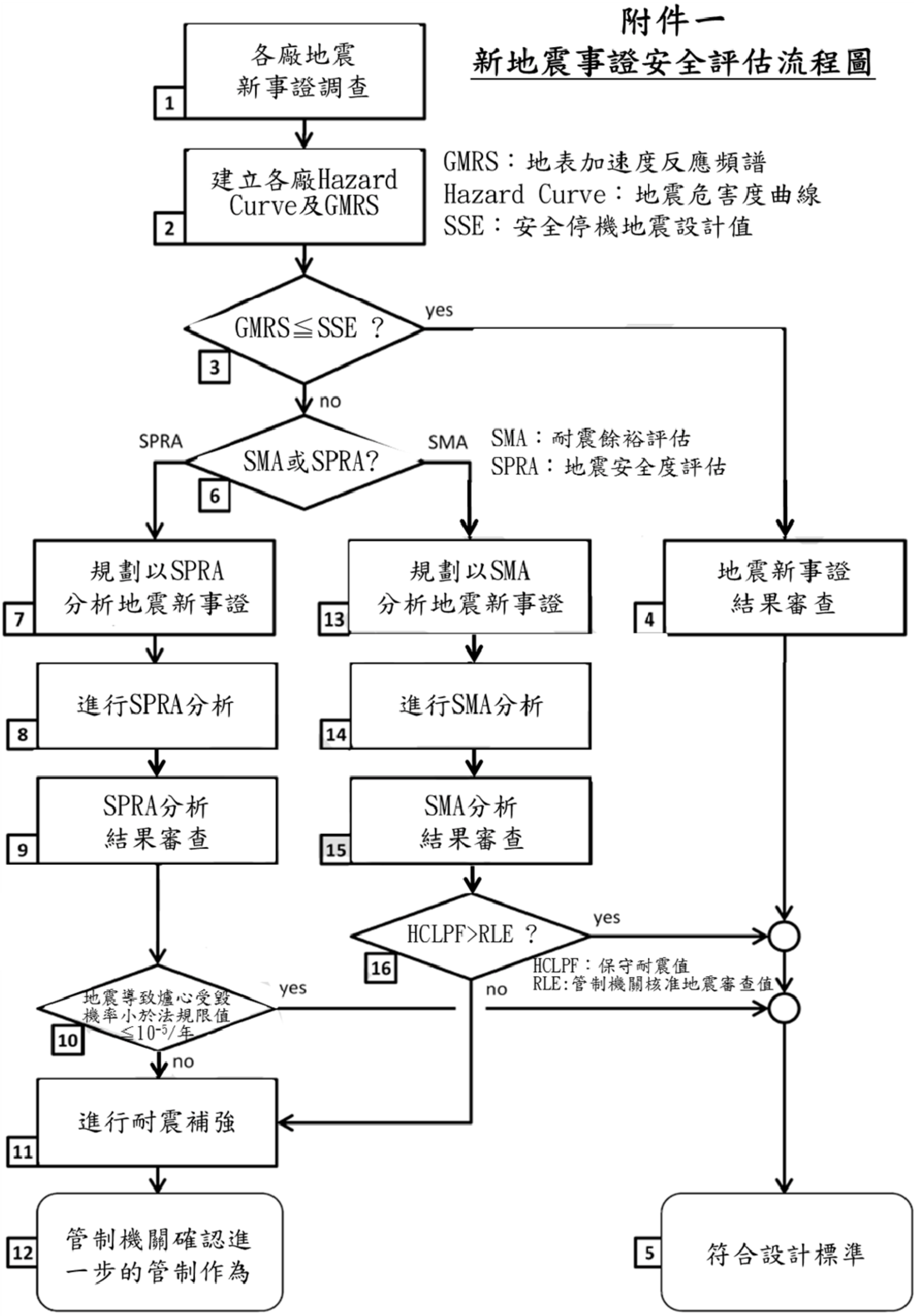
2.2.3.2 Weak points and cliff edge effects

The dike possible collapse location of Reservoir B is opposite to the terrain valley line from view of the station's A, B pool surrounding area via its contour line map. In case that the western pool of B pool happens the dike collapse event, spate water will dump to Gas Turbine Building and Black Start Diesel Generator Building along valley line. Therefore, the station may happen northern side dike collapse event of the western pool of Reservoir B pool caused by DBE earthquakes.

2.2.3.3 Measures envisaged to increase robustness of the plant

The station already installed each baffle plate on the western side and the threshold in the southern side of Gas Turbine Building as well as on the threshold in the southern side of Black Start Diesel Generator Building in order to reduce spate water directly crashing into building to damage equipment in case of embankment collapsed. In case that the spate water inundated into Gas Turbine Building, it will flow along the site north eastern load and its drainage trench and then inundate into parking lot, central park and office area. Because the above inundation compass areas are so extensive that the water depth can be instantly reduced and major factory areas will not be impacted.

Attachment 2-1 Safety Evaluation Flow Chart for New Seismic



Attachment 2-2 KSNPP Seismic case study

The event-tree of KSNPP Seismic case study includes 11 events, beginning with the initiating event as the first heading and ending with the shutdown cooling state as the last heading. Each heading in the event sequence development is described as follows:

1. Initiating Event -- The beginning of this event tree:

   For Loss of off-site power event induced by earthquakes, please refer to KSNPP Seismic Event Tree EO.EVT. This initiating event is defined as "simultaneously loss of off-site power and gas turbine" (that means loss of 345 kV* 69 kV* G/T) as shown in figure 1. The median value for the intensity of site earthquakes that induce a loss of off-site power is 0.61g and its critical equipment (weak point) is G/T Anchor Bolt.

2. Reactor Scram:

   It is conservatively assumed that core damage will inevitably result from an Anticipated Triensient Without Scram (ATWS) in which the occurrence of a loss of off-site power event is followed by failure to scram the reactor by insertion of all control rods or injection of boron. This event is defined as "Control Rod Drive Mechanism (CRDM) failed to insert control rod" as shown in figure 1. The vibratory intensity of CRDM is 1.28g and its critical equipment (weak point) is Core Top Guide.

3. DC Power and I & C:

   In the case of a loss of offsite power induced by strong earthquakes, even with a reactor scram being successfully actuated, it is still conservatively assumed that core damage will occur if the DC power (or I&C) for the following systems all fail, including steam-driven RCIC system and HPCS Diesel Generator.

   A. Control power for steam-driven RCIC system: 125 V DC Bus 1RDA,
   B. Control power for HPCS pump driven by HPCS Diesel Generator： 125 V DC Bus 1ODG

   RCIC and HPCS shall be inoperable if either one of them is lost. This event is defined as "simultaneously loss of 125V DC Bus 1RDA and Bus 1ODG" (that means loss of 125V DC Bus 1RDA * 125V DC Bus 1ODG) as shown in figure 1. The vibratory intensity of DC power is very low (only 0.77g) and its critical equipment (weak point) is 125V DC Switchgear.

4. RCIC and HPCS Water Injection:

   Same as the previous item, RCIC and HPCS are inoperable because loss of off-site power induced by strong earthquakes and RCIC / HPCS are inoperable due to RCIC and HPCS pumps or its water supply (CST) failure although reactor scram is successful. This event is defined as "simultaneously loss of Reactor Core Isolation Cooling (RCIC) and High Pressure Core Spray (HPCS)" (that means loss of RCIC * HPCS) as shown in figure 1. The seismic strength of RCIC and HPCS as assessed is sufficient to withstand a vibratory intensity > 3g such that there is no potential damage expected from effects of earthquakes.

5. Reactor Pressure Relief:

Under the condition that loss of off-site power is induced by strong earthquakes, reactor scram is successful, early phase high pressure water injection is successful, but long term water makeup is inoperable due to loss of on-site AC power or RHR / SPCM inoperable and reactor SRV can't relieve pressure in time so that low pressure water injection system can't inject water to reactor and further result in core damage. The station is equipped with 16 sets of Safety Relief Valves (SRV). Under the condition that high pressure water injection system is inoperable and without ATWS, at least 3 sets of SRV shall be opened to relieve the reactor pressure in order for that low pressure water injection system can inject water to reactor. This event is defined as "equal or more than 14 sets of SRVs failed to open" as shown in figure 1. The vibratory intensity of Reactor pressure relief is 1.61g and its critical equipment (weak point) is Accumulator.

6. Site AC Power and ECW:

   Under the condition that a loss of off-site power is induced by strong earthquakes and reactor scram is successful and early phase high pressure water injection is successful, but long term high pressure and low pressure water makeup is inoperable due to loss of on-site power or containment cooling (RHR/SPCM mode), it will result in core damage. The station AC power is equipped with Emergency Diesel Generators 1RG1 & 1GG1 and HPCS DG (1OG1) for each unit, and the Fifth Diesel Generator DG-5 for both units. 1RG1, 1GG1 & 1OG1 are water-cooled type by means of ECW cooling (also called UHS). This event has two conditions as follows:

   A. Success of High Pressure Water Injection:

      Long term core water makeup still depends on SPCM to cool down the suppression Pool (S/P) in order to avoid containment overpressure. Low pressure water injection and water makeup shall be considered as its possible path in case of long term high pressure water makeup failure.

   B. Failure of High Pressure Water Injection and Water Makeup

      If long term high pressure water injection and water makeup are inoperable, on-site AC power shall provide power to 3 sets of LPCI pump and 1 set of LPCS pump in order for them to carry out low pressure water injection to reactor. However, low pressure water injection and water makeup cannot achieve their intended function if high pressure water injection and water makeup are inoperable because it still needs AC power and SPCM. Therefore, jump directly to item 9 to inquire about alternative core water makeup.

      This event is defined as "simultaneously loss of all diesel generators" (1RG1, 1GG1, 1OG1 & DG-5) and its relevant support systems (that is 4.16 kV SWGR +1RG1 *1GG1*10G1 * DG-5 ECHW+ECW) as shown in figure 1. The vibratory intensity of AC power is 1.19g and its critical equipment (weak point) is 4.16 kV SWGR.

7. LPCI and LPCS Reactor Water Makeup:

   Following the above-mentioned issue, this event inevitably failed so as to jump to event 9 to examine Alternative Core Water Makeup.

8. Containment Cooling and RHR:

Under the condition that loss of off-site power is induced by strong earthquakes and reactor scram is successful and early phase high pressure water injection is successful, but long term high pressure and low pressure water makeup is inoperable due to loss of containment cooling (RHR/SPCM mode), it is conservatively assumed that it will directly result in core damage as listed in the event sequence of KSNPP Seismic Event Tree EO.EVT. This analysis proposes the feasible measures in reference to procedure 1451 "Unit Ultimate Response guidelines" proposed the most feasible first aid measures.

This event is defined as "loss of SPCM and its relevant backup systems" (that is RHR +ECW) as shown in figure 1. The vibratory intensity of Containment Cooling and RHR is 1.87g and its critical equipment (weak point) is ECW pump.

9. Alternative Core Water Makeup and Fire Water:

   Fire water system (FIREW) or fire water reservoir truck is used to provide alternative core water makeup. It is conservatively assumed that it will directly result in core damage if alternative core water makeup is fail. Containment cooling via containment exhaust shall be executed if alternative core water makeup is available. This event is defined as "loss of fire water and fire water reservoir truck" as shown in figure 1. The vibratory intensity of alternative core water makeup and its critical equipment is pending check.

10. Containment Venting:

    It is conservatively assumed that long term alternative high pressure core water makeup can be successful operated, Containment Cooling still only depends on Containment Exhaust. If Containment Venting fails, it is conservatively assumed that it will result in core damage.

    This event is defined as "Containment Venting failure" as shown in figure 1. The seismic strength of the Containment Vent as assessed is sufficient to withstand a vibratory intensity > 3g such that there is no potential damage expected from effects of earthquakes.

11. Shutdown Cooling -- The ending state of this event tree.

    A. Reactor shutdown cooling is successful and the reactor is safe from core damage.

    B. Reactor shutdown cooling fails and reactor core damage occurs.

It can be concluded from above KSNPP seismic case discussions that there are two successful reactor shutdown cooling success paths as follows:

(1) Success path 1: The sequence of events for both reactor scram and long term alternative high pressure core water makeup including containment cooling are all successful under the condition of a loss of off-site power caused by earthquakes.

(2) Success path 2: The sequence of events for successful long term alternative high pressure core water makeup including Containment Venting under the following condition: a loss of off-site power caused by earthquakes and a failure in high pressure core water makeup with reactor scram being successful.

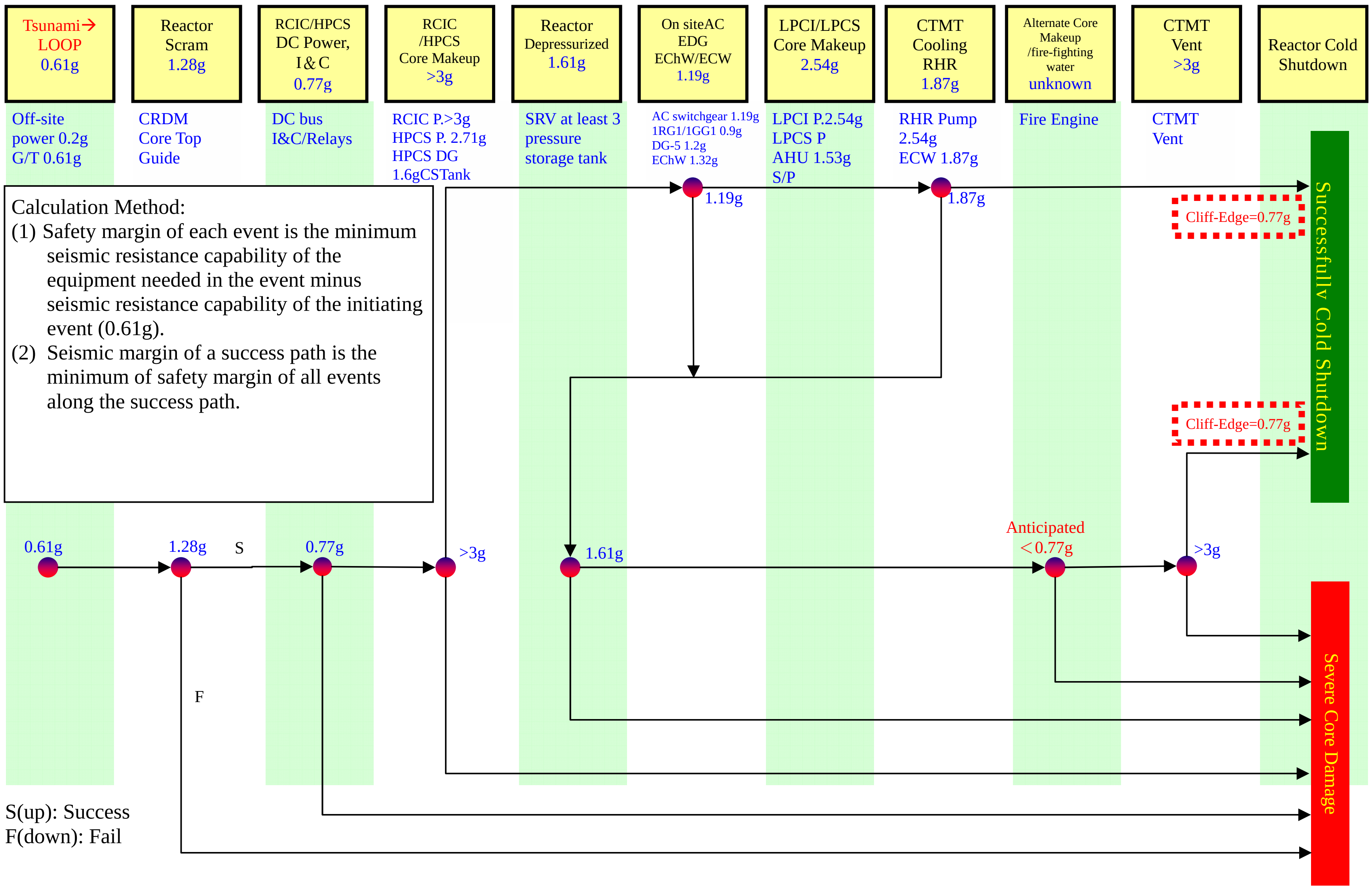
The safety margin and associated cliff-edge of each success path is described as follows:

(1) The cliff edge of a success path is the minimum seismic resistance capability in the event tree and safety margin is the minimum seismic resistance capability in the event tree minus seismic resistance capability of initiating event.

(2) For Success path 1, the cliff edge is 0.77g and the safety margin is 0.16g (0.77g-0.61g).

(3) For Success path 2, cliff-edge is expected to be <0.77g (seismic resistance capability of alternative core water makeup to be further verified).

The cliff-edge of this scenario (lost of off-site power) is the maximum seismic resistance capability of successful cooling paths, i.e., success path 1, cliff edge = 0.77g and safety margin = 0.16g.



Attachment 2-2 Fig. 1 KSNPP Seismic Event Tree

Attachment 2-2 Table 1 KSNPP Seismic Assessment Event Tree Sequence Check List

Earthquake derived Event Tree	Description	Whether consideration of Success Path in Seismic Stress Test Event Tree
EO	Earthquake and Loss of Off-site Power	Yes
ES	Earthquake and SRV / Accumulator damaged	Yes
EOS	Earthquake and Loss of Off-site Power and SRV / Accumulator damaged	Yes
EO3	Earthquake and Loss of Off-site Power and Div. III HPCS DG damaged	Yes
EO5	Earthquake and loss of off-site power and the fifth DG damaged	Yes
EO5S	Earthquake and Loss of Off-site Power and the fifth DG damaged and SRV / Accumulator damaged	Yes
EOD	Earthquake and Loss of Off-site Power and Div. I, II DG damaged	Yes
EODS	Earthquake and Loss of Off-site Power and Div. I, II DG damaged and SRV / Accumulator damaged	Yes
EC	Earthquake and ATWS	Yes
ECS	Earthquake and ATWS and SRV / Accumulator damaged	Yes
ECO	Earthquake and Loss of Off-site Power and ATWS	Yes
EA	Earthquake and large-break LOCA	No, but the cliff-edge of pipe break is very low and won’t create a success path

Note: E: Earthquake, O: Loss of Off-site Power, S: SRV / Accumulator damaged,
3: Div. III HPCS DG damaged,
5: The fifth DG damaged,
D: Div. I, II DG damaged, C: Anticipated Triensient Without Scram (ATWS)

3. Flooding

3.1 Design basis

3.1.1 Flooding against which the plant was designed

3.1.1.1 Characteristics of the DBF (Design Basis Flooding)

Due to the characteristics of the Kuosheng nuclear power plant, the flooding design basis of the plant considers the influence of tsunami and storms.

1. Tsunami:

   Flooding design basis of the Kuosheng nuclear power plant estimates possible height of tsunami waves by using historical records as reference, and considers influence of both climate and geographical topography on the plant. According to the evaluation of FASR, the maximum tsunami run-up height is 7.78 meters; if tides and geographical topography are also taken into account, the maximum tsunami run-up is 10.28 meters, which is still lower than the plant elevation of 12 meters.

2. Flooding:

   Based on the 30-year historical records of nearby areas before the construction of the power plant and the statistic analysis result, the plant estimates that the probable maximum precipitation (PMP) in every 10,000-statistically-calculated reoccurrence interval years is 241mm/hr. In accordance with that, the drain capability of the plant was designed to be 138 cms at river trench A and 114 cms at river trench B respectively (cms: m^3/second).

   Moreover, regarding the question whether the debris flows would result in onsite flooding, since there is no river across the site and the nearest streams, between which, one is Yuantan Stream, 1.5 km west of the site, and the other one is Mashu Stream, 4.5 km east of the site. Both streams flow into ocean and are separated from the site by mountain hills, they will not cause onsite flooding. After reviewing the debris flow data issued by Soil and Water Conservation Bureau, Council of Agriculture, Executive Yuan, and precipitation data announced by Central Weather Bureau, it is concluded that the possibility of the plant damaged by debris flows and storms is very low.

3.1.1.2 Methodology used to evaluate the design basis flood

1. Tsunami:

   Information about tsunami design basis in the summary of FSAR 2.4.6.A is described as below:

Based on historical experience, it was concluded that tsunami originated from the central and western Pacific Ocean would not cause any damage. Therefore, tsunami design basis of the plant in FSAR mainly considered the potential tsunami threat from north of the site. From historical records of Government Central Weather Bureau and Japanese documents, there were two severe tsunamis in Taiwan in 1867 and 1918. Especially, the tsunami induced by the undersea volcano at 134 km north of Keelung in 1867 was more serious, it has caused severe damage in Keelung area. As documented in historical record, the height of the tsunami wave was 7.5 m*.

* The wave height of 2.4 m near the epicenter of tsunami in the 1867 was estimated from the observed height of 7.5 m on coast, and then calculated the height in the epicenter as follows:

$$He = 7.5 / (Kr \times Ks \times Kd \times Kc \times Ku) = 2.4m.$$

Where:

Kr: the refraction coefficient = 0.183

Ks: the shoaling coefficient = 1.53

Kd: the diffraction coefficient = 1.95

Kc: the contraction coefficient = 1.414

Ku: the run-up coefficient = 4.16

The influence of climate and geographic landscape factors on the site should be included as part of the plant design basis and be also taken into account as the design basis to protect against tsunami. The severe tsunami that happened in 1867 is estimated to have waves of 7.78meters, a result of the height of the tsunami center combining the influence of season winds. A tsunami with such height breaks when it reaches the shore near the plant and runs up onto the land. According to the theory of solitary waves, the height of a run-up at a shore of angle 1/10 can reach up to 6.5 meters, and it is 9 meters when the angle is 1/5. Plus, with the help of the highest tide 1.28 meters, the maximum run-up height is 10.28 meters. However, the ground elevation of the plant is 12 meters, so the plant will not be threaten based on the above geographic data.

2. Flooding:

Flooding design basis of the plant was described in FSAR 2.4.3.1. The plant mainly considered the probable maximum precipitation at the plant and based on which to design its drain capability against storms.

As stated in FSAR, precipitation intensity is directly related to elevation and geographic environment. With the fact of the completeness and the logic of the historical record acquired, it's discovered that the calculated probable maximum precipitation (PMP) of the plant was similar to the PMP value of Keelung, a geographic region resembling to the plant (pocket-type rocky shore surrounded by high mountains). Additionally, the plant also used the precipitation data measured at the nearest weather station of Keelung, between 1947 and 1976, as a basis for the evaluation.

Based on statistics analysis, the PMP values of different recurrence interval years are all smaller than the estimated values by PSAR. Nevertheless, for conservative considerations, the plant still used 241 mm/hr, the once every 10,000-year PMP at the nearest weather station, as the basis of the design drain capability against storms.

The drain system of the plant is comprised of three parts—the main building area, west of the site, and east of the site:

(1) The drain system for the main building area was made up with onsite ditches, pumps, manholes and pipes to collect ground runoff and drained out of the area.
(2) The drain system in the west of the site area collects ground runoff from rainfall at the warehouse area, the power switchyard and the hills in west of the main building area and drained out through trench A.
(3) The drain system in the east of the site area collects ground runoff from rainfall at the hills in east of the main building area, expelled through trench B.

The trenches A and B are both open type of man-built trenches, making water go into the ocean at a slope rate of 0.2% to 0.5%. The maximum drain capability of both trenches is acquired via calculation with the PMP value at the site; the acquired result of the calculation is to be 138 cms at the river trench A and 114 cms for trench B.

3.1.1.3 Conclusion on the adequacy of the design basis for flooding

1. The adequacy of design basis for tsunami

As stated before, the DBF of the plant is formed by using the statistically calculated tsunami wave height while considering the most severe tsunami in record induced by an undersea volcano in 1867 and the influence of climate and geographic topography factors over the plant. After the Fukushima accident and based on the known and related analyses and investigations that includes tsunami analysis done by NSC, Taipower has showed that the current design basis height of 10.28 m, as induced by submarine volcano eruption in FSAR, is not exceeded. Since all the elevation of the important buildings and equipment in Kuosheng is higher than 12 meters, they will not be affected by possible tsunami intrusion. While Taipower will continuously evaluate the effect of possible eruption of submarine volcanoes and the slide down of submarine mountains to ensure the appropriateness of tsunami design basis.

2. The adequacy of design basis for flooding

By calculating the daily probable maximum precipitation data measured at nearest weather stations in Keelung over past 30 years (see Attachment 3-1), the plant has recently estimated and concluded that PMP at the site is 123.1mm/hr. Also, the PMP in every 10,000 statistically-calculated recurrence- interval years is calculated with common methods of 1-day precipitation analysis and listed as below:

	Log Pearson type III
Keelung Station	208.9 mm/hr

The statistic calculation result indicates the biggest PMP of every 10,000 statistically-calculated recurrence-interval years is still smaller than the PMP design basis of the plant described in FSAR, 241mm/hr. Therefore, the flooding design basis for the plant is appropriate.

3.1.2 Protection against the DBF

3.1.2.1 Key SSC required to achieve safe shutdown state after flooding

1. The ground elevation of the plant is 12 meters which is higher than all potential heights of tsunami mentioned above, that include the height of the design basis tsunami brought by undersea volcanoes explained in FSAR, and the height of the tsunami induced by fault displacement, etc. evaluated by NSC. Therefore, based on the current geographic condition, the plant and all onsite facilities will not be threatened by tsunami.

2. As stated in FSAR 2.4.2.3.3, onsite areas except main buildings have the design of trenches A and B to protect the power plant against flooding resulting from storms. (The drain system of main buildings is designed in accordance with the precipitation of every 10,000 statistically- calculated recurrence interval year). Under this situation, the power plant has re-examined the precipitation in recent years and is certain that no precipitation in this time period exceeds the PMP design basis of the plant. Therefore, the design drain capability for the plant is still capable to dealing with flooding caused by storms and all facilities onsite will not be affected by the flooding.

3. In addition, after the Fukushima accident, the power plant immediately followed the recommendations in WANO SOER 2011-2 to “Verify the capability to mitigate internal and external flooding events required by plant design” and completed the verification by walkdown inspection for the appropriateness of equipment and material needed to mitigate external and internal flooding. The verified items contain:

   (1) Filling the penetrations on floor levels above and under ground.
   (2) Sump pumps and water-proof doors in emergency equipment areas in auxiliary buildings.
   (3) Fire-proof doors, emergency exits, and roller shutter doors of buildings that are direct accesses to the outside of the buildings.
   (4) Drain capability and spare drain equipment to protect buildings from flooding.

(5) Drain routes onsite.

This verification result indicated that there was no deviated situation in dealing with design basis flooding and they could function well by their design. For more detail, please refer to Attachment 3-2. All related information has been sent to WANO as well.

The verification of each item is summarized as followed：

⑴.Discharge route and pump：Discharge routes are cleaned quarterly and after each typhoon hit. All 32 discharge pumps of important equipment are periodically tested to verify their operability.

⑵.Water tight doors of important equipment：Door seals are tested to verify their integrity.

⑶.Sump pumps：Verified by plant procedure 718.1 to ensure their functions well.

⑷.Water tightness of building penetrations：Integrity of seals are verified according to procedures 796 (Periodical inspection of pipe penetration) and procedure 617.5.6.1 (Periodical inspection of cable penetration).

Operability and reliability of all equipment is verified and ensured by conducting the periodical tests and some necessary maintenance practices. Those test or maintenance frequencies are determined by plant technical specification requirement, equipment characteristics, related industry experiences or the corrective maintenance requirements following the maintenance rule.

Assessment on the flooding event of French Blayais NPP showed that the root cause was an over design basis rainfall combined with the high water level of nearby Gironde river which in turn hindered plant ground water from discharging to the river. As for Kuosheng, there is no nearby river of overflowing concern. All cable trenches and ground water discharge pipes are well above the mean sea water level so that there is no concern of site area flooding of seawater back flowing through these trenches or pipes. Plant current countermeasures against flooding are discussed as follows：

⑴.Maintain the integrity and blockage-free of discharge trenches in site area.

⑵.Improve and maintain water tightness by adding resisting facilities and inspecting the penetration seal.

⑶.Enhance the maintenance of sump pumps and drain holes to ascertain the sufficient capability to discharge possible intruded water.

⑷.Other practices: including the preparation of site area flooding prevention map, enlistment of flood-discharging equipment, exercises of hazard mitigation, etc.

3.1.2.2 Main measures taken to protect Kuosheng NPP against the possible flooding

1. Main buildings, at an elevation of 12 meters, are designed and built based on the combined consideration of potential maximum tsunami run-up height and additional safety margin. This can prevent the plant from the impact of tsunami and rule out their direct influence on onsite safety systems.

2. Dealing with potential maximum storms, the plant reroutes, design and build drain trenches to respond to PMP and protect the facilities against flooding.

3. After reviewing the debris flow information issued by the Soil and Water Conservation Bureau, Council of Agriculture, Executive Yuan and the precipitation data from Central Weather Bureau, the possibility of the plant damaged by debris flows and storms is very low. However, in order to prevent increased possibility of debris flows inferred by some new architecture development activities nearby, the plant has issued procedure 577.3 to regularly inspect whether any new development activities nearby the site exist. Other than the regular inspection, the plant also incorporated the mechanics of debris flow warning as well as the accident prevention practices into plant procedure to stop landslides or debris flows from affecting the drain capability of the plant and prevent inferred onsite flooding.

4. The spent fuel pool is located at 12 meters above mean sea water level. It is higher than the possible height of tsunami in FSAR design basis, derived from submarine volcano, and the National Science Committee assessment, derived from submarine fault displacement. Therefore, the plant shall not suffer the potential of tsunami attack as per the plant existing geological condition. Besides, each floor in the Fuel Building is equipped with drain holes which can collect building drain water, including equipment drain and floor drain to sump pit and then move it to the liquid radwaste system via two sets of 50 GPM capacity water pumps so that the abnormal inflow water can be removed.

5. Piping penetrations/Building walls water resistibility/Fire doors/Water tight doors：

   (1). There was no indication on the withstanding capability of water pressure for piping penetrations. However, based on the judgments of penetration type and sealant used, the penetrations should keep some waterproof ability.

   (2). Building walls and foundations are waterproof treated and can withstand up to 50 ft of static water pressure.

   (3). Watertight doors are one-way watertight. When flooding is opposed to the direction of door open, the ability to withstand water pressure is equivalent to that of the structures. If flooding is in the same direction as door open, watertight doors can withstand 0.5 kg/cm2 water pressure.

⑷ The sump pumps' capability and seismic category are listed in Attachment 3-8 "sump pump capability"

⑸. All facilities stated above are maintained, inspected and tested, according to their respective procedures, to verify their functions meet the design criteria.

⑹. Aging problem of facilities is covered by performing maintenance, inspection, test to verify their functionality.

3.1.2.3 Main practices to monitor and mitigate the possible consequence of flooding

Underground sump tanks and drain pumps are designed to locate around main buildings. When there is an abnormal inflow of water, signals will come out on OC99 panel to notify shift workers to go solve the situation following procedure 577 "Emergency operating procedure for heavy rain or flooding." Besides, all buildings and emergency equipment areas have floor sumps and drain pumps, so the plant can monitor water level in sumps from control rooms or waste control rooms any time when there is abnormal inflow of water. Complying with procedure 566.4 "Polluted liquid waste overload" to trace the inflow origin of water and isolate it appropriately, shift workers should immediately deal with any abnormal situations that can lead to flooding. The drain system of important buildings is gathered and disposed at Radwaste and Miscellaneous Dispose system (RMDS). There is no direct route for water to flow back from underground discharge pipes to inside important buildings to cause internal flooding. All discharge pipes of each sump are designed with check valves to prevent water from flowing back. There is also periodical preventive maintenance to make sure check valves are functional.

After the Fukushima accident, the plant reviewed drain operating procedure for flooding outside and inside of buildings, and waste shift workers would have to be responsible for temporary drain work and to deal with flooding inside buildings. The plant also decided that if there is severe flooding on the ground onsite due to natural disasters, the plant needs to follow the attachment of procedure 577 "Handling procedure for external and internal flooding" and to give different guidance depending on the floodwater level and the influence severity. When necessary, units take turn being brought to the safe shutdown status.

Power for sump level instruments is from none safety related power source (1YK/1YM). Therefore, the level instruments can not function under loss of off-site power condition.

Also, the newly added procedure 577.1 "Emergency drain operating procedure for buildings" specifies that workers need to be immediately sent to check whether sump pumps operate normally when buildings are flooded and that they need to follow procedure 566.4 tracing the origin of the water and isolating it. And when there is station blackout, comply with procedure to adopt mobile generators to provide sump pumps temporary power source or to use mobile gasoline-driven drain pumps. The power plant will also have the water drained to particular spots through planned routes.

In every emergency equipment room in every onsite building, if sump water level is higher than the maximum water level for safe operation specified in Emergency Operation Procedure (EOP), the plant should reduce power and bring reactor to safe shutdown mode in accordance with EOP-500.6; if water accumulation on the ground of a building becomes severe flooding, procedure 577 "Handling procedure for external and internal flooding" needs to be obeyed and different guidance needs to be given depending on the floodwater level in the main area of the main plant area and the severity of the influence. Then, reduce the power of the unit and bring reactor to safe shutdown state following procedure.

It is assumed that actuation of level instruments inside watertight rooms means all the equipment inside is no longer functional and further actions is needed. Therefore, if flooding outside important buildings is concurrent with flooding actuation of level instruments inside watertight rooms. It means there is an internal flooding and operation according to procedure 577.1 "Plant Emergency Internal Discharge Operation" needs to be done to mitigate the hazard.

The section 3.1.1.3 states that designed plant elevation as well as flood discharging capability is appropriate to cope with design basis hazards.

In consideration of combined natural hazards, plant's sump pumps may not operate properly. Additional portable pumps have been purchased to cope with the situation. According to the procedure No. 113.3 "Emergency Hazard Procedure", the combined capacity of all 31 portable pumps is about 7523 gpm, equivalent to 186 % of plant's sump pumps capacity, and can meet the emergency needs.

In terms of enhancing the mechanism of accident prevention and mitigation to lower damage, the plant has established handling procedure for flooding in buildings, emergency operating procedure for onsite flooding, typhoon-period operating procedure and other guideline regarding accident prevention and mitigation. Relevant procedures are as below:

577- "Emergency operating procedure for heavy rain or flooding"-- Once Central Weather Bureau issues early flooding warnings or heavy rain warnings, the plant will monitor the water level of drain sumps, inspect the operation situation of all equipment as well as water accumulation at every low spots, and obey the attachment of procedure 577--"External and internal flooding Handling procedure" (Refer to Attachment 3.3) when performing inspection.

577.1- "Emergency drain operating procedure for buildings"--When flooding occurs in buildings or onsite sump areas due to typhoons with heavy rain (mountain floods), seawater encroachment, tsunami, earthquakes, or multiple disasters, this procedure provides the plant the handling procedure for flooding in buildings and the emergency drain routes. These prevent flooding areas from expanding and protect emergency reactor cooling systems, so units can remain safe and operate normally again later.

577.2- "Tsunami emergency response procedure"-- This helps judge if a tsunami will affect the plant, based on the tsunami warnings by Central Weather Bureau. If the tsunami is considered to hit the plant and cause damage after judgment, units will take turns to be brought to cold shutdown. However, if it is not enough time to respond, the plant manually trip the reactors and follow EOP to bring the unit to cold shutdown status to quickly lower the pressure.

3.1.2.4 Other effects of the flooding taken into account

1. Consider the synergistic effect of loss of offsite power:

Power sources from outside of buildings of the plant contain two switchyard systems, 345kV and 69kV, which are at elevation of 27 meters and 30.7 meters respectively. In addition, the plant has two air-cooling gas turbine generators (Each can supply emergency power to two units.) located at elevation of 22 meters, both being much higher than the height of potential maximum tsunami run-up. The power source systems mentioned above will not be inundated by tsunami.

As included in the debris flow information by Water and Soil Conservation Bureau, Counsel of Agriculture, Executive Yuan, the debris flow potential of the only two streams near the plant (Yuantan Stream, Mashu Stream) is both medium, and debris flow warning will be issued when accumulated precipitation reaches 550mm, Also, both streams are separated from the plant by mountain hills. Moreover, according to the precipitation record of Keelung and Chinshan weather stations over past 30 years, the daily maximum precipitation is only 351 mm, which is far lower than the precipitation beyond which debris flow warnings will be issued. So the possibility of the plant affected by debris flows and storms and of the loss of external power source systems is both very low.

Every unit has two emergency diesel generators with seismic category 1 structure at elevation of 12 meters and also one emergency diesel generators (5^{th} EDG) shared for both units, so safety systems in buildings still have power supply after losing power sources from outside of buildings.

In regards to indirect influence of tsunami on power supply from power sources outside of buildings, relevant reviews and response strategies of the plant, detailed in Chapter 5 of this report Loss of power source and ultimate heat sink, are summarized as below:

(1) If station blackout happens and seawater cooling function loses, the fifth gas-cooling diesel generators and two gas turbines can provide emergency power source. The plant has also finished the planning of the fifth gas-cooling diesel generators providing emergent power to

both units. Related operating procedure is already included in procedure 1451 "Unit ultimate handling guidance." In case of emergency, each unit with one RHR (700HP), one ECWP (600HP), one E-chiller (400HP) running is enough to maintain long term reactor cooling. Power consumption of these three pumps plus some low voltage loads of 200kW are totally1475kW for each unit. The capacity of 5^{th} diesel generator is 3910kW, enough for both units with one ECCS Division running each. In case of the needs to run HPCS pump, 2500HP or 1875kW, 5^{th} diesel generator can independently provide power to HPCS pumps for both units. In summary, after calculation, 5^{th} diesel generator is capable of dealing with initial load demands for both units at the early stage of plant accident.

(2) The plant has finished the planning of emergency 4.16 kV power source supplying power directly to switch boxes bus when non-segregated phase bus ducts (NPBD) are out of order. Related operating procedure is included in procedure 1451.

(3) The plant has finished Design Change Request (DCR-4093/4094) and installed isolated switches behind switch box bus 1(2) A2, so power generated from diesel generators or 1500kW mobile power vehicles during blackout can be directly sent to switch box bus 1(2) A4 via cables without being affected by dysfunctional NPBD. The 1500kW mobile power vehicle is mounted on a 40-feet-long and one-meter-high trailer. Only if the flooding level is less than 1m, it will be supplying power and not be affected by flooding. Moreover, 200kW mobile D/G will be placed on a 1.3-meter-high cart to supply power and also will not be affected by the same scenario above.

Other response measures and enhancement programs aimed to the loss of power sources from outside of the buildings consist of enhancing the emergency diesel generator building as well as water-proofness of the emergency circulating water pump chamber, establishing strategies to extend operational duration of emergency diesel generators, and purchasing various mobile power sources for the plant to maintain its long-term ability to respond to accidents. These efforts will enable the plant to have ability to deal with plant accidents for a long time period and to ensure the reactors are covered by water at all time to maintain the intact status of the fuel.

The priority for the use of emergency power source for beyond design basis hazards is as follows：5^{TH} diesel generator (with explosion proof gate and air vent at elevation of 17 meters), two gas turbines (at elevation of 22 meters), two ancillary diesel generators of gas turbines (at elevation of 22 meters), 4.16 kV mobile diesel generators (at elevation of 31 meters). These four 4.16 kV power sources will be secured under site area flooding condition. However, there are still a number of 480V mobile diesel generators, it is very unlikely for the use of these backup power source. In case of needs, it can be transported to outside roll-up door of main turbine building by crewmembers of Emergency Reentrance Team after flood subsided.

2. Flooding may hinder or delay offsite staff and rescue equipment to arrive at the power plant, Mechanical section of plant will use heavy machinery to remove roadblocks after flooding subsided. Rescue equipment, as listed in Procedure No. 113.3 "Emergency Hazard Procedure", then will be transported to needed location to perform their function. Accidents may occur during office hours or off-duty hours:

   If accidents happen during office hours:

   (1) If operation crew on call can not arrive at the plant due to flooding, workers from the training shift at the simulator center and standby support shift, approximately 10 people (mostly licensees), can be on duty and assist with operation and handling of the units.
   (2) All workers from the maintenance division and long-term contractors are onsite during plant office hours. Therefore, maintenance manpower can reach around a hundred people, which is enough for meeting the demand of equipment maintenance during emergency.

   (3) There are 8 fire-fighting workers in every day-shift period. Emergency response team would organize 48 people into standby emergency fire-fighting manpower.

   (4)The plant can immediately set up an emergency mobilizing team onsite to support and respond to work about rush repair and operation.

   If accidents happen during off-duty hours:

   (1) The plant immediately starts mobilizing for emergency in compliance with procedure 1407 "TSC mobilizing and response procedure", procedure 1408 "OSC mobilizing and response procedure", and procedure 1409 "HPC mobilizing and response procedure". If road condition outside of the plant resulting from earthquakes can not allow vehicles or workers to pass, plant will immediately report it to Nuclear Emergency Preparedness Execution Committee (NEPEC) requesting for support. NEPEC will co-ordinate manpower and resources of whole company, then make a request to Nuclear Incident Response Headquarter led by the central government for support of sending engineering soldiers to repair offsite roads and bring the plant staff, workers, equipment, and goods to and out of the site by helicopters. Injured staff and workers can also be airlifted to hospitals. In response to plant request for backup, Central Hazards Response Center functions as follows：

      - Clear road blocks by use of heavy machinery.

      - Transport rescue crew and equipment by sea using plant nearby Ming-kwung wharf.

- Transport rescue crew and equipment by air using plant open ground or sports ground of nearby Dapong elementary school one kilometer away.

(2) There are 24 maintenance (mechanics, electricity, instruments, and maintenance) workers living in the onsite standby dormitory. They can also mobilize to help with equipment repair work. Besides, 23 workers from the maintenance group live in Chinshan and Wanli, which are regions closest to the power plant, and they can be notified as well to come to deal with emergency response. Also, the maintenance supporting contractors have almost 100 technicians who live in Chinshan and Wanli. In the maintenance contracts signed by both the power plant and these supporting contractors, emergency rescue and repairing work detail is included, so the plant can ask these supporting contractors to send workers nearby to help during emergency. Names and phone numbers of these contract workers who will be mobilized during the emergency are listed in procedure 1408 “OSC mobilizing and response procedure”. If the roads were blocked due to tsunami, technical support manpower may reach the plant on foot and relaying vehicle transportation.

(3) Presently fire-fighting shift manpower is acquired via outsourcing. 8 fire-fighting workers remain onsite during off-duty hours. All the fire-fighting workers are local residents, so they get to the site quickly once there is an emergency. Furthermore, security guards working onsite can join to assist with emergency related work.

3.1.3 Compliance of the plant with its current licensing basis (CLB)

3.1.3.1 General Procedures

In response to natural disasters, such as tsunami, storms, debris flows, and etc., as described in previous Section 3.1.2.3 , which containing three emergency operating procedures (577- “Emergency operating procedure for heavy rain or flooding” , 577.1- “Emergency drain operating procedure for buildings” and 577.2- “Tsunami emergency response procedure”), Kuosheng NPP also set up disaster prevention and mitigation procedures for the plant to follow during normal operation period and during special time period when natural disasters are expected to affect the plant, then to mitigate the potential damage the disasters might cause:

576- “Operation after typhoon warnings is issued”-- Considering the strong winds carried by typhoons, the plant faces more threat than it does in a normal weather condition. Once main or auxiliary transformers in the units can not function due to typhoons, the power needed to complete safe shutdown can only be supplied from offsite power sources or onsite emergency diesel generators; to prevent the onsite power supply from being affected during typhoons, this procedure, based on the operation specification, lays out in detail about operation dealing with typhoons of different intensity, such as Attachment 3-4 “Typhoon response measures” for operation workers to follow.

576.1- “Typhoon defense: preparedness and response”-- Before the typhoon season or May every year, the industrial safety division will send a checklist to each division for them to conduct investigation and make improvement; moreover, because typhoons can slam the site area, the plant has established a typhoon emergency response team as well as related inspection operating procedure, such as Attachment 3-5 “Typhoon emergency response procedure,” for each division to comply with in order to decrease potential damage caused by typhoons.

577.3-“Monitoring, warning, disaster prevention and mitigation procedure for active faults near the plant, precipitation, debris flow, and dip slopes”-- Because natural disasters, such as storms, earthquakes, debris flows, and landslides, etc. may happen around the site and cause damage, the plant periodically evaluates natural disasters resulting from changes of climate and geography near the site and implement walkdown inspection at the site before the typhoon season and before flooding prevention period every year.

3.1.3.2 Compliance on mobile equipment and supplies

As stated in the Section 3.1.1.3, the potential tsunami run-up height at the plant is lower than the tsunami run-up elevation in the design basis, so this ensures important buildings and equipment would not be inundated by tsunami. Also, after reviewing record of past 30 years, it is noticed that the onsite maximum precipitation is not higher than the PMP of the design basis for the plant, so the designed drain capability of the plant is appropriative. Therefore, after evaluating the design basis in current license, it is concluded that no flooding would occur around plant buildings.

The existing mobile equipment for mitigation responding to any accidents is prepared as specified in Attachment 2-6 “Existing disaster prevention and mitigation equipment.” After the Fukushima Accident, the plant has conducted a comprehensive review on the whole power plant based on the request of the Atomic Energy Council and guidance of Taipower Company and has further planned and prepared mobile equipment for mitigation to respond to any accident conditions, such as Attachment 2-7 “Additional procurement of disaster prevention and mitigation equipment to respond to a design basis accident similar to the Fukushima Accident.”

Under required compatible condition, Chinshan NPP and Lungmen NPP will support and supply mobile mitigating equipment when needed.

3.1.3.3 Deviations from CLB and remedial actions in progress

After the Fukushima Accident, Kuosheng reviewed all building structure and discovered that the elevation of the floor level where emergency circulating water pump motors were was 6.72 meters. Therefore, if tsunami run-up height was over 6.72 meters, seawater may enter emergency circulating water pump chambers through emergency circulating water intake trenches and this may lead to damage of panel casings relating to emergency circulating water pumps chambers due to flooding.

To ease this concern, Kuosheng has completed an improvement program, which is to install water-proof walls for emergency circulating water pump (ECW) chambers, to add water-seal doors right outside of the fire-proof doors at two current entrances/exits of the ECW equipment areas, and to set up 6 removable water-proof stainless steel walls between drain pumps and traveling screen. Once the top of the water-proof walls reaches ceiling and all related penetrations are fully sealed, the main equipment as well as its surrounding area become a water-proof region. All these efforts in the program are to prevent seawater from entering ECW pump rooms, make the elevation of the whole tsunami prevention to be 12 meters, and maintain the operability of ECW pumps.

3.1.3.4 Specific compliance check already initiated by the licensee

1. Based on the PMP measured at Keelung weather stations of Central Weather Bureau over past 30 years, the plant estimates that the hourly maximum precipitation and PMP are 123.1 mm/hr and 208 mm/hr respectively and concludes that the design basis of the plant is appropriative. However, extreme weather may bring precipitation that is beyond the design basis, so the site will install "floodwater panel" at the openings of important equipment buildings, making the elevation of the original flooding prevention structure to be 1 meter higher. By so doing, the plant's capability to cope with extreme weather is expected to be enhanced. A detailed plan of such enhancement and improvement is yet to be developed.

2. In view of the Fukushima Accident, to prevent losing onsite ultimate heat sink caused by earthquakes-induced tsunami, the plant will continue the following improvement programs to ensure there are enough cooling water sources to feed water into the reactor cores or to supply water to cool the units for a long term after accidents:

    (1) "Make underground fresh water pipes over ground (DCR-K0-3886)"-- This design change requirement will make it easier for the plant to quickly identify damaged sections of pipes, replace them, and recover the fresh water system after earthquakes. Once the system is back in operation, the A and B reservoirs of the fresh water system can feed water into the reactors through the RHR.

(2) "Increase the flexibility of particular sections of fresh water pipes. (DCR-K0-4057) "-- This design change requirement allows pipes to withstand displacement resulting from earthquake dislocation, so pipes will not break or crack easily.

(3) "Install backup feed water pipes for the RHR system (DCR-K1-4074/K2-4075)"-- Therefore, when the pipes connecting the fresh water reservoirs A and B on mountains with RHR system rupture, the plant can use mobile drain pumps or fire trucks to get water at onsite trenches, sanitary sumps or any water sources near the site to feed water into the reactors during emergency.

(4) "Install shut-off valves and quick connectors at ECW trenches (DCR-K1-4043/K2-4044)" -- By this installation, the plant can supply water to RHR system HX via the hoses of mobile engine drain pumps. Even when losing ultimate heat sink, the plant can use mobile drain pumps and fire-fighting hoses to deliver cooling water to RHR system.

(5) "Install weir gates in the channels of the A/B trenches (MMR-K0-257)"-- These gates are intended to serve as dams for trenches A and B, allowing either their upstream flows or seawater drawn from the circulating water discharge structure via mobile water pumps to be collected for use as a water source for all emergency cooling water / water supply after earthquakes.

(6) "Install fixed water pipes from Linhai Bridge to the plant main entrance gate (MMR-K0-259)"-- Therefore, the plant can use mobile water pumps to draw seawater from the circulating water discharge structure to inside of the newly installed weir gate in trench A. Seawater can thus be collected and tapped as a water source for all emergency cooling water/ water supply after earthquakes.

3. After the Fukushima Accident, Taipower Company has finished the investigation on both the oceanic and terrestrial geographic topography near the plant and again reviewed the tsunami design basis as well as the safety of plant facilities reported in FSAR.-Current design of the plant elevation is built on the statistic calculation of historical weather record of the neighborhood of the plant as well as on the consideration of the height of the historical tsunami that happened in this region and may seize the plant. Additionally, the design of the plant also takes the distribution of the oceanic trenches near the island into account, adding reasonable margin to be one elevation design basis of the plant. Related design basis of both tsunami elevation and plant elevation is detailed in Section 3.1.1.3 "Conclusion of appropriative DBF."

3.2 Evaluation of margins on CLB

3.2.1 Envisaged additional protection measures based on the warning lead time

1. Tsunami warning time and additional protection measures

   In order to gain more lead time after tsunami warning issued, Taipower Company has established an earthquake and tsunami warning network system between Central Weather Bureau and each of the nuclear power plants in Taiwan, also the warning and maintenance mechanism has been set up. The network is continuously gathering and sending information for the seismological center of Central Weather Bureau to use as a related improvement reference. Besides, to be able to deal with the impact of different natural disasters in advance, the plant has included all protection measures for prevention, response, and enhancement in the procedure as follow:

577.2- "Tsunami emergency response procedure"-- The following situations are monitored and used to judge whether tsunami will seize the plant.

A. Central Weather Bureau has issued tsunami warnings. (Attachment 3-6)

B. The seismograph in the plant captures earthquake activities and transfers warning signals.

C. Wave heights near intake structures suddenly drop to abnormal low points.

D. Huge waves appear near the plant.

E. Electric current indicators of circulating water pumps rapidly oscillate.

If tsunami will pound the plant and are expected to cause damage after judgment, the plant will follow procedure to enter cold shutdown status. However, if there is not enough time to respond, the plant will follow EOP to manually trip the reactor.

Next, shift manager asks workers at both seawater pump chambers and Yuantan Stream to evacuate and quickly relocate vehicles and equipment that support work of removing trash and debris in the intake pools of emergency seawater pump chambers to higher places.

After tsunami warnings are issued, the plant notifies the fire-fighting crew to immediately open security gates of drain trenches A and B, so no debris on land will stuck the gates or influences the drain capability after the tsunami recede.

When tsunami affects the power plant, the plant and Taipower Company will undertake necessary mobilization following the emergency response plan (1400 series procedure) of the company, depending on the influence of the tsunami cause over the power plant. If the disasters are likely to worsen, Kuosheng NPP and Taipower Company will comply with emergency response plans to notify related government agencies and organizations to establish the central disaster response center to respond.

2. Additionally, responses to extremely heavy rain or flooding warnings consist of monitoring and protection measures as the following procedure:

577- “Emergency operating procedure for extremely heavy rain or flooding”-- When Central Weather Bureau issues early flooding forecasts or warnings about heavy rain, or when the System Operation Division of Taipower company informs the plant warnings about typhoons/ extremely rain and the onsite water level gradually increases, the plant will obey this procedure to monitor the sump water levels and inspect operational situation of equipment as well as water accumulation situation at all low spots. Moreover, the plant will comply with Attachment 3-3 “External/ internal flooding handling procedure” to conduct inspections.

577.1- “Emergency drain operating procedure for buildings ”-- When flooding occurs in buildings or onsite sumps caused by typhoons carrying heavy rain (mountain floods) , seawater encroachment, tsunami, earthquakes or multiple disasters, the plant can quickly learn about and judge the flooding incident through the alarm panel in the control room, waste treatment buildings, or patrol personnel at the flooded spots. This procedure provides internal flooding handling procedure and emergency drain routes, so maintenance workers can quickly adopt all measures to prevent flooding areas from expanding and protect the emergency safety systems, making the units stay on a safe and operable status.

576- “Operation during typhoon warnings”-- According to typhoon alert issued by Central Weather Bureau and considering the wind speed measured at site and reliability of electric power (including offsite power and emergency diesel generators), reduce reactor power of the unit to the level so that generator can be normally disconnect from grid or shutdown reactor if necessary.

576.1- “Typhoon defense: preparedness and response”-- Before the typhoon season or May every year, the industrial safety division will send a checklist to each division for them to conduct inspection walkdown and make improvement to lower potential damage caused by typhoons; moreover, the plant needs to establish a typhoon emergency response team 18 hours prior the arrival of typhoons. The superintendent assigns work to related divisions as well as their workers based on previously assigned work, and workers start all inspection as well as rush repair for the arrival of typhoons in order to minimize potential damage and ensure the units to operate safely.

577.3- “Monitoring, warning, disaster prevention and mitigation procedure for active faults near the plant, precipitation, debris flow, and dip slopes”--Because natural disasters, such as storms, earthquakes, debris flow and landslides, etc. may happen around the site and cause damage, the plant periodically evaluates natural disasters resulting from changes of climate and geography near the site every year. If abnormal changes of the information or situations are discovered after comparing the evaluated results and these changes may result in damage at the power plant, the plant should immediately implement further evaluation, compile the result, and report to Taipower Company. However, if the abnormal changes of information will not cause damage, the power plant modifies the basis data or figures used as references.

3.2.2 Weak points and cliff edge effects

The design for the ground elevation at Kuosheng NPP was considering some safety margins and three factors from FSAR, which were the tsunami maximum run-up height, maximum wave height and maximum flood height. Hence, the ground elevation was high enough to fight against design basis of flooding.

According to the Stress Test and Evaluation Event Tree Analysis for Kuosheng NPP (Attachment 3-7), regarding the conclusion of the tsunami event in Kuosheng NPP, there was only one successful situation of reactor cold shutdown, which was that the reactor tripped successfully after the tsunami caused LOUH (loss of ultimate heat sink), but long-term high-pressure water makeup for the reactor failed. The success of the long-term alternative water makeup for the reactor (including containment ventilation) requires event sequences.

Among which, description of safety margin and its cliff edge is as follow:

Since there is only a success path, its cliff edge is the cliff edge of this tsunami case. Its safety margin needs to adopt the smallest safety margin of each heading, namely 0.3m (12.3m-12m); its cliff edge also needs to use the smallest figure of each heading, namely 12.3m.

In case of a tsunami seize, sea water may intrude into CWP or ECW channels, but both ends of these channels are open to sea only and capable of withstanding the pressure up to 150 psi, it can prevent sea water from intrusion. If a beyond DBF tsunami should strike, sea water will enter site facilities from ground doors or roll-up doors. Under such circumstance, the routes of water intrusion and its disposition are described in Attachment 3-3 site area flooding. Counter measures are described in sections 3.2.1 and 3.2.3.

Scenarios of site area flooding are analyzed in chapter 4.

3.2.3 Envisaged measures to increase robustness of the plant

After the Fukushima Accident, Taipower Company immediately established a nuclear plant tsunami evaluation team to conduct an investigation on the oceanic and terrestrial geographic topography near the plant, once again review the tsunami design basis in FSAR and plant facility safety, and complete the following improvement measures:

1. The plant has re-evaluated the investigation and analysis on probable tsunami run-up height, and confirmed that the tsunami run-up height chosen by FSAR at the time the power plant was building is safe enough. Based on the known and related analyses and investigations that includes tsunami analysis done by NSC, Taipower has showed that the current design basis height of 10.28 m, as induced by submarine volcano eruption in FSAR, is not exceeded. It shows that the elevation design of the plant against tsunami has enough safety margins, so there is no concern of threat posed by earthquake-induced tsunamis.

2. After discovering the vulnerability in the protection capability of the ECW pump chambers against tsunami, Kuosheng immediately corrected and completed filling and blocking measures about the water-seal doors of ECW pump chambers in order to increase their protection capability against tsunami. After the completion, the height of the tsunami run-up protection wall at ECW pump chambers is the same as the ground of main buildings, namely 12 meters.

3. Kuosheng has finished reviewing onsite flooding and onsite drain function and again examined the historical record of the daily maximum precipitation over past 30 years to confirm that the drain trenches of the plant can withstand extreme precipitation resulting from extreme weather and there is no concern of flooding.

4. Aiming at the historical records of onsite environment and geography as well as past daily maximum precipitation, the plant reviewed its prevention against debris flows. Furthermore, Kuosheng has accomplished new procedure, which is to periodically inspect land development near the power plant. Meanwhile, the power plant needs to include the debris flow mechanisms of warning, prevention, and mitigation in the procedure in compliance with the precipitation information by Central Weather Bureau and the debris flow warning information by Soil and Water Conservation Bureau, Counsel of Agriculture, Executive Yuan.

5. Kuosheng has drawn maps of both inundation-prone areas inside and outside of buildings in order to planning for drain methods in advance; the plant has added maps of flooding prevention for both inside and outside of buildings to further improve the drain capability of buildings. Additionally, the power plant also completed lists of all drain routes and their capability for both inside and outside of buildings.

6. Kuosheng has reviewed past experience of flooding caused by typhoons and heavy rain at power switchyard battery chambers and the bottom floor of the turbine building. It is also confirmed that the operating procedure has required in detail the reliability of related sealing quality control mechanism after penetrating related work and asked no similar problems would happen again. The plant has also finished walkdown inspection on the design and completeness of water-proof

doors in buildings, barriers (including well grids and etc.), and penetrator sealing to ensure everything is satisfactory.

Attachment 3-1: Precipitation data from Central Weather Bureau

Maximum daily precipitation at Keelung Weather Station in 1980-2010 (Unit: mm)

Year	Maximum daily precipitation	Year	Maximum daily precipitation	Year	Maximum daily precipitation
1980	351.3	1991	162	2002	117.5
1981	167.5	1992	101.5	2003	118.2
1982	125.6	1993	109	2004	240.2
1983	138.8	1994	178	2005	257
1984	151.4	1995	126	2006	193
1985	218.2	1996	198	2007	205.8
1986	201	1997	217	2008	178.5
1987	301.2	1998	309.5	2009	179
1988	242	1999	113.5	2010	345.5
1989	189	2000	271.8		
1990	186.6	2001	269.5		

Attachment 3-2: Verifying the appropriation and adequacy of equipment and material needed to mitigate external and internal flooding by walkdown.

Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
1. Penetrations underground				
Auxiliary building				
Cable penetrations (Fire zone 11)	RCIC PUMP ROOM (A/B 1F) EL.(-)40'–0"	Y	Y	N
Cable penetrations (Fire zone 12)	RHR A AREA (A/B 1F) EL.(-)40'–0"	Y	Y	N
Cable penetrations (Fire zone 13)	LPCS AREA (A/B 1F) EL.(-)40'–0"	Y	Y	N
Cable penetrations (Fire zone 16)	EAST PIPE SHAFT (A/B 1F) EL.(-)40'–0"	Y	Y	N
Cable penetrations (Fire zone 17)	WEST PIPE SHAFT (A/B 1F) EL.(-)40'–0"	Y	Y	N
Cable penetrations (Fire zone 18)	NORTH CABLE VAULT (A/B 1F) EL.(-)40'–0"	Y	Y	N
Cable penetrations (Fire zone 19)	MIDDLE CABLE VAULT (A/B 1F) EL.(-)40'–0"	Y	Y	N
Cable penetrations (Fire zone 20)	SOUTH CABLE VAULT (A/B 1F) EL.(-)40'–0"	Y	Y	N
Cable penetrations (Fire zone 22)	HPCS AREA (A/B 1F) EL.(-)40'–0"	Y	Y	N
Cable penetrations (Fire zone 23)	RHR C AREA (A/B 1F) EL.(-)40'–0"	Y	Y	N
Cable penetrations (Fire zone 24)	RHR B AREA (A/B 1F) EL.(-)40'–0"	Y	Y	N
Cable penetrations (Fire zone 27)	RWCU RECIRC PUMP A ROOM (A/B 2F) EL.(-)15'–0"	Y	Y	N

Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
Cable penetrations (Fire zone 28)	RWCU RECIRC PUMP B ROOM (A/B 2F) EL.(-)15'–0"	Y	Y	N
Cable penetrations (Fire zone 30)	SWITCHGEAR AND MCC ROOM (A/B 2F) EL.(-)15'–0"	Y	Y	N
Cable penetrations (Fire zone 32)	PIPING PENET ROOM NORTH OF SWITCHGEAR & MCC ROOM (A/B 2F) EL.(-)15'–0"	Y	Y	N
Cable penetrations (Fire zone 34)	Cable Shaft (A/B 2F)~A/B 3F~A/B 4F EL.(-)15'–0"	Y	Y	N
Cable penetrations (Fire zone 35)	f(A/B 2F)~A/B 3F~A/B 4F EL.(-)15'–0"	Y	Y	N
Cable penetrations (Fire zone 36)	Cable Shaft (A/B 2F)~A/B 3F~A/B 4F EL.(-)15'–0" Cable Shaft (A/B 2F)~A/B 3F~A/B 4F EL.(-)15'–0"	Y	Y	N
Cable penetrations (Fire zone 37)	Cable Shaft (A/B 2F)~A/B 3F~A/B 4F EL.(-)15'–0"	Y	Y	N
Cable penetrations (Fire zone 47)	480V MCC ROOM (A/B 3F) EL. 1'–0"	Y	Y	N
Cable penetrations (Fire zone 48)	S.W. ELEC PENET ROOM (A/B 3F) EL.1'–0"	Y	Y	N
Cable penetrations (Fire zone 51)	N.W. ELEC PENET ROOM (A/B 3F) EL.1'–0"	Y	Y	N
Cable penetrations (Fire zone 53)	N.E ELEC PENET ROOM (A/B 3F) EL. 1'–0"	Y	Y	N
Cable penetrations (Fire zone 54)	S.E ELEC PENET ROOM (A/B 3F) EL. 1'–0"	Y	Y	N
Cable penetrations (Fire zone 55)	480V LOAD CENTER AREA (A/B 3F) EL. 1'–0"	Y	Y	N

Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
Cable penetrations (Fire zone 49)	PIPE PEN ROOM NORTH OF S.W. ELEC PEN ROOM (A/B 3F) EL.1'–0"	Y	Y	N
Cable penetrations (Fire zone 57)	480V MCC AREA (A/B 4F) EL. 21'–10"	Y	Y	N
Cable penetrations (Fire zone 58)	S.W ELEC PEN ROOM (A/B 4F) EL. 21'–10"	Y	Y	N
Cable penetrations (Fire zone 63)	S.E. ELEC PENET ROOM (A/B 4F) EL. 21'–10"	Y	Y	N
Cable penetrations (Fire zone 82)	CABLE TRAY TUNNEL ON AUX BLDG ROOF (A/B 5F) EL. 39'–10"	Y	Y	N
Cable penetrations (Fire zone 66)	THE FLOOR OF SOUTH HALF ENCLOUSE BLDG (A/B 5F) EL. 39'–10"	Y	Y	N
Cable penetrations (Fire zone 42D, 42B)	THE WEST/EAST CORRIDOR OF 2TH FLOOR AUX BLDG (A/B 2F) EL.(-)15'–0"	Y	Y	N
Cable penetrations (Fire zone 42B, 42D)	THE EAST/WEST CORRIDOR OF 2TH FLOOR AUX BLDG (A/B 2F) EL.(-)15'–0"	Y	Y	N
Cable penetrations (Fire zone 56B, 56D)	THE WEST/EAST CORRIDOR OF 3TH FLOOR AUX BLDG (A/B 3F) EL. 1'–0"	Y	Y	N
Cable penetrations (Fire zone 56B, 56D)	THE EAST/WEST CORRIDOR OF 3TH FLOOR AUX BLDG (A/B 3F) EL. 1'–0"	Y	Y	N
Cable penetrations (Fire zone 65A, 65D)	THE WEST/EAST CORRIDOR OF 4TH FLOOR AUX BLDG (A/B 4F) EL. 21'–10"	Y	Y	N
Cable penetrations (Fire zone 65D, 65A)	THE EAST/WEST CORRIDOR OF 4TH FLOOR AUX BLDG (A/B 4F) EL. 21'–10"	Y	Y	N
Building penetrations	A/B 1F East walls and corridor floors	Y	Y	N

Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
	EL.(-)40'–0"			
Building penetrations	A/B 1F South walls and corridor floors EL.(-)40'–0"	Y	Y	N
Building penetrations	A/B 1F West walls and corridor floors EL.(-)40'–0"	Y	Y	N
Building penetrations	A/B 1F North walls and corridor floors EL.(-)40'–0"	Y	Y	N
Building penetrations	A//B 2F East walls and corridor floors EL.(-)15'–0"	Y	Y	N
Building penetrations	A//B 2F South walls and corridor floors EL.(-)15'–0"	Y	Y	N
Building penetrations	A//B 2F West walls and corridor floors EL.(-)15'–0"	Y	Y	N
Building penetrations	A//B 2F North walls and corridor floors EL.(-)15'–0"	Y	Y	N
Building penetrations	A/B 3F East walls and corridor floors EL. 1'–0"	Y	Y	N
Building penetrations	A/B 3F South walls and corridor floors EL. 1'–0"	Y	Y	N
Building penetrations	A/B 3F West walls and corridor floors EL. 1'–0"	Y	Y	N
Building penetrations	A/B 3F North walls and corridor floors EL. 1'–0"	Y	Y	N
Building penetrations	A/B 4F East walls and corridor floors EL. 21'–10"	Y	Y	N
Building penetrations	A/B 4F South walls and corridor floors EL. 21'–10"	Y	Y	N

Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
Building penetrations	A/B 4F West walls and corridor floors EL. 21'–10"	Y	Y	N
Building penetrations	A/B 4F North walls and corridor floors EL. 21'–10"	Y	Y	N
Building penetrations	A/B 5F East walls and corridor floors EL. 39'–10"	Y	Y	N
Building penetrations	A/B 5F South walls and corridor floors EL. 39'–10"	Y	Y	N
Building penetrations	A/B 5F West walls and corridor floors EL. 39'–10"	Y	Y	N
Building penetrations	A/B 5F North walls and corridor floors EL. 39'–10"	Y	Y	N
Building penetrations	A/B 6F East walls and corridor floors EL. 51'–3"	Y	Y	N
Building penetrations	A/B 6F South walls and corridor floors EL. 51'–3"	Y	Y	N
Building penetrations	A/B 6F West walls and corridor floors EL. 51'–3"	Y	Y	N
Building penetrations	A/B 6F North walls and corridor floors EL. 51'–3"	Y	Y	N
Building penetrations	A/B 7F East walls and corridor floors EL. 76'–3"	Y	Y	N
Building penetrations	A/B 7F South walls and corridor floors EL. 76'–3"	Y	Y	N
Building penetrations	A/B 7F West walls and corridor floors EL. 76'–3"	Y	Y	N
Building penetrations	A/B 7F North walls and corridor floors EL. 76'–3"	Y	Y	N
Control building				

Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
Cable penetrations (Fire zone 116)	Unit 1 Remote Shutdown Room (C/B 2F) EL.(-)20'–0"	Y	Y	N
Cable penetrations (Fire zone 117)	Unit 1 Div. II Battery Room 1 GDBB (C/B 2F) EL.(-)20'–0"	Y	Y	N
Cable penetrations (Fire zone 118)	Unit 1 Div. II Battery Room 1 GDBD (C/B 2F) EL.(-)20'–0"	Y	Y	N
Cable penetrations (Fire zone 119)	Unit 1 NORTH ESF SWITCHGEAR ROOM (Div. II) (C/B 2F) EL.(-)20'–0"	Y	Y	N
Cable penetrations (Fire zone 120)	Unit 1 Battery Room 1 RDBD (Div. I) (C/B 2F) EL.(-)20'–0"	Y	Y	N
Cable penetrations (Fire zone 121)	Unit 1 Battery Room 1 RDBC (Div. I) (C/B 2F) EL.(-)20'–0"	Y	Y	N
Cable penetrations (Fire zone 122)	Unit 1 SOUTH ESF SWITCHGEAR ROOM (Div. I) (C/B 2F) EL.(-)20'–0"	Y	Y	N
Cable penetrations (Fire zone 123)	Unit 2 SOUTH ESF SWITCHGEAR ROOM (Div. II) (C/B 2F) EL.(-)20'–0"	Y	Y	N
Cable penetrations (Fire zone 124)	Unit 2 Battery Room 2 GDBB (Div. II) (C/B 2F) EL.(-)20'–0"	Y	Y	N
Cable penetrations (Fire zone 125)	Unit 2 Battery Room 2 GDBD (Div. II) (C/B 2F) EL.(-)20'–0"	Y	Y	N
Cable penetrations (Fire zone 126)	Unit 2 NORTH ESF SWITCHGEAR ROOM (Div. I) (C/B 2F) EL.(-)20'–0"	Y	Y	N
Cable penetrations (Fire zone 127)	Unit 2 Battery Room 2 RDBC (Div. I) (C/B 2F) EL.(-)20'–0"	Y	Y	N

Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
Cable penetrations (Fire zone 128)	Unit 2 Battery Room 2 RDBA (Div. I) (C/B 2F) EL.(-)20'–0"	Y	Y	N
Cable penetrations (Fire zone 129)	Unit 2 REMOTE SHUTDOWN ROOM (C/B 2F) EL.(-)20'–0"	Y	Y	N
Cable penetrations (Fire zone 304)	Unit 1 ERF Battery Room (C/B 2F) EL.(-)20'–0"	Y	Y	N
Cable penetrations (Fire zone 305)	Unit 2 ERF Battery Room (C/B 2F) EL.(-)20'–0"	Y	Y	N
Cable penetrations (Fire zone 131)	CABLE SPREADING ROOM (C/B 3F) EL. 1'–0"	Y	Y	N
Cable penetrations (Fire zone 132)	Unit 1 North RPS MG set room (C/B 3F) EL. 1'–0"	Y	Y	N
Cable penetrations (Fire zone 133)	Unit 1 South RPS MG set room (C/B 3F) EL. 1'–0"	Y	Y	N
Cable penetrations (Fire zone 134)	Computer room (C/B 3F) EL. 1'–0"	Y	Y	N
Cable penetrations (Fire zone 135)	ERF Computer room (C/B 3F)EL. 1'–0"	Y	Y	N
Cable penetrations (Fire zone 136)	Unit 2 South RPS MG set room (C/B 3F) EL. 1'–0"	Y	Y	N
Cable penetrations (Fire zone 137)	Unit 2 North RPS MG set room (C/B 3F) EL. 1'–0"	Y	Y	N
Cable penetrations (Fire zone 143B)	Unit 1 Control Cabinet Area (C/B 4F) EL. 30'–0"	Y	Y	N
Cable penetrations (Fire zone 143C)	Unit 2 Control Cabinet Area (C/B 4F) EL. 30'–0"	Y	Y	N
Building penetrations	C/B 1F East walls EL.(-)40'–0"	Y	Y	N
Building penetrations	C/B 1F South walls EL.(-)40'–0"	Y	Y	N

Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
Building penetrations	C/B 1F West walls EL.(-)40'–0"	Y	Y	N
Building penetrations	C/B 1F North walls EL.(-)40'–0"	Y	Y	N
Building penetrations	C/B 2F East walls EL.(-)20'–0"	Y	Y	N
Building penetrations	C/B 2F South walls EL.(-)20'–0"	Y	Y	N
Building penetrations	C/B 2F West walls EL.(-)20'–0"	Y	Y	N
Building penetrations	C/B 2F North walls EL.(-)20'–0"	Y	Y	N
Building penetrations	C/B 3F East walls EL. 1'–0"	Y	Y	N
Building penetrations	C/B 3F South walls EL. 1'–0"	Y	Y	N
Building penetrations	C/B 3F West walls EL. 1'–0"	Y	Y	N
Building penetrations	C/B 3F North walls EL. 1'–0"	Y	Y	N
Building penetrations	C/B 4F East walls EL. 30'–0"	Y	Y	N
Building penetrations	C/B 4F South walls EL. 30'–0"	Y	Y	N
Building penetrations	C/B 4F West walls EL. 30'–0"	Y	Y	N
Building penetrations	C/B 4F North walls EL. 30'–0"	Y	Y	N
Diesel generator building				
Cable penetrations (#1, 2Fire zone 273)	Div. II DIESEL GENERATOR ROOM EL. 1'–0"	Y	Y	N
Cable penetrations (#1, 2Fire zone 274)	Div. I DIESEL GENERATOR ROOM EL. 1'–0"	Y	Y	N

Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
Cable penetrations (#1, 2Fire zone 275)	Div. Ⅲ DIESEL GENERATOR ROOM EL. 1'–0"	Y	Y	N
Building penetrations D/G Div. I	East walls EL. 1'–0"	Y	Y	N
Building penetrations D/G Div. I	South walls EL. 1'–0"	Y	Y	N
Building penetrations D/G Div. I	West walls EL. 1'–0"	Y	Y	N
Building penetrations D/G Div. I	North walls EL. 1'–0"	Y	Y	N
Building penetrations D/G Div. II	East walls EL. 1'–0"	Y	Y	N
Building penetrations D/G Div. II	South walls EL. 1'–0"	Y	Y	N
Building penetrations D/G Div. II	West walls EL. 1'–0"	Y	Y	N
Building penetrations D/G Div. II	North walls EL. 1'–0"	Y	Y	N
Building penetrations D/G Div. III	East walls EL. 1'–0"	Y	Y	N
Building penetrations D/G Div. III	South walls EL. 1'–0"	Y	Y	N
Building penetrations D/G Div. III	West walls EL. 1'–0"	Y	Y	N
Building penetrations D/G Div. III	North walls EL. 1'–0"	Y	Y	N
Building penetrations	All areas on the roofs EL. 1'–0"	Y	Y	N
BOP Battery E.F				
Cable penetrations (#1Fire zone 101)	Unit 1 BOP Battery E.F EL. 1'–0"	Y	Y	N
Cable penetrations (#2Fire zone 101)	Unit 2 BOP Battery E.F EL. 1'–0"	Y	Y	N

Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
Turbine buildings				
Building penetrations	T/B 2F East walls and north corridor floors EL.(-)15'–9"	Y	Y	N
Building penetrations	T/B 2F South walls and north corridor floors EL.(-)15'–9"	Y	Y	N
Building penetrations	T/B 2F West walls and north corridor floors EL.(-)15'–9"	Y	Y	N
Building penetrations	T/B 2F North walls and north corridor floors EL.(-)15'–9"	Y	Y	N
Building penetrations	T/B 3F East walls and north corridor floors EL. 1'–0"	Y	Y	N
Building penetrations	T/B 3F South walls and north corridor floors EL. 1'–0"	Y	Y	N
Building penetrations	T/B 3F West walls and north corridor floors EL. 1'–0"	Y	Y	N
Building penetrations	T/B 3F North walls and north corridor floors EL. 1'–0"	Y	Y	N
Building penetrations	T/B 4F North walls EL. 21'–10"	Y	Y	N
Rad Waste buildings				
Building penetrations	RW/B 1F East walls EL.(-)40'–0"	Y	Y	N
Building penetrations	RW/B 1F South walls EL.(-)40'–0"	Y	Y	N

Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
Building penetrations	RW/B 1F West walls EL.(-)40'–0"	Y	Y	N
Building penetrations	RW/B 1F North walls EL.(-)40'–0"	Y	Y	N
Building penetrations	RW/B 2F East walls EL.(-)15'–9"	Y	Y	N
Building penetrations	RW/B 2F South walls EL.(-)15'–9"	Y	Y	N
Building penetrations	RW/B 2F West walls EL.(-)15'–9"	Y	Y	N
Building penetrations	RW/B 2F North walls EL.(-)15'–9"	Y	Y	N
Building penetrations	RW/B 3F East walls EL. 1'–0"	Y	Y	N
Building penetrations	RW/B 3F South walls EL. 1'–0"	Y	Y	N
Building penetrations	RW/B 3F West walls EL. 1'–0"	Y	Y	N
Building penetrations	RW/B 3F North walls EL. 1'–0"	Y	Y	N
Building penetrations	RW/B 4F East walls EL. 21'–10"	Y	Y	N
Building penetrations	RW/B 4F South walls EL. 21'–10"	Y	Y	N
Building penetrations	RW/B 4F West walls EL. 21'–10"	Y	Y	N
Building penetrations	RW/B 4F North walls EL. 21'–10"	Y	Y	N
Building penetrations	RW/B 5F East walls EL. 50'–0"	Y	Y	N
Building penetrations	RW/B 5F South walls EL. 50'–0"	Y	Y	N
Building penetrations	RW/B 5F West walls EL. 50'–0"	Y	Y	N
Building penetrations	RW/B 5F North walls EL. 50'–0"	Y	Y	N

Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
Fuel buildings				
Building penetrations	F/B 1F East walls EL.(-)40'–0"	Y	Y	N
Building penetrations	F/B 1F South walls EL.(-)40'–0"	Y	Y	N
Building penetrations	F/B 1F West walls EL.(-)40'–0"	Y	Y	N
Building penetrations	F/B 1F North walls EL.(-)40'–0"	Y	Y	N
Building penetrations	F/B 2F East walls EL.(-)15'–9"	Y	Y	N
Building penetrations	F/B 2F South walls EL.(-)15'–9"	Y	Y	N
Building penetrations	F/B 2F West walls EL.(-)15'–9"	Y	Y	N
Building penetrations	F/B 2F North walls EL.(-)15'–9"	Y	Y	N
Building penetrations	F/B 3F East walls EL. 1'–0"	Y	Y	N
Building penetrations	F/B 3F West walls EL. 1'–0"	Y	Y	N
Building penetrations	F/B 3F Driveways EL. 1'–0"	Y	Y	N
LFM M-G				
Building penetrations	LFM M-G SET A East walls EL. 1'–0"	Y	Y	N
Building penetrations	LFM M-G SET A South walls EL. 1'–0"	Y	Y	N
Building penetrations	LFM M-G SET A West walls EL. 1'–0"	Y	Y	N
Building penetrations	LFM M-G SET A North walls EL. 1'–0"	Y	Y	N

Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
Building penetrations	LFM M-G SET B East walls EL. 1'–0"	Y	Y	N
Building penetrations	LFM M-G SET B South walls EL. 1'–0"	Y	Y	N
Building penetrations	LFM M-G SET B West walls EL. 1'–0"	Y	Y	N
Building penetrations	LFM M-G SET V North walls EL. 1'–0"	Y	Y	N
Auxiliary boilers				
Building penetrations	Four walls and all areas on the roofs EL. 1'–0"	Y	Y	N
2.a Emergency equipment-sump drain pumps				
LPCS Sump Pump 1P-62A, 1P-62B	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
HPCS Sump Pump 1P-97A, 1P-97B	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
RHR A Sump Pump 1P-92A, 1P-92B	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
RHR B Sump Pump 1P-93A, 1P-93B	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
RHR C Sump Pump 1P-94A, 1P-94B	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
FUEL BLDG. Sump Pump 1P-28A, 1P-28B	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
CRD Sump Pump 1P-53A, 1P-53B	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
RCIC Sump Pump 1P-64A, 1P-64B	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
LPCS Sump Pump 2P-62A, 2P-62B	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
HPCS Sump Pump 2P-97A, 2P-97B	Auxiliary buildings EL.(-)40'–0"	Y	Y	N

Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
RHR A Sump Pump 2P-92A, 2P-92B	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
RHR B Sump Pump 2P-93A, 2P-93B	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
RHR C Sump Pump 2P-94A, 2P-94B	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
FUEL BLDG. Sump Pump 2P-28A, 2P-28B	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
CRD Sump Pump 2P-53A, 2P-53B	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
RCIC Sump Pump2P-64A, 2P-64B	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
2.b Water-proof doors to emergency equipment in auxiliary buildings				
#1 Southeast corners	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#1 Perforated tubes (2F east right)	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#1 Perforated tubes (2F east left)	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#1 1P-56A	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#1 1P-56B	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#1 RWCU (A)	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#1 RWCU (B)	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#1 HPCS	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#1 RHR C	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#1 RCIC (Internal)	Auxiliary buildings EL.(-)40'–0"	Y	Y	N

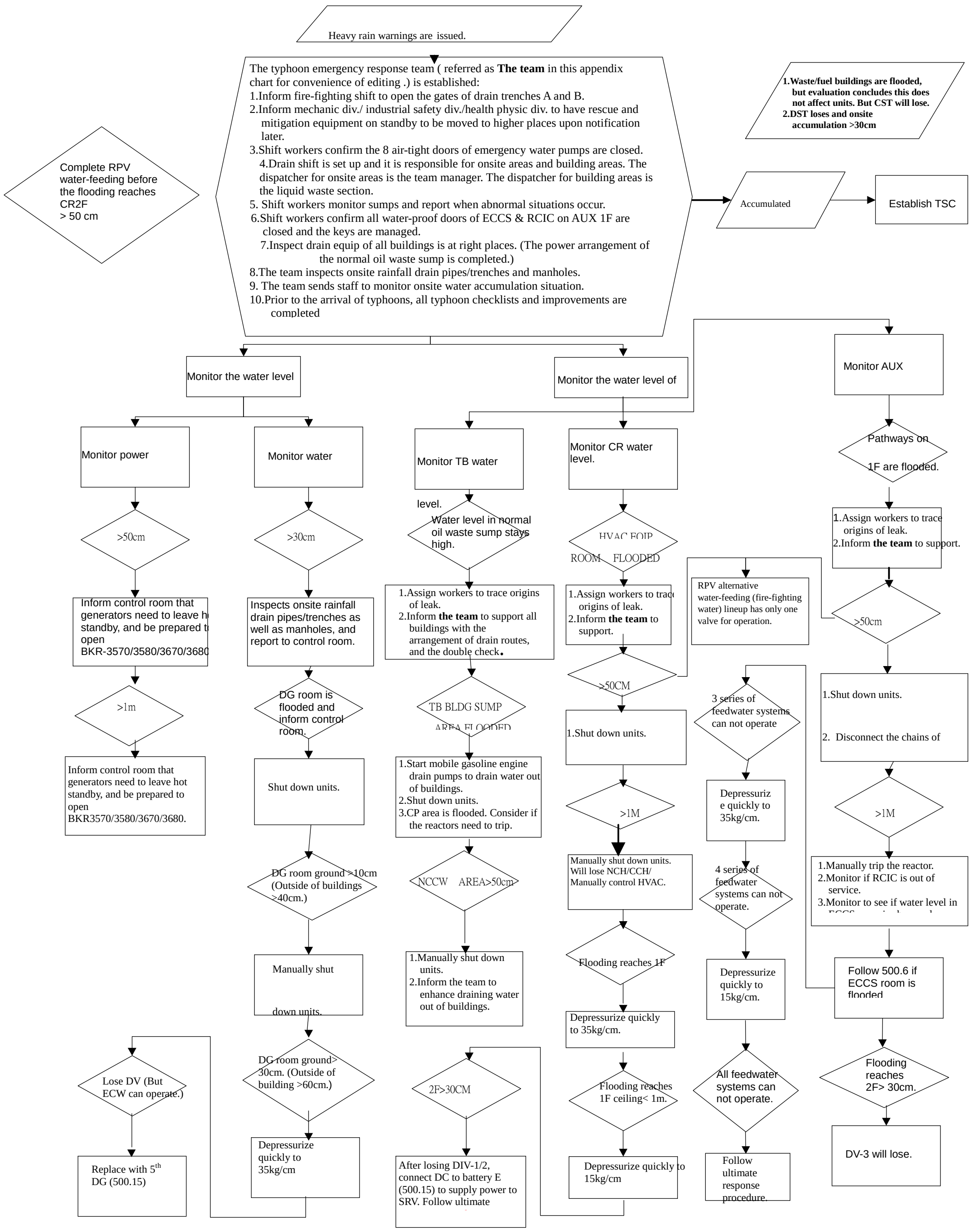
Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
#1 RHR B	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#1 RHR A	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#1 LPCS	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#1Perforated tubes(2F west side)	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#2 2P-56A	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#2 2P-56B	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#2Perforated tubes(2F east right)	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#2Perforated tubes(2F east left)	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#2 RWCU (A)	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#2 RWCU (B)	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#2 HPCS	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#2 RHR C	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#2 RCIC (Internal)	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#2 Southwest corners	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#2 RHR B	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#2 RHR A	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#2 LPCS	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
#2 Perforated tubes (2F west side)	Auxiliary buildings EL.(-)40'–0"	Y	Y	N

Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
3. Water-proofness of fire-proof doors, emergency exits, and roller shutter doors on the ground floor of buildings				
#1 Div. I roller shutter doors and fire-proof doors in DG Bldg.	EL.(-)0'–0"	Y	N	N ※ Note: Elevation of related buildings listed on the left is 12 meters, which is higher than the stated potential maximum tsunami run-up height in FSAR 2.4, namely 10.28 meters. Hence, there is no protection design against flooding.
#1 Div. II roller shutter doors and fire-proof doors in DG Bldg.	EL.(-)0'–0"	Y	N	
#1 Div. III roller shutter doors and fire-proof doors in DG Bldg.	EL.(-)0'–0"	Y	N	
#2 Div. I roller shutter doors and fire-proof doors in DG Bldg.	EL.(-)0'–0"	Y	N	
#2 Div. II roller shutter doors and fire-proof doors in Bldg.	EL.(-)0'–0"	Y	N	
#2 Div. III roller shutter doors and fire-proof doors in DG Bldg.	EL.(-)0'–0"	Y	N	
#1 Fuel Bldg. roller shutter doors	EL.(-)0'–0"	Y	N	
#2 Fuel Bldg. roller shutter doors	EL.(-)0'–0"	Y	N	
Roller shutter doors in radiate buildings	EL.(-)0'–0"	Y	N	
Rad Waste Bldg. Emergency Exit E236	EL.(-)0'–0"	Y	N	
Aux. Bldg. Emergency Exit E044	EL.(-)0'–0"	Y	N	
Aux. Bldg. Emergency Exit E065	EL.(-)0'–0"	Y	N	

Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
Aux. Bldg. Emergency Exit E404	EL.(-)0'–0"	Y	N	
Aux. Bldg. Emergency Exit E398	EL.(-)0'–0"	Y	N	
Turbine Bldg. Roller shutter doors	EL.(-)0'–0"	Y	N	
Turbine Bldg. Emergency Exit E542	EL.(-)0'–0"	Y	N	
Turbine Bldg. Emergency Exit E545	EL.(-)0'–0"	Y	N	
Turbine Bldg. Emergency Exit E549	EL.(-)0'–0"	Y	N	
Turbine Bldg. Emergency Exit E557	EL.(-)0'–0"	Y	N	
Turbine Bldg. Emergency Exit E565	EL.(-)0'–0"	Y	N	
Turbine Bldg. Emergency Exit E523	EL.(-)0'–0"	Y	N	
4. Building drain function and standby flooding drain equipment				
Sum drain pumps in Turbine Bldg.	Turbine buildings EL.(-)40'–0"	Y	Y	N
Sumps in Aux. Bldg. *	Auxiliary buildings EL.(-)40'–0"	Y	Y	N
Sump drain pumps in Fuel Bldg.	Fuel buildings EL.(-)40'–0"	Y	Y	N
Sump drain pumps in Rad Waste Bldg.	Radiate buildings EL.(-)40'–0"	Y	Y	N
6 gasoline engine drain pumps	EL.(+)60'–0"	Y	Y	N
* No drain pumps are set up at auxiliary building sumps. Flooding is removed through gravity to turbine buildings sumps first and then to the on site drain systems via the sump pumps in turbine buildings.				

Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
5. Onsite drain routes				
Drain at power block	Drain system (yard drain system) in power block.	Y	Y	N
Drain at west of buildings	Surface runoff resulted from the rainfall in the warehouse area, power switchyard areas and hills in west of main building area is removed through trench A (Creek A).	Y	Y	N
Drain at east of buildings	Surface runoff resulted from the rainfall at hills in east of buildings is removed through trench B (Creek B).	Y	Y	N

Attachment 3-3 External/ internal flooding handling flowchart



Attachment 3-4: Typhoon emergency response measures

Typhoon status	Measures to be adopted	Steps of procedure
Sea and land typhoon warnings are issued, and the radius of the typhoon with gust over Beaufort Force 7 will reach the site alert area in 18 hours. (Note 1)	The plant is in “typhoon watching period” mode: • The electricity shift leader writes a typhoon report. • Confirm that Div. I.Ⅱ.Ⅲ emergency diesel generators can operate in 8 hours. Confirm that the gas turbine can operate in 8 hours.	5.1.1 5.1.1.a 5.1.6 5.1.7
The radius of the typhoon with Beaufort Force 7 will reach the site in 10 hours. (Note 1)	The plant is in “typhoon alert period” mode: • The electricity shift leader writes a typhoon report. When the typhoon emergency response team is established: • The leader of the typhoon emergency response team informs the shift manager the establishment of the typhoon emergency response team. • Once the typhoon emergency response team is set up, the shift manager reports to the nuclear power department. • The shift manager should assign a person to start the IBM natural disasters reporting system (NDS) and to confirm as well as report that NDS is connected. • If the plant is seized by typhoon and there is an abnormal situation with power generating or an accident, the team should report following procedure for natural disasters, abnormal power generating, emergency incidents. • The shift manager should continuously stay in contact with the leader of the typhoon emergency response team.	5.1.8 5.1.8.a 5.1.9 5.1.9.a 5.1.9.b 5.1.9.c 5.1.9.d 5.1.9.e

When the radius of the typhoon with Beaufort Force 7 (13.9m/s) will reach the site (25°2’N, 121°67’E) in 1 hour, (Note 1), or is expected to reach the plant and 10/15- minute sustained winds measured on site is above Beaufort Force 10.	• Start a gas turbine, connect it to 69 kV bus for isolated operation; the other one is on standby. • Stop related function tests on RPS and NSSS system.	5.1.10.a 5.1.10.b

The following situations (A, B, C, D, and E) are regulated by technical specification.
Timing of use: when the typhoon forecasts show that the radius of the typhoon with Beaufort Force 10 has reached Kuosheng NPP alert area.(Note)

Intensity / Action / Situation	Mild/ Moderate typhoon	Severe typhoon
A	The plant operates in the alert mode.	Reduce power to turbine trip bypass set point of RPS in 3 hours. (Note 2)
B	Reduce power to turbine trip bypass set point of RPS in 3 hours. (Note 2)	Reduce reactor thermal power to about 20% in 3 hours. (Note 2)
C	Reduce reactor thermal power to about 20% in 3 hours. (Note 2)	Disconnect from grid and stay in hot standby mode in 4 hours.
A+D	Disconnect from grid and stay in hot standby mode in 4 hours.	Disconnect from grid and stay in hot standby mode 4 hours, then achieve cold shutdown mode in 24 hours.
B+D	The reactors leaves hot standby in 4 hours and reach the shutdown status in the following 24 hours.	Immediately shutdown reactor and achieve cold shutdown mode as soon as possible.
E	Immediately shutdown reactor and achieve cold shutdown mode as soon as possible.	Immediately shutdown reactor and achieve cold shutdown mode as soon as possible.

<table>
<tr><td colspan="3">Definition of the situations:
A. 10/15- minute sustained winds measured on site reach Beaufort Force 10 (over 24.5m/s).
B. 10/15- minute sustained winds measured on site reach Beaufort Force 12 (over 32.7m/s).
C. 10/15- minute sustained winds measured on site reach Beaufort Force 15 (over 46.2m/s)
D. When any unit has one of the following situations:
(1) An emergency diesel generator can not operate, or
(2) Only one or two 345 kV offsite power source loops can function, or
(3) Lose 69kV offsite power source and one gas turbine
E. When any unit has one of the following situations:
(1) Lose two offsite power sources, or
(2) lose an emergency diesel generator and an offsite power source, or
(3) Lose two emergency diesel generators.
Note: Definition of the “Area on alert” for Kuosheng NPP during typhoon: this area is centered in Taipei, ranging from 100km east and south of Taipei as well as 50km west and north of Taipei, namely 24°5’～25°5 N, 121°～122°5 E.</td></tr>
<tr><td>Typhoon status</td><td>Measures to be adopted</td><td>Steps of procedure</td></tr>
<tr><td>Wind speed is close to 60m/s.</td><td>Follow procedure 1401-H “Natural disasters and other situations that influence unit safety” and procedure 1403 “Emergency preparation and response incident procedure.”</td><td>5.4.</td></tr>
<tr><td>Confirmation:
1.The radius of the typhoon with Beaufort Force 10 leaves the "Area on Alert" of the plant, or
2.10/15- minute sustained winds measured on site are below Beaufort Force 9 (20.8m/s), and the weather information shows the threat posed by the typhoon becomes less.</td><td>After the superintendent or his authorized person confirms that the units are not damaged and can still be operated and that the typhoon checklist has been followed (Appendix 1), the units need to start uprating or return to operation. Besides, once the power switchyard director and the Keelung Regional Dispatching Center confirm that the 69kV offsite power supply is normal. Then, the gas turbine returns to be on standby or shutdown. However, the power plant still needs to continuously watch the latest status of typhoon until Central Weather Bureau dismisses the typhoon warning.

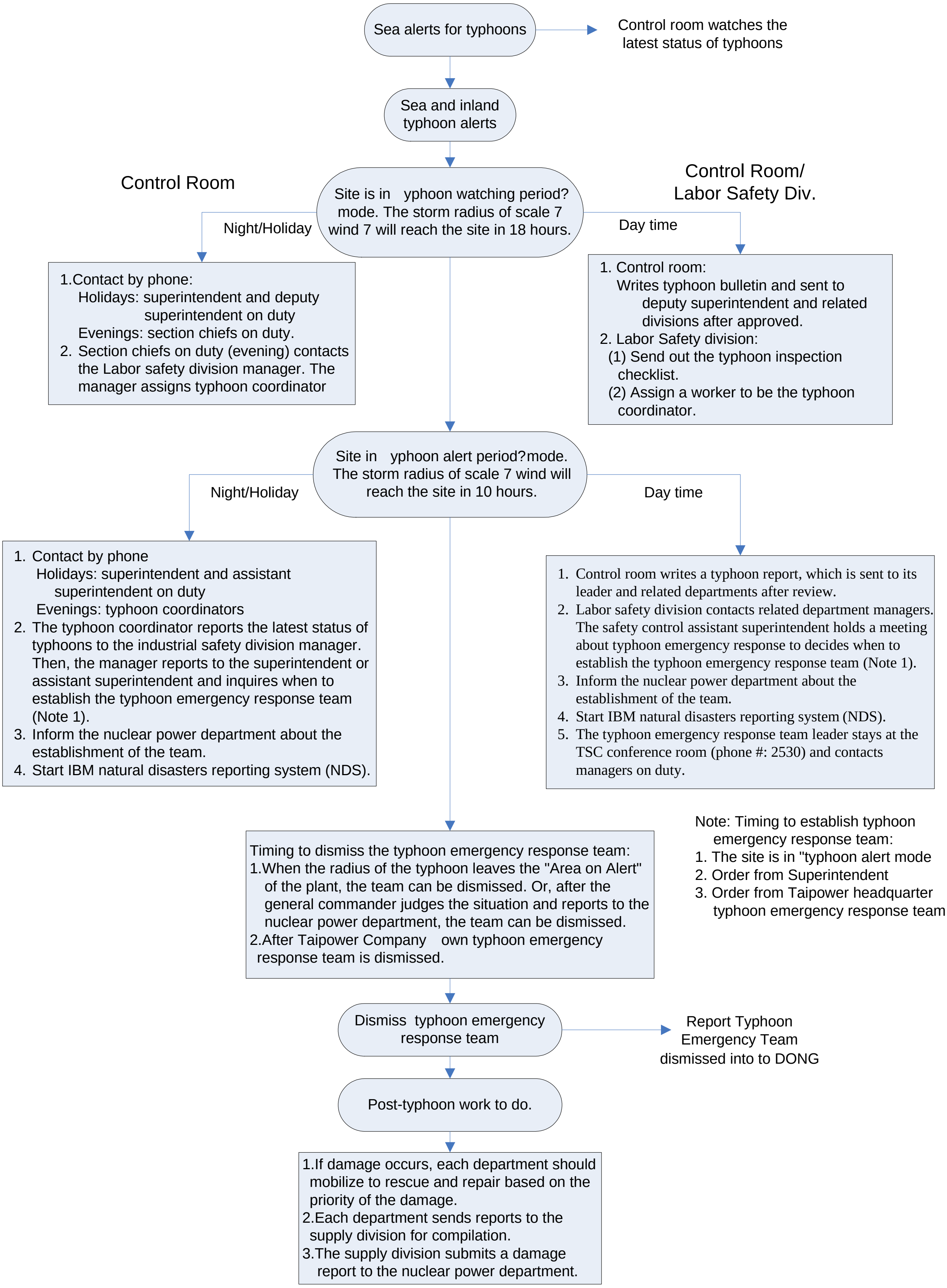
Once the typhoon emergency response team is dismissed, the shift manager reports to the nuclear power department.</td><td>6.C

6.D</td></tr>
</table>

Note 1: To learn about the time when a typhoon will arrive at the plant, go to the internal web site of Kuosheng NPP and follow the links to get to a web site providing typhoon information: GS NPP internal Internet/operation information/typhoon approaching. Then, enter the typhoon location, radius of typhoon with Beaufort Force 7 or 10, moving direction and speed, and predicted typhoon location (an optional entry), after calculation, the estimated time needed for the radius of typhoon with Beaufort Force 7 or 10 to reach the site or "Area on Alert" is available.

Note 2: The timing for the nuclear units to stop reducing power is when the plant judges that there is no need for emergency responses and related meteorological information shows that the threat posed by the typhoon also becomes less, the superintendent or his authorized person commends that the units can stop reducing power.

Attachment 3-5 Typhoon emergency response procedure



Attachment 3-6: Tsunami warning announcement operation guide of Central Weather Bureau, Ministry of Transportation and Communication

1 Far-land earthquake-induced tsunami:

1.1 Once Central Weather Bureau receives a tsunami warning from Pacific Tsunami Warning Center, it immediately sends staff to observe onsite in order to judge potential seizing locations as well as the time, and response items.

1.2 3 hours before a tsunami reaches Taiwan, CWB judges that the tsunami may pose as a threat to the Taiwan region, it will send the tsunami warnings to related government agencies of coast guards and of disaster prevention and mitigation via cell phone text and fax.

1.3 2 hours before tsunami reach Taiwan, CWB judges that the tsunami may pose as a threat to the Taiwan region, it will issue tsunami warnings to related government agencies and the media to ask coastal residents to be prepared to respond.

2. Offshore earthquake-induced tsunami:

2.1 When the earthquake reporting system of Central Weather Bureau (CWB) detects an offshore earthquake of magnitude 6.0 or above and the depth of the epicenter is less than 35kms, CWB should note in the earthquake report that the coastal areas in Taiwan should be cautious about the sudden changes of seawater level.

2.2 When the earthquake reporting system of Central Weather Bureau (CWB) detects an offshore earthquake of magnitude 7.0 or above and the depth of the epicenter is less than 35kms, CWB should issue tsunami warnings to related government agencies and the media to ask coastal residents to be prepared to respond.

3. CWB should dismiss the tsunami warning in accordance with information from Pacific Tsunami Warning Center or CWB tidal stations after the tsunami event.

Attachment 3-7: a tsunami case at Kuosheng NPP

The tsunami case for Kuosheng NPP, including the initiating event, and the final cooling shutdown consequence, contain a total of 11 headings, plus their related event sequence progression. There are two scenarios in this tsunami case; one is the basic situation of the tsunami case and the other one is the consequence of the tsunami-induced LOUH. The following only discusses the consequence of the tsunami-induced LOUH and detailed description is as below:

1. Initiating event: This is the beginning of the event tree. After earthquakes result in the loss of outside power and induce the tsunami, LOUH happens. As shown in Fig. 2-1, the earthquake- induced tsunami at Kuosheng NPP causes the value of LOUH to be 12m. As a result, the key element, the height of ECW pumps 12m.

2. Reactor trip: the tsunami causes ATWS. Therefore, the key element is the height of CRDM.

3. DC power source and I&C: the tsunami causes the DC power source (125 VDC Bus 1RDA, Bus 1ODG) or the control panels of both RCIC and HPCS pumps to fail, so the key element, the height of DC SWBD/ control panel, 12.3m.

4. RCIC/HPCS reactor injection: the same as above, tsunami cause RCIC pumps or their control panels to fail. Hence, the key element, the height of RCIC pumps/control panels, to be 12m. (The tsunami causes LOUH, so HPCS DG (1OG1) definitely fails.)

5. Reactors depressurizing: the tsunami causes the SRV control panel to fail, so the key element is the height of SRV control panel.

6. Onsite AC power (diesel generators) and ECW: the tsunami causes LOUH, so water-cooling 1RG1, 1GG1, and 1OG1definitely fail and only DG-5 can operate. This sub-subject contains two situations:

   a. Success of high-pressure water injection: this still needs SPCM to cool S/P, but SPCM fails owning to LOUH.

   b. Failure of high-pressure water injection/water makeup: when high-pressure water injection/ water makeup fails, DG-5 needs to supply power to 3 LPCI and 1 LPCS pumps in the two units to inject water in the low-pressure reactors. However, because low-pressure water injection/water makeup also requires AC power and SPCM, low-pressure water injection/water makeup definitely fail when failure of high-pressure water injection/water makeup occurs. Therefore, directly jump to step 9 to understand the alternative water makeup for the reactors.

As shown in Fig. 3-1, the key element for onsite AC power in Kuosheng NPP failure is the lowest height of AC Switchgear/DG-5/DG-5control panel that is 12m.

7. LPCI/LPCS water makeup for the reactors: follow previous result, LPCI/LPCS water makeup for the reactors definitely fails, so directly jump to step #9 to address the alternative water makeup for the reactors.

8. Containment cooling/RHR: follow previous result, containment cooling/RHR definitely fails, so directly jump to step #9 to address the alternative water makeup for the reactors.

9. Alternative water makeup/ fire-fighting water for the reactors: according to previous discussion, the tsunami results in LOUH and then the loss of FIREW. Therefore, as shown in Fig. 3-1, the alternative water makeup for the reactors at Kuosheng NPP fails, so the key element will be the height of the feedwater pipe from FIREW to LPCI-B, it is 12.3M.

10. Containment ventilation: the tsunami causes LOUH to have very little influence on containment ventilation.

11. Shutdown cooling: this is the end of the event tree and contains two scenarios. The first scenario is that the reactors would not melt down if the reactors shutdown cooling succeeds. The second is that the reactors shutdown cooling fails and the reactors melt down.

As described above in this report, based on the conclusion of the tsunami case for Kuosheng NPP, there is only one successful situation of reactor cold shutdown, which is:

After the tsunami cause LOUH, the reactor trip succeeds, but long-term high-pressure water makeup for the reactors fails. The success of the long-term alternative water makeup for the reactors (including containment ventilation) leads to success consequence.

Among which, description of safety margin and its cliff edge is as follow:

Because there is only a success path, its cliff edge is the cliff edge of this tsunami case. Its safety margin needs to adopt the smallest safety margin of each heading, namely 0.3m (12.3m-12m); its cliff edge also needs to use the smallest figure of each heading, namely 12.3 meters.

Attachment 3-8 “sump pump capability”

Building	Sump	Pump	Capacity (gpm)	Elevation (feet)	Seismic Category
Turbine Building	TURBINE PLANT DRAIN SUMP PUMP	1/2P-50A/B	260 each	(-) 47	II
	TURBINE BLDG. NORMAL WASTE SUMP PUMP	1/2P-107A/B	100 each	(-) 47	II
Reactor Building	DRYWELL FLOOR DRAIN SUMP PUMP	1/2P-54A/B	50 each	(-) 28	II
	DRYWELL EQUIPMENT DRAIN SUMP PUMP	1/2P-30A/B	50 each	(-) 28	II
	REACTOR BLDG. FLOOR DRAIN SUMP PUMP	1/2P-32A/B	50 each	(-) 14	II
	REACTOR BLDG. EQUIP. DRAIN SUMP PUMP	1/2P-31A/B	50 each	(-) 14	II
Auxiliary Building	LPCS PUMP ROOM DRAIN SUMP PUMP	1/2P-62A/B	50 each	(-) 46	II
	RCIC PUMP ROOM DRAIN SUMP PUMP	1/2P-64A/B	50 each	(-) 46	II
	HPCS PUMP ROOM DRAIN SUMP PUMP	1/2P-97A/B	50 each	(-) 46	II
	RHR PUMP "A" ROOM DRAIN SUMP PUMP	1/2P-92A/B	50 each	(-) 46	II
	RHR PUMP "B" ROOM DRAIN SUMP PUMP	1/2P-93A/B	50 each	(-) 46	II
	RHR PUMP "C" ROOM DRAIN SUMP PUMP	1/2P-94A/B	50 each	(-) 46	II
	CRD PUMP AREA SUMP PUMP	1/2P-53A/B	50 each	(-) 46	II

Fuel building	FUEL STORAGE BLDG. DRAIN SUMP PUMP	1/2P-28A/B	50 each	(-) 41	Ⅱ
Radwaste Building	RADWASTE BLDG. DRAIN SUMP PUMP	1/2P-29A/B	50 each	(-) 45	Ⅱ

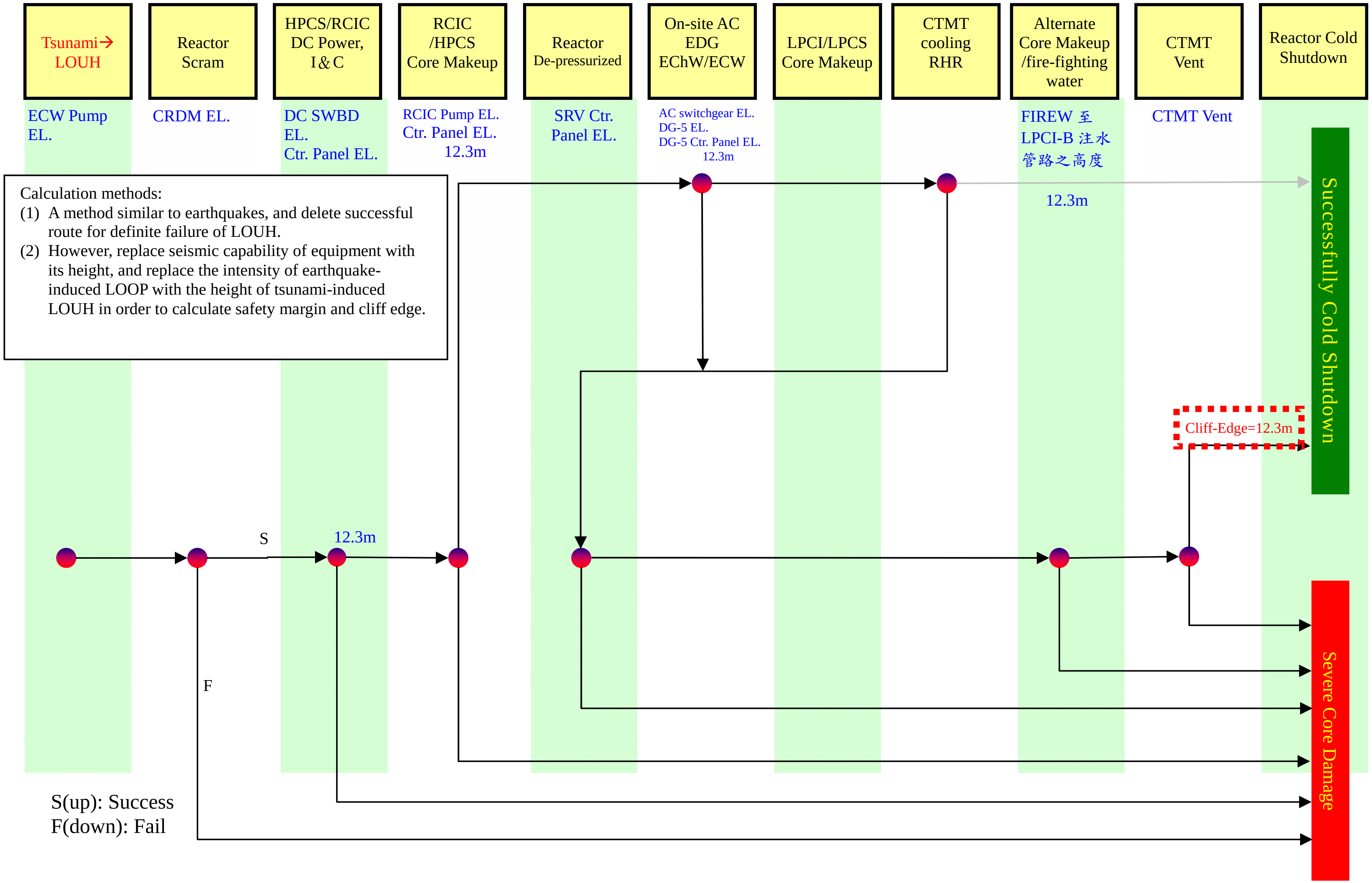


Fig. 3-1 Kuosheng Power Plant tsunami event tree

4 Extreme natural events

4.1 Very bad weather conditions (storms, heavy rainfalls)

Natural events in the past often occurred in sync with the climate cycle, displaying some patterns. However, abnormal weather situations appear in recent years and the level of their influence increases. Even though human already have significant amount of knowledge about climate change, it is still imperative to be fully prepared for disaster prevention.

Taiwan Environment Information Center reported that the typhoon season in year 2010 did not begin until late in August. In mid-September, Typhoon Fanapi pounded and inundated southern Taiwan, being the most serious typhoon of the year. The first northeast cold front following Typhoon Fanapi flooded some part of northern Taiwan. After the destructive Typhoon Morakot, academic discussion started on whether extreme weather events are a special case or will become common in the future. However, it is important to know that scholars have warned that "heavy precipitation" type of climate will threaten Taiwan in the future.

Facing the impact of extreme weather, "adjusting" may be the only option. In Extreme Weather Situation Severe Weather of the Final safety analysis report (FSAR) of Kuosheng Nuclear Power Plant, the plant takes storm into consideration when deciding its design basis events. Kuosheng Power Plant has verified that all protection equipment of the plant meets the requirement of the design basis after the Fukushima Accident. Meanwhile, to respond to the impact of extreme weather, by using stress tests for combined natural events of "typhoons and heavy rainfalls/ and debris flow," and beyond design basis, Taipower Company reviewed the protection capability of all the three nuclear power plants in September, 2011 in order to find out their vulnerabilities and to enhance protection capability of these power plants.

4.1.1 Events and any combination of events – reasons for a selection (or not) as a design basis event

When choosing severe weather conditions as the design basis events of the plant, natural events ~~of~~ such as heavy precipitation, typhoons, and thunderstorms had been taken into consideration. The original plant design basis for protection against natural events, as well as two recently emerging natural-event issues, i.e., landslide susceptibility and debris flow potential, are described as follows:

1. Elevation of the plant

   The plant site is located on a coastal plain at an elevation of 12 meters above mean sea level. The site is about 500 meters inland from the seashore which faces an open bay on the East China Sea. It has a drainage system in main building area and man-made incline drainage trenches A/B to help drainage on both east and west side of the plant, next to the main building area.

There is no river across the site. The nearest streams are Yuantan Stream, 1.5km west of the site, and Mashu Stream, 4.5km east of the site. Both streams flow into the ocean and are separated away from the plant by mountain hills, so they will not cause onsite flooding.

2. Drainage capability of the plant

(1) Drainage system

The drainage system of the plant is divided into three major parts—the main building area, west area of the site, and east area of the site (FSAR 2.4.2.3.3):

The first drainage system is located in main building area (Power Block). It collects surface flow from rainfall in main building area as well as drained water from emergency cooling water system. Then, water from both places is removed through the drainage system in main building area (yard drainage system). The drainage system in main building area comprises onsite side trenches, pumps, manholes, and pipes.

The drainage system in the west of site area collects surface flow from rainfall at warehouse area, power switchyard, and hills in the west of main building area, and drains out through trench A (Creek A).

The drainage system in the east of site area collects surface flow from rainfall at the hills in the east of main building area, and expels through trench B (Creek B).

The trench A and B are both open man–made trenches, making water go into the ocean at slope rate of 0.2% to 0.5%. The maximum drainage capability of both trenches is acquired via calculation with the PMP figure at the site; the acquired result of the calculation is 138cms at the river mouth of trench A and 114cms for trench B. Besides, the security booth at the gate of the plant is 100m (elevation 3.4m) from the shore. According to FSAR 2.4.5.2, even if the surge wave in the sea is 1.2m (including high tide water level) during typhoons, it would not affect the drainage capability of the plant.

All these 3 drainage systems discharge into the sea eventually.

(2) Drainage capability

According to the record of Central Weather Bureau, the maximum daily precipitation recorded by Keelung weather station is 123.11mm/hr. Using statistical method to calculate the max daily precipitation is 208.9mm/hr for recurrence period of 10,000 year. It is still lower than 241 mm/hr estimated by FSAR. Thus the drainage capability of the site is capable of handling the extreme heavy rainfall induced by climate change without flooding. Please refer to Section 3.1.1.3 for detailed description.

3. Sustainability of buildings against strong winds

(1) Building structures

According to the description in FSAR 3.3 and FSAR Table 3.3-1~3 of Kuosheng Power Plant, all structures must be able to resist against minimum design wind speed of 120mph = 53.6 m/sec, similar to wind pressure of $37lb/ft^2$ or $180kg/m^2$, generated from a gust wind that is considered Force Level 16 in the wind intensity classification of Central Weather Bureau.

Meanwhile, seismic category 1 structures must be capable of resisting against wind pressure of $63lb/ft^2$ (or $307kg/m^2$) resulting from typhoons with minimum design wind speed of 157mph＝70.2m/sec, similar to wind that is wind intensity of Force Level 17 in the wind intensity classification of Central Weather Bureau and resisting against collision from typhoon-generated missiles.

Because wind pressure depends on height of structures, and wind speed depends on wind pressure , so minimum design wind speed of all structures of the plant is set as 120mph at height of 30feet. Wind pressure generated from maximum design wind speed, 206mph or 92.1m/sec, of plant buildings that have a seismic category 1 structure is $109lb/ft^2$ or 532.1 kg/m^2. The height of these structures is between 175 and 200 feet.

Note: The maximum scale of wind force in the wind intensity classification of Central Weather Bureau is Force Level 17, whose wind speed lies between 56.1 and 61.2m/s.

Missiles: Objects damaged by typhoons, such as broken tree branches and damaged store signs.

Wind pressure: Pressure generated due to different wind speeds at different height of structures, whose shape is also an influence factor.

Design of the structure of safety related buildings in the plant is seismic category 1 structure, which is still safe during super typhoons with wind intensity classified as Force Level 17. Therefore, safety related system associated with plant shutdown can be assured safety when strong winds slam the plant.

(2) Switchyard structures

The design guideline for the structure of the transmission route towers states that the transmission route of this plant is an important route in western Taiwan. The sustainability of the structure against winds is shown in the table below. Design wind speed at 44.9m/sec is Force Level 14 and gust speed that can reach 61.9 m/sec is Force Level 17. However, even if the plant loses offsite power sources, the plant still has DIV I/II/III diesel generators, gas turbine generators, and the 5th diesel generator. All of these units can provide power required for safe shutdown of the plant.

Table 4-1 Criteria of reference velocity pressures for design of supporting structures of transmission lines

Loading Condition		Reference Velocity Pressure q_o (kg/m^2)	Wind Speed (m/sec)		
			Reference Wind Speed (10-minute Average)	Gust Factor G_{RF}	Gust Wind Speed V_G
Ordinary Time (Island wide)		20			17.5
TYPHOON	West Region Regular Lines	200	39.8	1.45	57.7
	West Region Essential Lines	230	44.9	1.38	61.9
	East Region Regular Lines	260	50.6	1.3	65.8
	East Region Essential Lines	300	54.4	1.3	70.7
Line-work Time (Island wide)		20			17.5

4. Sustainability of the plant against debris flows

(1) Information published by Water and Soil Conservation Bureau, Council of Agriculture in May, 2011 indicates that the potential of debris flow-prone streams in this area are all medium. Main buildings in the plant are not within the range of influence of these debris flow-prone streams. #2 waste warehouse and 2 waste storage trench are within the influence range of Mashu Stream. However, based on the debris flow-prone stream classification, the debris flow potential of Mashu Stream is medium and it has never had any historic record of debris flow incidents. Besides, there is no land excavation activity in the basins of Mashu Stream. As shown on photos taken in the air, vegetation in this area prospers and the surface of slopes is well maintained. According to warning system of Water and Soil Conservation Bureau, Council of Agriculture, if extremely heavy rainfall warnings is issued by Central Weather Bureau forecast that the precipitation warning level is 550mm/day; alerts for debris flow-prone streams are issued.

Kuosheng Power Plant estimates that when debris flows happen at Mashu Stream, the affected area should not be large and it could possibly block only one small section of drainage trench B, which is between # 2 waste warehouses and its waste storage trench. Moreover, # 2 and # 3 waste warehouses have their own drainage facilities. Besides, the area of water accumulation is not large, there should not be any concern of overflowing since the dimension of the side trenches near the buildings is 30cm x 30cm. Even if overflow or other overland flow situations happen, they would also be drained quickly toward the mid-stream and downstream of trench B as well as into the sea due to the landscape. Hence, there is no concern of flooding.

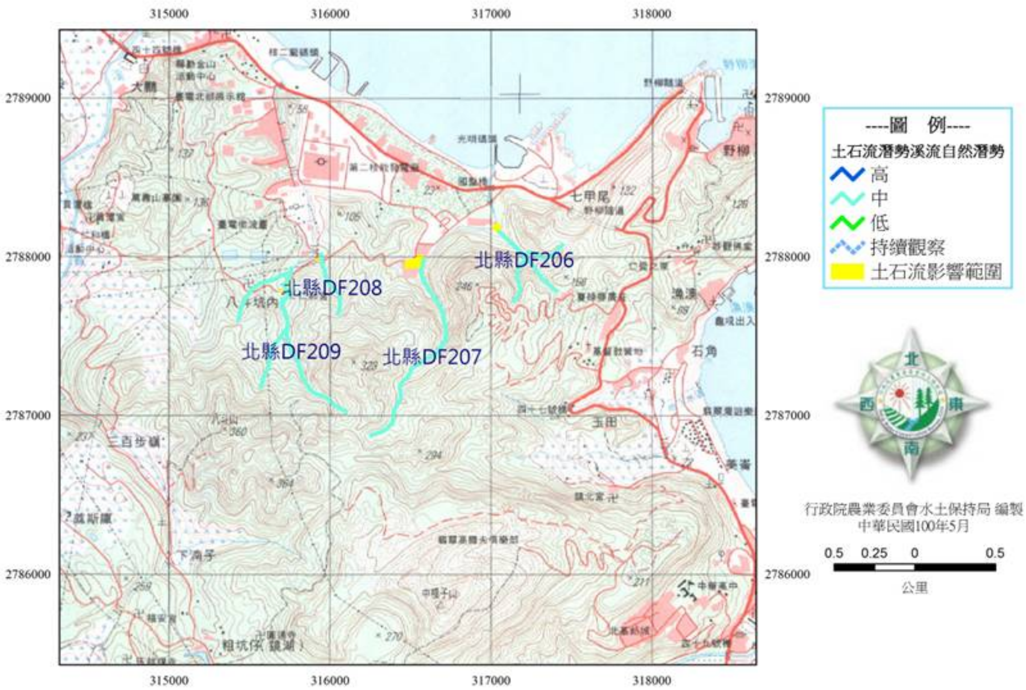


Fig. 4-1 Location and range of influence of debris flow- prone streams near the plant

(2) According to the geologic maps (Fig. 4-2, 4-3) from “Geological Database and Map Book for Metropolitan Areas and Surrounding Hill and Land Environment” published by Central Geological Survey, MOEA in 2008, they show that there is a dip-slope landscape 400 meters southeast of the main buildings. This dip-slope area is between #2 and # 3 waste warehouses. There are totally a dip-slope and a toe of slope that have never been excavated, so underground layers are not exposed and vegetation here prospers. As a result, landslide potential is minimal.

Furthermore, references to *maps on environmental geology of slopelands*, and *maps on distribution of environmental geologic hazard sensitive areas* have found the slope land in the vicinity of the plant power block to be within a “low susceptibility to landslide zone.” Thus, concern over slope sliding or rock falling would be minimal. The slope on east of # 2 and #3 waste warehouses is found to be within a “moderate susceptibility to landslide zone.” Because on west side of the plant is a dip-slope, the slope on east side should be an escarpment. Theoretically, the possible destruction mechanism should be rock falling or destruction of overturning.

Through site survey, the plant learns that this slope has intact vegetation and a prosperous forest. 15 meters from the toe of the slope is drainage trench B, so surface flow can be drained quickly and would not permeate into the ground easily to cause the rising of underground water level. Hence, there should be no rock falling or destruction of overturning.

Fig. 4-2 Map of landside susceptible and/or potential debris flow areas near and surrounding Kuosheng site

Fig. 4-3 Map of environmental geologic hazard sensitive areas near and surrounding Kuosheng site

5. Lightning and hail consideration

Each major buildings of the plant had already been equipped with lightning arresters that can prevent those buildings from destruction by lightning strike. Safety related building structures are all designed as seismic category I that its intensity can withstand hail attack.

Therefore, in case lightning or hail happened, it shall not directly damage safety related equipment but may result in damage on off-site power transmission equipment so as to lose off-site power.

6. Disaster caused by ground surface change (elevated or sunk) and soil liquefaction under strong earthquake.

Generally, soil liquefaction is associated with uniform and saturated sand stratum. By checking the soil backfill data from the construction period, the backfill compact density of KSNPP site surrounding the buildings after excavation (Main backfill material is clean sand) are all more than 85%. As per the survey result of Japan Nigita earthquake in 1971 by Seed&Idriss, soil liquefaction scarcely occur for the site area of density between 70~75%. Therefore, it is concluded that KSNPP site shall not have the potential of soil liquefaction.

Moreover, the important safety related facilities and buildings of the plant are all sitting on the bedrock and there is not any Fault underneath in this area, so there is no surface change (rising or sinking) during strong earthquake. It is concluded that KSNPP site has no vulnerability of surface change and soil liquefaction as a result of site characteristic and plant construction methods.

Flooding in SWYD Battery Room and Turbine Building Basement Floor of the plant has ever happened in 1987 due to extra heavy rain during typhoon. The root cause of the Turbine Building basement floor flooding was piping penetration seal leakage, which resulted from that piping penetration sealing not being tightly sealed after installation of cable penetration. Similar events had never happened again at this plant as per the implementation of plant procedure 1265「Cable and Piping Penetration and Drilling Sealing Procedure 」.

The reason of the SWYD battery room flooding was that the gate of creek A was stuck by the falling leaves and branches, which caused flowing into the SWYD field. Kuosheng plant has established inspection program as per Kuosheng plant emergency procedure 576.1 “Typhoon defense: preparedness and response”. There is no recurrence since then.

Based on the above description, it is confirmed that the plant has enough protection capability to respond to severe weather conditions. However, extreme weather may change more drastically and appear in the form of combined natural events. So, the plant uses the stress tests with scenarios of combined natural events of “storms, heavy rainfalls and/or debris flows,” of similar events that are beyond design basis, and of events that are beyond the knowledge of the plant, to examine the protection capability of the plant. The detail is described in Attachment 4-1 Stress Tests of Combined Natural Events of Typhoons and heavy rainfall / debris flows.

4.1.2 Weak points and cliff edge effects

A stress-test scenario using combined natural events of Typhoons, Heavy Rainfalls and Debris Flows for Kuosheng Nuclear Power Plant is delineated in Attachment 4-1. Vulnerabilities and cliff edge effects of the plant in extreme weather conditions are estimated and described as follows, along with responding enhancement measures:

Scenario A: The plant site is located at an elevation of 12 meters above mean sea level and about 500 meters inland from the seashore. Natural terrain together with engineered drainage systems have contributed to the plant's long-standing fulfillment of the "dry site" requirements. Nevertheless, the main area of the plant is in between and lower than both of the west and east sides of the plant, and fences in north of the low area in the main building area isolate the power station and turn it into a man-made bowl-shaped depression in the land. In a heavy rainfall scenario, with the help of the drainage trenches B/A on east /west sides of the plant, debris flows would not happen. However, if debris flows that are beyond expectation appear and cause flooding to reroute and to enter the main building area, units would be in dangerous situation.

Scenario B: The drainage capability of the plant is based on the assumption that probable maximum precipitation of a storm, 241mm/hr, falls in the plant. Now, in order to create a scenario of extreme weather, assuming a beyond design basis storm to descend upon the plant, without inducing debris flows, the beyond design basis precipitation can not be drained by the drainage trenches and therefore generates surface flow entering the main building area of the plant. Since it is a man-made bowl-shaped depression in the land, units of the plant may be affected.

Note: The assumed scenarios A and B are already beyond the design basis of the plant. This is to help conduct the stress tests to find vulnerabilities and cliff edge effects of the plant.

1. Detailed enhancement measures responding to the scenarios A and B:

   (1) Maintaining drainage trenches A/B clear with free flows will minimize damage in case of a highly unlikely debris-flow event. Kuosheng plant emergency procedures 576.1-- "Typhoon defense: preparedness and response" and 576.2-- "Flood defense: preparedness and response" require that the yard drainage system（e.g., gutters） be cleaned, the drainage trenches be cleared and the trench gates be functional before the typhoon or flood seasons begin. A comprehensive defense checklist is provided in each of these two procedures, itemizing every task, along with its responsible section, necessary to complete the requirement, among others.

   (2) Develop a plan to install floodwater baffle panel at the mainguard house gate and the southeast gate of the power block area to prevent reroute of drainage trenches on east /west sides of the plant or to prevent overland flow from entering the plant, so the plant can minimize the threat of heavy rainfall overflowing on east /west sides of the plant into the main building area.

(3) Comply with the newly established procedure 577.3 --"Monitoring, warning, disaster prevention and mitigation procedure for active faults near the plant, precipitation, debris flow, and dip slopes". The plant periodically evaluates natural disasters resulting from changes of climate and geography near the site and implement walkdown and inspection at the site before the typhoon season begins.

2. If conditions similar to scenario A (reroute of drainage trenches or overland flow entering the main area of the plant leading to onsite flooding) happen, enhance water-proofing function of roller shutter doors at all buildings and enhance the maintenance of sealing of underground penetrations. Thus, these enhancements can prevent flooding from affecting safety related equipment on ground floor of buildings or the switch gear room and result in safety concern of the units.

   Detailed enhancement measures to attain the goals are as follows:

   (1) Suggest that floodwater panels be installed at ingresses/egresses of the power block. As a result, main buildings face less threat of external flooding entering the buildings through entrances/exits.

   (2) Enhance the management regarding procedure 1265 --"Procedure for diamond sawing and sealing construction at penetrations of cables and pipes," which requires management mechanism in detail of related sealing at penetrations after construction, and abide by procedure 796 --"Procedure for Periodical inspection of penetrations in buildings" to ensure the intact status of underground penetrations and decrease the threat of flooding in the main building entering buildings.

   (3) Initiate intensive training & drill programs to familiarize emergency flood crews with their responsive capability at setting up emergency flood-pumping stations in the turbine building~~s~~, normal ~~oil~~ waste sumps, and the bottom floor in the auxiliary buildings. These programs are also directed at maintaining emergency flood crews' proficiency in implementing the newly added plant emergency procedure 577.1 -- "Emergency pumping operation: removing flood water from the power block" mitigate possible damage to safety equipment on each bottom floor when external flooding enters buildings.

   (4) Those waterproofing materials are all located underneath the structure or between the structures. If there is degradation, it is unable to deal with. However, those waterproofing materials are all located at the place without sunlight so that are not susceptible to degradation and its seepage water volume is also little so as not to result in hazards.

3. Review or revise procedure to better achieve disaster prevention and mitigation goal

   Detailed enhancement measures to attain the above goals are as follows.

(1) Revise procedure 577 -- "Heavy rainfall or flooding emergency response procedure" by changing the outline format to guideline and item format, so workers can obey the procedure easily in limited time. Provide guidance based on the severity of the influence of flooding water level in the main building area or in buildings on the units, so workers can comply with the procedure to reduce the power of reactors and bring it to safe shutdown mode.

For detail, please refer to Attachment 4-2 Newly added internal/external flooding response process in procedure 577 -- "Heavy rainfall or flooding emergency response procedure."

(2) Revise procedure 576 --"Procedure for operation during typhoon warnings." The new addition needs to cite forecast information from Central Weather Bureau. If it is certain that super typhoons that require the plant to enter "emergency event category HA1" and whose maximum sustained wind speed is > 60m/sec, the plant needs to make conservative decisions depending on the situations to bring the units to cold shutdown mode to prevent units from being in danger.

For more detail, please refer to Attachment 4-3 Procedure 576 --"Procedure for operation during typhoon warnings."

(3) Add procedure 577.3 --"Monitoring, warning, and disaster prevention and mitigation procedure for fault, precipitation, debris flows, and dip-slopes near the plant" to periodically inspect land development activity near the plant. Meanwhile, in accordance with the rainfall information from Central Weather Bureau and debris flow warning information by Water and Soil Conservation Bureau, Council of Agriculture, include debris flow warnings, disaster prevention and mitigation mechanism in the procedure to prevent landslides or debris flows from affecting the drainage capability of the plant and therefore leading to onsite flooding.

(4) Strategy KS.1-04 in plant procedure 1451 "Water injection to reactor via fire fighting truck or mobile equipment" applies to outdoor operation under strong wind and heavy rain condition. However, if raw water pipe is not damaged under extreme weather conditions, the indoor strategy KS.1-01 for reactor injection via raw water shall be first adopted so that the safety concern of outdoor operation under the strong wind and heavy rain condition had been considered. If outdoor operation is required, it shall be carried out under the sufficient protective measures (for example, operators are escorted by large truck for protection.).

4. The plant is also planning to provide supplemental workforce to respond to onsite flooding. The detail is available in Section 3.1.2.4 "Other effects of the flooding taken into account" in this report, under "2. Flooding may hinder or delay offsite staff and rescue equipment to arrive at the power station." The plan supports disaster prevention, emergency preparedness, and disaster response, protects important equipment and prevents the plant from entering danger scenarios.

5. Refer to the plant procedure 1451 for description of each kind of power supply system. The station power supply systems are redundant and most of them are stationary and indoor type. The

sequence of usage is from indoor to outdoor. There is only the strategy KS.2-02 “Tie-in connection of 480V 200kW mobile diesel generators” that is the final electrical supporting equipment. Therefore, it is considered that power supply interface operation under strong wind and heavy rain condition shall be avoided to prevent the operator from electrical shock or prevent the equipment from short circuit. All the power supply system of the plant has already been aligned with the malfunction isolation equipment during initial stage. Please refer to Plant procedure 1451「7.0 Implementation Operation Procedure」 for more detail about each strategy.

4.1.3 Measures envisaged to increase robustness of the plant

Considering the probable maximum precipitation (PMP) of 241mm/hr design, Kuosheng Power Plant designed trenches A and B. The plant evaluates its drainage system with stress tests of assumed scenarios of the power station suffering from extreme climate and combined natural events that are beyond design basis. The purpose is to find out vulnerabilities and cliff edge effects of areas and buildings in the plant, including the highest flooding water levels that the safety related equipment can sustain, and to establish response measures to reach the goal of prevention.

Possible invasion locations of external flooding are the gate at security booth, the gate on southeast of the plant, and all exterior entrances/exits of buildings. The highest flooding water levels the safety equipment can sustain are respectively 5 meters at the bottom floor pathway in auxiliary buildings (via the evaluation of the net pump suction head the water-proof doors of all safety related equipment can sustain, and hence the plant may lose all safety water makeup systems), and 50cms on the ground of the 2nd floor in control buildings (via the evaluation of flooding at the switchboards and hence the plant will lose the safety system in DIV-1&2 switchgear room, which will lead to loss of power sources). These two invasion locations are likely to force units to proceed with procedure 1451 --“Unit ultimate response guideline procedure”, therefore response measures must be established to prevent flooding to reach this height.

Enhancement measures responding to the vulnerabilities described above are to prevent flooding from entering the plant and buildings and to provide response methods, but the main significance is to prevent flooding from entering the plant and buildings and thus to stop units from entering dangerous scenarios. Therefore, the plant will develop a plan to install “floodwater panels” at ingresses/egresses of the power block to further protect the power block from effects of extreme weathers such as inundation by intruding floodwater. Description of these enhancement measures is as follows:

(1) Develop a plan to install “floodwater panels” at the main guardhouse gate and southeast gate of the power block area to separate the power block area from the east side and west side of the plant, in order to prevent the flooding caused by overland flow or reroute of drainage trenches on east/west sides of the plant from entering the main building area.

(2) Develop a plan to install "floodwater panels" at ingresses/egresses of the power block to prevent external flooding from entering main buildings. Evaluation and calculation demonstrated that, for 1 meter increase in the height of overall flooding protection of buildings, the buildings can withstand against continuous rainfall of precipitation of 344mm/hr for 24hours; as for continuous rainfall of precipitation reaching 560 mm/hr, buildings in the plant can sustain for 7.7 hours.

(3) If precipitation exceeds all extreme scenarios above, the plant can create a man-made drainage opening at low lands near north fences of the plant or open a gate when accumulated water in the main building area almost reaches 1 meter, in order to drain accumulated water in the main building area into the sea with descending landscape and slope ratio. This can ensure no increase of water accumulation in the main building area and hence ensure plant safety.

(4) Rescue equipment (such as power-operated flood pumps) is stocked in high-ground warehouses designed for adequate earthquake resistance and with easy access for rescue workers such that flood water intruding the power block can be expeditiously removed from the buildings.

Preventive measures and the assessment of static water head and dynamic water head for the tsunami wave are described in Chapter 3 of this report. The discussion in this chapter mainly deals with impacts of flooding resulting from typhoon and extreme heavy rainfall, so dynamic water pressure is not considered. However, the associated design of shielding plate still take the required water pressure head and the safety coefficient of structural intensity into consideration to achieve waterproof capability. If the shielding facility can withstand water pressure, the cliff edge effect will become the external flooding level exceeding the building elevation plus the height of the shielding facility.

Concluding from all the description above, corresponding enhancement measures are already included in all plant procedures, and a detailed plan will be developed for installation of 1-meter "floodwater panels" to enhance protection capability of the plant. From the consideration of flood defense, the power block area will then be separated, and better protected, from the two drainage trenches on the west side and east side of the plant. Moreover, "floodwater panels" will be installed at exterior openings at main buildings or buildings with important equipment to increase the elevation of the overall protection for 1 meter to prevent flooding from entering the main building area or main buildings. At the same time, workers in the control rooms can also have enough time to take care of onsite flooding to ensure that buildings are safe and gain confidence in facing the seizure of extreme weather conditions.

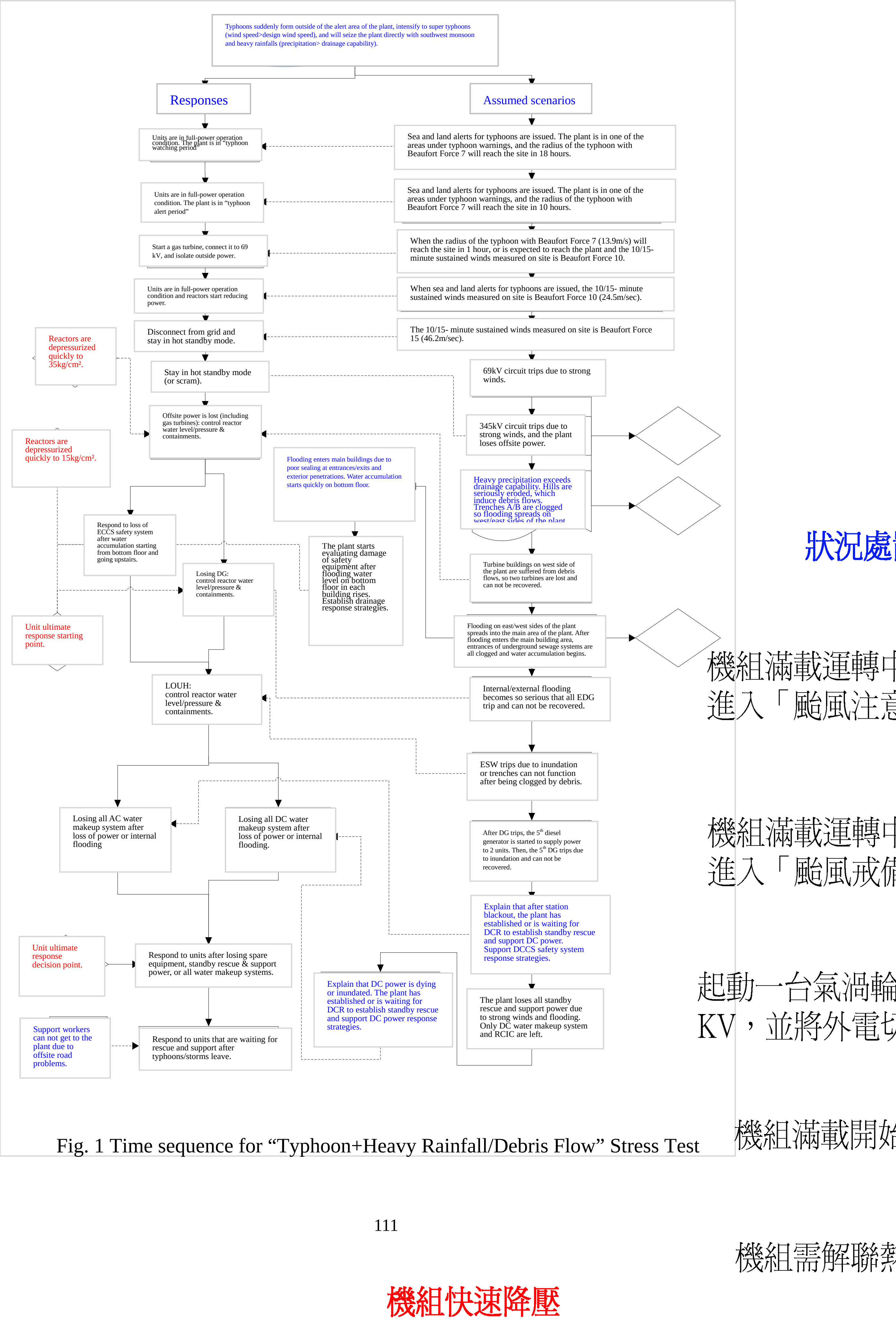


Fig. 1 Time sequence for "Typhoon+Heavy Rainfall/Debris Flow" Stress Test

Fig. 2“Typhoons +heavy rainfalls / debris flows” Stress Tests”

Scenario:
1. A severe typhoon is going to seize the plant and is expected to bring heavy rainfalls.
2. Typhoon emergency team is established and 6 workers from a fire-fighting shift and typhoon emergency response workers are standby.
3. Next shift of workers is standby in the standby dormitory.
4.2 units are in full operation.

Next:
5. The typhoon brings in strong winds and very heavy rainfall, causing the loss of offsite power sources and emergency standby power sources. Flooding spreads onsite because Debris flow clogs drainage trenches, leading to flooding on the ground of the main building area as well as on bottom floor of main buildings and the subsequent loss of feedwater function of safety systems. ECW is also flooded which results in LOUH.

Assumed scenario	Design basis & various scenario base line	Protection intensity	Procedure Response	Manpower and work duration
Central Weather Bureau issues sea and land alerts for typhoons, and the plant is in an areas under the typhoon warning. Typhoons of Beaufort Force 7 is 18 hours away from the alert area of the plant The plant is in “typhoon watching period” mode.	Power switchyard/ transmission route gust design 57.7m/sec, namely Force 17 Main buildings 70.2m/sec, namely Force17 and above	Power sources 1. 345kV 4 loops 2.69kV 2 loops 3. Gas turbine generators 4. Diesel generators 5. Air-cooling generator (5th) 6. Gas turbine generators fail, so start diesel generators (DCR) 7.1500kw mobile diesel generator (DCR) 8. TSC/OSC two 480V 200kw diesel generators 9. Four 480V mobile diesel generators 10. DC replaces. Feedwater system 1. CP/FW 2. CRD 3.RCIC 4.HPCS 5.LPCS 6. LPCI*3 7.SBLC receives water via TEST TK 8.CST via FW.RHR. LPCS. HPCS feedwater pipes 9.Fire-fighting water via RHR-B 10.Fire-fighting pump via RHR-B 11.Fire-truck with water tank via RHR-B Heat sink 1.CWP/BOOSTER PP 2.ECW 3.Freshwater replaces ECW 4.DST replaces ECW 5.Suppresion pool (Fresh water)	The plant goes to “typhoon watching period” mode. 1. The electricity shift leader writes a “typhoon notification.” 2. Confirm in 8 hours that DIV I. II . III emergency diesel generators can operate. 3. Confirm in 8 hours that the gas turbine can operate. 4. All divisions conduct inspection based on “typhoon checklists” and make improvement. (Industrial safety division can perform the inspection in advance depending on the latest status of typhoons and shift situations.) (576/576.1)	On shift/8hrs All divisions/ 10 hours before typhoons of Beaufort Force 7 arrive at the alert area of the plant
Central Weather Bureau issues sea and alerts for typhoons, and the plant is in an area under the typhoon warning. Typhoons of Beaufort Force 7 is 10 hours away from t the alert area of the plant. The plant is in “typhoon alert period” mode.	Power switchyard/ transmission route gust design 57.7m/sec, namely Force 17 Main buildings 70.2m/sec, namely Force17 and above	Same as above	The plant goes to “typhoon alert period” mode. 1. The electricity shift leader writes a “typhoon notification.” When the typhoon emergency response team is established: 1. The leader of the typhoon emergency response team informs the shift manager the establishment of the typhoon emergency response team. 2. Once the typhoon emergency response team is set up, the shift manager reports to the nuclear power department. 3. The shift manager should assign a person to start the IBM natural disasters reporting system (NDS) and to confirm as well as report that DNS is connected. 4. If the plant is seized by typhoon and there is an abnormal situation with power generating or an accident, the team should report following procedure for natural disasters, abnormal power generating, emergency incidents. 5. The shift manager should continuously stay in contact with the leader of the typhoon emergency response team.	On shift/ 4hrs

Fig 2-1. “Typhoon+Heavy Rainfall/Debris flow” Stress Test Flow Chart

Fig. 2"Typhoons +heavy rainfalls / Debris flow " Stress

Assumed scenario	Design basis & various scenario base line	Protection intensity (Response)	Procedure (Response)	Manpower and work duration
One hour before radius of typhoons of Beaufort Force 7 (13.9m/sec) arrives at the plant or the plant is expected to be in the radius soon. Actual 10/15-minuet sustain wind measured at the plant reaches Beaufort Force 10. (24.5m/sec)	Power switchyard/ transmission route gust design 57.7m/sec, namely Force 17 Main buildings 70.2m/sec, namely Force17 and above	Power sources 1. 345kV 4 loops 2.69kV 2 loops 3. Gas turbine generators 4. Diesel generators 5. Air-cooling generator (5th) 6. Gas turbine generators fail, so start diesel generators (DCR) 7.1500kw mobile diesel generator (DCR) 8. TSC/OSC two 480V 200kw diesel generators 9. Four 480V mobile diesel generators 10. DC replaces. Feedwater system 1. CP/FW 2. CRD 3.RCIC 4.HPCS 5.LPCS 6. LPCI*3 7.SBLC receives water via TEST TK 8.CST via FW.RHR. LPCS. HPCS feedwater pipes 9.Fire-fighting water via RHR-B 10.Fire-fighting pump via RHR-B 11.Fire-truck with water tank via RHR-B Heat sink 1.CWP/BOOSTER PP 2.ECW 3.Freshwater replaces ECW 4.DST replaces ECW 5.Suppresion pool (Fresh water)	1. Start a gas turbine, connect it to 69 kV, and isolate outside power; the other is on standby. 2. Stop related function tests on RPS and NSSS system.	On shift/ 0.5hr
Central Weather Bureau issues sea and alerts for typhoons, and the plant is in an area under the typhoon warning. Actual 10/15-minuet sustain wind measured at the plant reaches Beaufort Force 10. (24.5m/sec)	Power switchyard/ transmission route gust design 57.7m/sec, namely Force 17 Main buildings 70.2m/sec, namely Force17 and above	Same as above	Reduce power to turbine trip bypass set point of RPS in 3 hours. (reactor thermal power 30%)	On shift/ 1hr
Actual 10/15-minuet sustain wind measured at the plant jumps to Beaufort Force 15. (46.2m/sec)	Power switchyard/ transmission route gust design 57.7m/sec, namely Force 17 Main buildings 70.2m/sec, namely Force17 and above	Same as above	Disconnect from grid and stay in hot standby mode in 4 hours.(576/245)	On shift/ 4hrs Disconnect from grid and leave on hot standby.

Fig 2-2. "Typhoon+Heavy Rainfall/ Debris Flow" Stress Test Flow Chart

Fig. 2"Typhoons +heavy rainfalls/ debris flows" Stress

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Assumed scenario	Design basis & various scenario base line	Protection intensity (Response)	Procedure (Response)	Manpower and work duration
69kV transmission cable trips >57.7m/sec.	Power switchyard/ transmission route gust design 57.7m/sec, namely Force 17	Power sources 1. 345kV 4 loops 2.69kV 2 loops LOSS 3. Gas turbine generators 4. Diesel generators 5. Air-cooling generator (5th) 6. Gas turbine generators fail, so start diesel generators (DCR) 7.1500kw mobile diesel generator (DCR) 8. TSC/OSC two 480V 200kw diesel generators 9. Four 480V mobile diesel generators 10. DC replaces. Feedwater system 1. CP/FW 2. CRD 3.RCIC 4.HPCS 5.LPCS 6. LPCI*3 7.SBLC receives water via TEST TK 8.CST via FW.RHR. LPCS. HPCS feedwater pipes 9.Fire-fighting water via RHR-B 10.Fire-fighting pump via RHR-B 11.Fire-truck with water tank via RHR-B Heat sink 1.CWP/BOOSTER PP 2.ECW 3.Freshwater replaces ECW 4.DST replaces ECW 5.Suppresion pool (Fresh water)	1. Immediately shutdown reactor and achieve cold shutdown mode as soon as possible. 2. Confirm if gas turbine generators supply power to 69kV bus, or emergency bus should be supplied with power from DG.(576/245/501.3)	On shift/ 12hrs till cold shut down
345kV transmission cable trips >57.7m/sec.	Power switchyard/ transmission route gust design 57.7m/sec, namely Force 17	Power sources 1. 345kV 4 loops LOSS 3. Gas turbine generators 4. Diesel generators 5. Air-cooling generator (5th) 6. Gas turbine generators fail, so start diesel generators (DCR) 7.1500kw mobile diesel generator (DCR) 8. TSC/OSC two 480V 200kw diesel generators 9. Four 480V mobile diesel generators 10. DC replaces. Feedwater system 1. CP/FW LOSS 2. CRD 3.RCIC 4.HPCS 5.LPCS 6. LPCI*3 7.SBLC receives water via TEST TK LOSS 8.CST via FW.RHR. LPCS. HPCS feedwater pipes LOSS 9.Fire-fighting water via RHR-B 10.Fire-fighting pump via RHR-B 11.Fire-truck with water tank via RHR-B	1. Immediately shutdown reactor and achieve cold shutdown mode as soon as possible. 2. If units have tripped, recover the tripping. 3. Inspect if 345kV emergency bus is supplied with power from DG (576/245/501.2/248) Heat sink 1.CWP/BOOSTER PP LOSS 2.ECW 3.Freshwater replaces ECW 4.DST replaces ECW LOSS 5.Suppresion pool (Fresh water)	On shift/ 12hrs till cold shut down

Fig 2-3. "Typhoon+Heavy Rainfall/ Debris Flow" Stress Test Flow Chart

Fig. 2"Typhoons +heavy rainfalls/debris flows" Stress

Assumed scenario	Design basis & various scenario base line	Protection intensity	Procedure Response	Manpower and work duration
Heavy precipitation exceeds drainage capability. Mt. hills are seriously eroded and this leads to debris flows which clog trenches A/B and consequently flooding spreads on the west/east sides of the plant. (precipitation> 180mm/hr) Gas turbine bldg on west side of the plant suffers from debris flows, so the plant loses 2 gas turbines and can not recover.	Drainage capability on east/west sides of the plant 180mm/hr Info of Water & Soil Bureau shows no debris flows Gas turbine buildings EL.22m & are installed with floor barrier plates.	<u>Power sources</u> 3. Gas turbine generators LOSS 4. Diesel generators 5. Air-cooling generator (5th) 6. Gas turbine generators fail, so start diesel generators (DCR) 7.1500kw mobile diesel generator (DCR) 8. TSC/OSC two 480V 200kw diesel generators 9. Four 480V mobile diesel generators 10. DC replaces. <u>Feedwater system</u> 2. CRD 3.RCIC 4.HPCS 5.LPCS 6. LPCI*3 9.Fire-fighting water via RHR-B 10.Fire-fighting pump via RHR-B 11.Fire-truck with water tank via RHR-B <u>Heat sink</u> 2.ECW 3.Freshwater replaces ECW 5.Suppresion pool (Fresh water)	1. By far, offsite power sources including gas turbine generators fail. Inspect if all emergency buses are supplied with power from DG. 2. Comply with procedure 500 EOP to maintain reactor water level (>L8/Start HPCS when necessary) & depressurize to 35kg/cm, control containment pressure/start cooling suppression pools to lower their temperature as much as possible. 3. Start CONT VENT inside valve and cut off power. 4. If flooding on east/west sides of the plant is expected to enter the main area of the plant, inspect if entrances/exits of buildings have floor barrier plates (in progress) or sandbags. (500.EOP/500.12-4/500.14-3/577)	Continue. On shift/ 1hr
After flooding spreads on the east/west sides of the plant and enters the main area of the plant, entrances/exits of the sewage system are clogged and accumulation starts quickly. (precipitation> 241mm/hr) Water-shielding plates or sandbags at ground floor of buildings (in progress)	Main buildings EL.12m.Drainage capability of the sewage system 241 mm/hr Info of Water & Soil Bureau shows no debris flows Install floor barrier Plates at fences near security booth/ at southeast gate of the plant to prevent flooding at the east/west sides of the plant from entering (MMR) Entrances of the sewage system scatters around the plant (Also, underground permeating sump well scatters around the plant 4*4 unit/ Each unit drains 200gpm.) (And, ECW trench 2*2 unit/Each unit drains 150/50gpm.)	<u>Power sources</u> 4. Diesel generators 5. Air-cooling generator (5th) 6. Gas turbine generators fail, so start diesel generators (DCR) 7.1500kw mobile diesel generator (DCR) 8. TSC/OSC two 480V 200kw diesel generators 9. Four 480V mobile diesel generators 10. DC replaces. <u>Feedwater system</u> 2. CRD 3.RCIC 4.HPCS 5.LPCS 6. LPCI*3 9.Fire-fighting water via RHR-B 10.Fire-fighting pump via RHR-B 11.Fire-truck with water tank via RHR-B <u>Heat sink</u> 2.ECW 3.Freshwater replaces ECW 5.Suppresion pool (Fresh water)	1. If water accumulation starts in the main area of the plant, follow procedure, confirm units are shut down and announce HA1, & establish TSC. 2. If TSC can not enter the plant, follow procedure 1408 "OSC mobilization and response procedure" to start emergency mobilization. 3. Monitor alarms for sumps outside of buildings/ Sump pumps are operating normally. 4. Pile sandbags at emergency equipment in main area of the plant or install floor barrier plates at entrances/exits of main buildings to prevent flooding from entering (577/245/1408)	Continue

Fig 2-4. "Typhoon+Heavy Rainfall/ Debris Flow" Stress Test Flow Chart

Fig. 2"Typhoons +heavy rainfalls/debris flows" Stress

Assumed scenario	Design basis & various scenario base line	Protection intensity	Procedure / Response	Manpower and shift duration
Flooding enters main buildings because of poor sealing of entrances/exits or penetrations. Water starts accumulating quickly on the bottom floor. The plant evaluates the damage rising accumulation water level on bottom floor of all buildings. causes to safety systems. The plant evaluates the damage accumulation going upstairs. can cause to safety systems. Drainage response strategies.	Water-shielding plates or sandbags at ground floor of buildings (in progress) Periodically inspect sealing of penetrations (Procedure 796) All room doors for ECCSare water-seal to prevent containment suppression pools from leaking to inside of the rooms.(But can not sustain when pressure added from the side, about>5m) There are two 50gpm drainage pumps and flood alarms in the room. Accumulation on walkways in AUX/Control/TB bldgs flow to the Normal waste sump in TB bldg (drainage capability 100gpm/unit*2) Fuel/Waste treatment bldgs flow to their own sumps (drainage capability 500 gpm/unit*2) Equipment group in mechanic div. in charge of the supply of drainage equipment when flooding occurs. (10 mobile generators to supply power, 8 electric drainage pumps, 9 gasoline engine drainage pumps (procedure 577))	<u>Power sources</u> 4. Diesel generators //>0.3m (CR2F)LOSS DIV-1&2,// >0.3m(AUX 2F)LOSS DIV-3 5. Air-cooling generator (5^{th}) 6. Gas turbine generators fail, so start diesel generators (DCR) 7.1500kw mobile diesel generator (DCR) 8. TSC/OSC two 480V 200kw diesel generators 9. Four 480V mobile diesel generators 10. DC replaces. <u>Feedwater system</u> 2. CRD //>AUX0.5mLOSS 3.RCIC //>AUX1.4LOSS (or>AUX5mLOSS) 4.HPCS //>AUX5mLOSS 5.LPCS //>5mLOSS 6. LPCI*3 //>AUX5mLOSS 9.Fire-fighting water via RHR-B 10.Fire-fighting pump via RHR-B 11.Fire-truck with water tank via RHR-B <u>Heat sink</u> 2.ECW 3.Freshwater replaces ECW 5.Suppresion pool (Fresh water)	1.Monitor water level of building sumps and if the sump pumps are operating normally. If water level is abnormal, follow procedure 566.4 to trace origins of excessive water and isolate them. 2. Follow procedure 577.1. When sump pumps fail and there is power outage, use mobile generators to supply power to drainage pumps or mobile gasoline engine drainage pumps. Conduct drainage via trenches based on choices of nearby building emergency doors. 3. The plant plans to temporarily set up temporary drainage station at 4 locations (2*2)—normal oil waste sumps of #1/#2and aux bldg bottom floor, to handle big amount of accumulation on bottom floor (PCN) (566.4/577.1/577 (PCN)/500.6) 4. Evaluation of the influence of accumulation on bottom floor of all buildings on safety equipment is as below: (fig. 2) The evaluation of each floor should focus on the influence of damage of equipment of the floor on reactor safety. Also, evaluation of doors or equipment rooms should focus on if opposite push would cause permeating or collapse and lead to damage of safety equipment inside. 1. Accumulation on 1F of control bldgs rises, so the plant will lose normal/emergency cooling system and control bldg HVAC. If the accumulation goes up to 2F, DIV-1/2 switch room/battery room will fail and freshwater goes into reactor pipe valves and flood the reactors. Response is as below: *If accumulation on 1F in control bldg>50cm, shut down units. * If accumulation on 1F in control bldg>1m, manually trip units. *If accumulation on 1F in control bldg reaches the ceiling<2m, quickly depressurize to 35kg/cm². * If accumulation on 1F in control bldg reaches the ceiling<1m, quickly depressurize to 15kg/cm². * If accumulation on 2F in control bldg >30cm, adopt ultimate response and follow procedure 500.15 to connect with battery E to supply power to SRV.	3workers/2 hrs/set up drainage pumps (typhoon emergency response team) Continue.

Fig 2-5. "Typhoon+Heavy Rainfall/ Debris Flow" Stress Test Flow Chart

Fig. 2“Typhoons +heavy rainfalls /debris flows” Stress

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Assumed scenario	Design basis & various scenario base line	Protection intensity	Procedure / Response	Manpower and work duration
Flooding enters main buildings because of poor sealing of entrances/exits or penetrations. Water starts accumulating quickly on the bottom floor. The plant evaluates the damage rising accumulation water level on bottom floor of all buildings. causes to safety systems. The plant evaluates the damage accumulation going upstairs. can cause to safety systems. Drainage response strategies. Describe the situation of flooding on bottom floor of all buildings going up to ground floor complying procedure.	Same as above	Same as above	2. After accumulation on corridors of AUX bldg rises to 1m, RCIC pipe rupture series interlock instrument starts to isolate it. Water may permeate due to reversed water pressure at the water-proof doors of ECCS. If the water level is >1.4m, RCIC speed controller may fail. If the water level is > 5m, doors of ECCS rooms may collapse due to reversed water pressure, so response is as follows: *If accumulation on corridors of UX bldg 1F>50cms, (1) Shut down units. (2) Remove RCIC pipe rupture series interlock instrument (3) Start mobile gasoline engine drainage pump to drain water out of buildings. (4) RPV replaces feedwater (fire-fighting water). Lineup only has 1 valve left. * If accumulation on corridors of UX bldg 1F>50cms, (1) Manually trip units. (2) Monitor if RCIC is out of order. (3) Monitor if water level of ECCS rooms is abnormal. *If ECCS rooms are flooded, follow procedure 500.6. *If more than 3 series of feedwater systems can not operate, quickly depressurize to 35kg/cm. *If more than 4 series of feedwater systems can not operate, quickly depressurize to 15kg/cm. *If all feedwater systems can not operate, follow ultimate response. *If accumulation continues to 2F>30cm, the plant will lose DIV-3. 3. If accumulation on the ground of diesel generator Bldg>30cm, the plant will lose AVR panel and then DG. 4.Flooding on bottom floor of turbine bldgs will cause loss of feedwater system. 5. Flooding on bottom floor of the waste treatment bldg does not affect reactor cores. 6. Flooding on bottom floor of fuel bldgs will cause loss of fuel pools. Watch temperature of cooling systems. The plant loses CST, PP&P-56. 7.Flooding in tap water plant/AUX reactor bldg/miscellaneous liquid waste treatment bldg will cause units to lose auxiliary systems.	NA

Fig 2-6. “Typhoon+Heavy Rainfall/ Debris Flow” Stress Test Flow Chart

Fig. 2“Typhoons +heavy rainfalls/debris flows” Stress

Assumed scenario	Design basis & various scenario base line	Protection intensity	Procedure / Response	Manpower and work duration
Respond to flooding going upstairs from bottom floor of all buildings and subsequent loss of ECCS safety system.	Equipment/power supply of ECCS is: 1.Multiple cooling systems and reliable 2.Capabile of handling any size of pipe rupture 3.At least 2 independent System for a voltage 4.Has its own power source 5.Only 1 region can supply the power needed for safe shutdown Water-shielding plates or sandbags at ground floor of buildings (in progress) Periodically inspect sealing of penetrations (Procedure 796) All room doors for ECCS are water-seal to prevent containment suppression pools from leaking to inside of the rooms.(But can not sustain when pressure added from the side, about>5m) There are two 50gpm drainage pumps and flood alarms in the room. Accumulation on walkways in AUX/Control/TB bldgs flow to the Normal waste sump in TB bldg (drainage capability 100gpm/unit*2) Equipment group in mechanic div. in charge of the supply of drainage equipment when flooding occurs. (10 mobile generators to supply power, 8 electric drainage pumps, 9 gasoline engine drainage pumps (procedure 577))	Power sources 4. Diesel generators //>0.3m (CR2F)LOSS DIV-1&2,//>0.3m(AUX 2F)LOSS DIV-3 5. Air-cooling generator (5th) 6. Gas turbine generators fail, so start diesel generators (DCR) 7.1500kw mobile diesel generator (DCR) 8. TSC/OSC two 480V 200kw diesel generators 9. Four 480V mobile diesel generators 10. DC replaces. Feedwater system 2. CRD //>AUX0.5mLOSS 3.RCIC //>AUX1.4LOSS (or>AUX5mLOSS) 4.HPCS //>AUX5mLOSS 5.LPCS //>5mLOSS 6. LPCI*3 //>AUX5mLOSS 9.Fire-fighting water via RHR-B 10.Fire-fighting pump via RHR-B 11.Fire-truck with water tank via RHR-B Heat sink 2.ECW 3.Freshwater replaces ECW 5.Suppresion pool (Fresh water)	Based on the safety evaluation above, it is learned that only situations In AUX bldg and control buildings can affect ECCS; (Note: the following may have been performed, so the plant only needs to verify the completion.) 1. If accumulation at the corridor at ECCS pumps in AUX bldg>1m, eater may permeate into rooms and the pumps can not function. *If flooding makes more than 3 series of feedwater systems fail, quickly depressurize to 35kg/cm. *If flooding makes more than 4 series of feedwater systems fail, quickly depressurize to 15kg/cm. *If all feedwater systems fail, follow ultimate response procedure. 2. If accumulation happens at power sources of ECCS Bus, *If accumulation on 2F of control bldgs>30cm, the plant will lose DIV-1/2. * If accumulation on 1F of control bldgs reaches ceiling<2m, quickly Depressurize to 35kg/cm. * If accumulation on 1F of control bldgs reaches ceiling<1m, quickly Depressurize to 15kg/cm. *If accumulation on 2F of control bldgs>30cm, follow ultimate response and procedure 500.15 to connect to battery E to supply power to SRV. *If accumulation in AUX bldg reaches 2F>30cm, the plant will lose DIV-3. In conclusion, when there is concern of damage to ECCS, quickly depressurize RPPV to 15kg/cm and line up alternative feedwater (fire-fighting water) and use only 1 valve. (577(PCN)/500.6)	Continue.

Fig 2-7. “Typhoon+Heavy Rainfall/ Debris Flow” Stress Test Flow Chart

Fig. 2“Typhoons +heavy rainfalls/debris flows” Stress

Assumed scenario	Design basis & various scenario base line	Protection intensity	Procedure / Response	Manpower and shift duration
Internal/external flooding is serious so all diesel generators trip and can not recover. (DG loss: reactor water level/ pressure & containment control)	DG building EL.12m & 1m of Water-shielding plates at entrances/exits DG is diversified and Independent, totally 2 regions, but only one regions can supply the power needed for safe shutdown	Power sources 4. Diesel generators LOSS 5. Air-cooling generator (5^{th}) 6. Gas turbine generators fail, so start diesel generators (DCR) 7.1500kw mobile diesel generator (DCR) 8. TSC/OSC two 480V 200kw diesel generators 9. Four 480V mobile diesel generators 10. DC replaces. Feedwater system 2. CRD LOSS 3.RCIC 4.HPCS LOSS 5.LPCS LOSS 6. LPCI*3 LOSS Note:5^{th} DG can supply 1DIV, so either LPCS or LPCI can operate. 9.Fire-fighting water via RHR-B 10.Fire-fighting pump via RHR-B 11.Fire-truck with water tank via RHR-B Heat sink 2.ECW 3.Freshwater replaces ECW 5.Suppresion pool (Fresh water)	1.After confirming all DG trip, press the emergency stop button. Follow procedure. 500.15 to use 5^{th} diesel generator to supply power to one of each #1/#2 unit DIVs (A4first) 2. When 5^{th} diesel generator total load< design capacity 3910kw, it is allowed to overload 10% (4300kw) for 2 hours. 3.Confirm again CONT VENT inside valve is open and power cut off is done. 4. Follow procedure 500. EOP to control water level (>L8/ Start HPCS when necessary) and containment pressure, and to depressurize reactors to 15kg/cm and continue using S/P cooling to lower the temperature. 5.Line up alternative feedwater (fire-fighting) and use only 1 valve. (500.15/1451)	On shift/ 0.5hr On shift/ 0.5hr
Emergency pump room trips due to flooding or trenches can no function due to debris (Heat loss: reactor water level/pressure & containment control)	A removable steel floor barrier Wall is installed at pumps and electric panels in emergency pump rooms. Entrances/exits for workers are water-seal. Inlets at emergency pump rooms allow water to pass by permeating, so no debris or drifting wood.	Power sources 5. Air-cooling generator (5^{th}) 6. Gas turbine generators fail, so start diesel generators (DCR) 7.1500kw mobile diesel generator (DCR) 8. TSC/OSC two 480V 200kw diesel generators 9. Four 480V mobile diesel generators 10. DC replaces. Feedwater system 3.RCIC 5.LPCS or 6. LPCI*3 LOSS Note: either LPCS or LPCI can operate. 9.Fire-fighting water via RHR-B 10.Fire-fighting pump via RHR-B 11.Fire-truck with water tank via RHR-B Heat sink 2.ECW*2// LOSS 3.Freshwater replaces ECW 5.Suppresion pool (Fresh water)	1. 5^{th} DG supplies power to emergency bus and line up ECW alternative Cooling (1451 Appendix 4.1.A/C). After verifying S/P thermal capacity, use it when necessary. 2.Emergency bus is losing power source. To increase thermal capacity, change water and conduct S/P drainage (Appendix 4.2.) & S/P water makeup (Attchment 6.2.1 or 2). 3.Continue following procedure 500.EOP to maintain water level and containment pressure. (1451/500/EOP)	On shift/ 1hr On shift/ 1hr

Fig 2-8. “Typhoon+Heavy Rainfall/ Debris Flow” Stress Test Flow Chart

Fig. 2"Typhoons +heavy rainfalls/debris Flows" Stress

Assumed scenario	Design basis & various scenario base line	Protection intensity	Procedure Response	Manpower and shift duration
After the 5^{th} diesel generator supplies power to 2 units, it is inundated and can not recover. After explaining station blackout, the plant established or will wait for DCR to be set up and then establishes response strategies for standby rescue and support AC power to support ECCS safety system.	5^{th} DG EL. 12m, and one 1m of floor barrier plate & one explosion-proof door at the entrances/exits This DCR is added after the lesson learned, and designed to be higher than EL.22m to avoid inundation.	Power sources 5. Air-cooling generator (5^{th})LOSS 6. Gas turbine generators fail, so start diesel generators (DCR) 7.1500kw mobile diesel generator (DCR) 8. TSC/OSC two 480V 200kw diesel generators 9. Four 480V mobile diesel Generators 6/7/8/9 items are in DCR, so they are assumed not be able to operate. 10. DC replaces. Feedwater system 3.RCIC 5.LPCS or 6. LPCI*3 LOSS Note: either LPCS or LPCI can operate. 9.Fire-fighting water via RHR-B 10.Fire-fighting pump via RHR-B 11.Fire-truck with water tank via RHR-B Heat sink 3.Freshwater replaces ECW 5.Suppresion pool (Fresh water)	By far, the plant loses all AC power sources and only has DC to support reactors, abide by procedure and wait till DCR is established to support AC power sources and then use them. 1.When gas turbine generators fail, shift workers start diesel generators by switching D.S. to supply power till emergency NPBD. (This DCR is scheduled to be completed by the end of Oct. 2011. 2.Shift workers switches D.S. and start 1500kw mobile diesel generators to supply power till emergency NPBD. (This DCR is scheduled to be completed by June, 2012) 3. Connect two 480v 200kw diesel generators of TSC/OSC to LC 1(2)B3/1(2)B4 (This DCR is scheduled to be completed by the middle of Nov. 2011.) 4. After onsite flooding recedes, relocate four 480v mobile diesel generators to the turbine bldg and connect them with temporary cables to LC1(2)B3/1(2)B4 (This DCR is scheduled to be completed by the end of Dec , 2011.) (1451)	On shift/ 2hrs On shift/ 2 hrs Electric div./ 1hr Electric div./3hrs
Due to loss of power or internal flooding, the plant loses all AC power.	ECCS equipment of AC power source is: 1.Multiple cooling systems and reliable 2.Capabile of handling any size of pipe rupture 3.At least 2 independent System for a voltage. 4.Has its own power source 5.Only 1 region can supply power needed for safe shutdown All room doors for ECCS are water-seal to prevent containment suppression pools from leaking to inside of the rooms.(But can not sustain when pressure added from the side, about>5m) There are two 50gpm drainage pumps. 5^{th} DG EL. 12m, and one 1m of floor barrier plate & one explosion-proof door at the entrances/exits	Power sources 10. DC alternative Feedwater system 3.RCIC 9.Fire-fighting water via RHR-B 10.Fire-fighting pump via RHR-B 11.Fire-truck with water tank via RHR-B Heat sink 3.Freshwater replaces ECW 5.Suppresion pool (Fresh water)	1. Confirm if RCIC supported by DC can still function, maintain reactor Pressure at 15kg/cm, and confirm if the plant is ready for the following response: *Confirm if water source is available and plan about priorities. Meanwhile, Feedwater route has established and completed. *Primary containment ventilation operation route has been established. (500.EOP/1451)	Continue .

Fig 2-9. "Typhoon+Heavy Rainfall/ Debris Flow" Stress Test Flow Chart

Fig. 2"Typhoon +heavy rainfall/debris flow" Stress Tests

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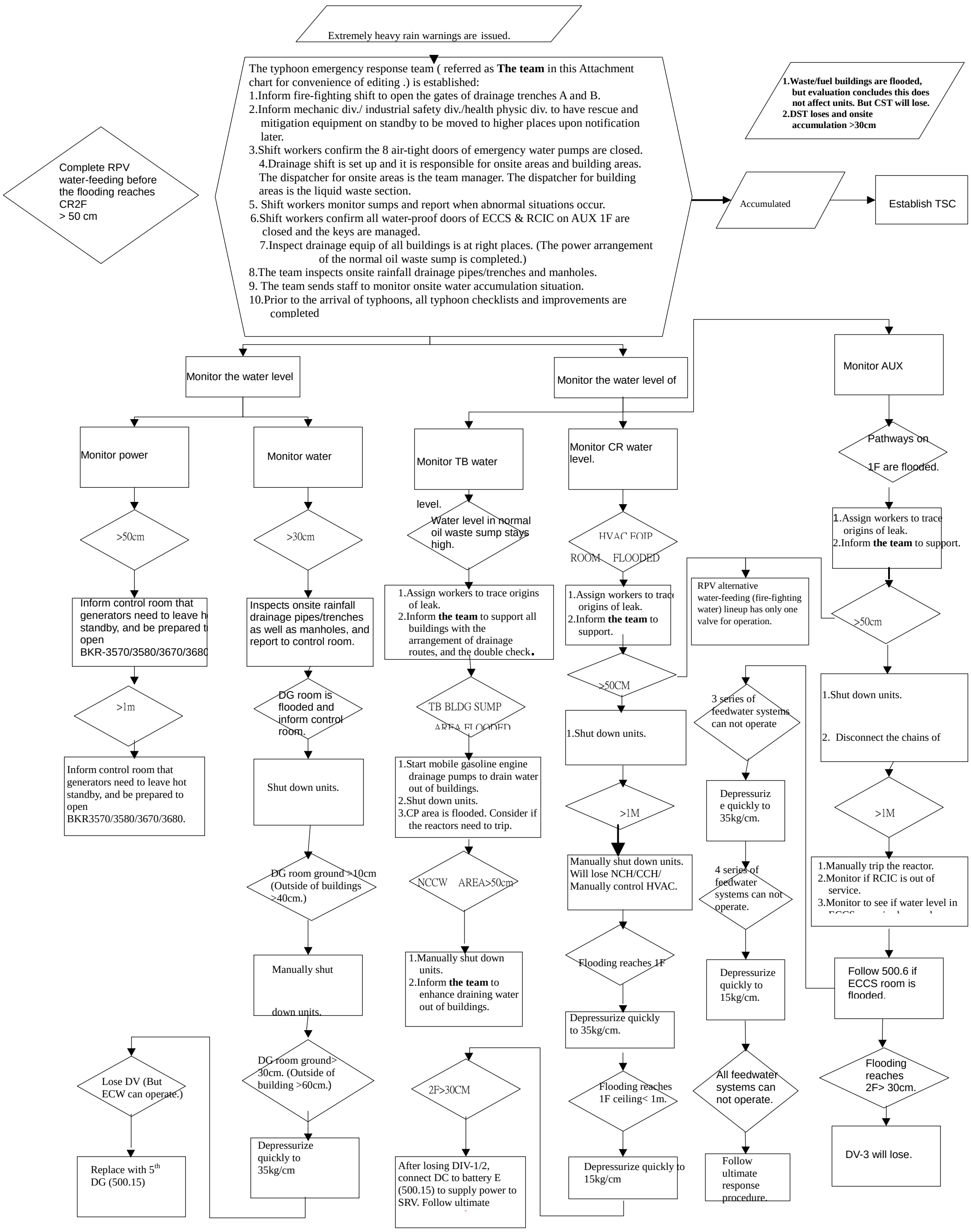
Assumed scenario	Design basis & various scenario base line	Protection intensity	Procedure / Response	Manpower and shift duration
The plant loses standby rescue and support AC power due to strong winds and flooding. Only DC water makeup system and RCIC system are left. Explain DC power will die or be inundated. The plant has established or is waiting for DCR to be set up and then establishes response strategies for standby rescue and support DC power.	All room doors for RCIC are water-seal to prevent containment suppression pools from leaking to inside of the rooms.(But can not sustain when pressure added from the side, about>5m) There are two 50gpm drainage pumps. *Batteries A/B/C/D can function for 8 hours and are on CR 2F. *Can function for 24 hours if unnecessary load is turned off. *If power is supplied by diesel generators, they can supply power for 8 hours every time after oil is added.	Power sources 10. DC replaces. Feedwater system 3.RCIC 9.Fire-fighting water via RHR-B 10.Fire-fighting pump via RHR-B 11.Fire-truck with water tank via RHR-B Heat sink 3.Freshwater replaces ECW 5.Suppresion pool (Fresh water)	Continue using RCIC to keep reactors covered in water (Watch primary containment pressure and conduct containment ventilation once to ensure RCIC would not trip due to high ventilation pressure.). Monitor changes of reactor water level. When necessary, remove low pressure of RCIC, & isolate CSP/ change the interlock of the intake of suppression pools. (500.13 EOP) *Extend DC power. *Unnecessary load is turned off. *Connect to battery E. *Diesel generators (1451/500.15)	On shift/ 1hr On shift 0.5hr On shift/ 0.5hr
The plant loses all DC water makeup system due to loss of power or internal flooding.	Same as above	Power sources 10. DC replaces. Feedwater system 3.RCIC LOSS 9.Fire-fighting water via RHR-B 10.Fire-fighting pump via RHR-B 11.Fire-truck with water tank via RHR-B Heat sink 3.Freshwater replaces ECW 5.Suppresion pool (Fresh water)	1.Confirm if any of the DIV supported by AC is available for use. Abide by procedure 500.EOP to maintain reactor pressure and water level (>8). If only 1 series of feedwater system can use, maintain reactor pressure at 15kg/cm and be prepared to complete the following response. *Confirm if water source is available and plan about priorities. Meanwhile, feedwater route has been completed. *Primary containment ventilation operation route is completed. (500.EOP/1451)	Continue .
Ultimate response for the situation in which The plant loses all standby rescue and support power or all water makeup system.	Reactor cores must be covered by water all the time. Containments must intact. Use steam for cooling (loss of all feedwater)	Power sources 10. DC replaces. (supply SRV) Feedwater system 9.Fire-fighting water via RHR-B 10.Fire-fighting pump via RHR-B 11.Fire-truck with water tank via RHR-B Heat sink 3.Freshwater replaces ECW 5.Suppresion pool (Fresh water)	After confirming the plant loses all water makeup function for reactors, obey ultimate response procedure. 1.Depressurize to below the pressure for alternative feedwater. 2.Inject prepared freshwater or seawater into reactors. 3.Conduct containment ventilation (1451)	On shift/ 0.5hr

Fig 2-10. "Typhoon+Heavy Rainfall/Debris Flow" Stress Test Flow Chart

Attachment 4-2 Abstract Process chart from Procedure 577 and 577.1 to handle "Heavy Rainfall or Flooding at site or inside Building"



Attachment4-3 Procedure 576 add "Operation under Typhoon Alert" Process Chart

Timing to establish TSC:
1. Typhoon alerts are issued and the wind speed is expected to be close to 60 m/sec. When the radius of the typhoon with Beaufort Force 7 reaches the alert area of the plant, the plant needs to judge depending on situations whether to start cold shutdown and establish TSC.
2. When precipitation is close to the drainage capability180mm/hr, the plant arranges cold shutdown and establishes TSC.

↓

Sea alerts for typhoons are issued. ← Typhoons are 24hours away, and they may seize the sea area that is 100kms from Taiwan. Control rooms watch the latest status of typhoons.

↓

Sea and land alerts for typhoons are issued. ← Typhoons are 18 hours away, and they may seize the inland area. If the plant is in one of the areas under the typhoon warnings, go to the next step.

↓

The plant is in the "typhoon watching mode." ←

1. The electricity shift leader writes a "typhoon notification."
2. Confirm in 8 hours that DIV I.Ⅱ.Ⅲ emergency diesel generators can operate.
3. Confirm in 8 hours that the gas turbine can operate.
4. All divisions conduct inspection based on "typhoon checklists" and make improvement. (Industrial safety division can perform the inspection in advance depending on the latest status of typhoons and shift situations.)

↓

The plant is in the "typhoon alert mode." ←

When typhoons are 10 hours away:
1. The electricity shift leader writes a "typhoon notification."
2. The leader of the typhoon emergency response team informs the shift manager the establishment of the typhoon emergency response team.
3. Once the typhoon emergency response team is set up, the shift manager reports to the nuclear power department.
4. The shift manager should assign a person to start the IBM natural disasters reporting system (NDS) and to confirm as well as report that DNS is connected.
5. If the plant is seized by typhoon and there is an abnormal situation with power generating or an accident, the team should report following procedure for natural disasters, abnormal power generating, emergency incidents.
6. The shift manager should continuously stay in contact with the leader of the typhoon emergency response team.

↓

The radius of the typhoon with Beaufort Force 7 (13.9m/s) will reach the site in 1 hour ←

1. Start a gas turbine, connect it to 69 kV, and isolate outside power; the other is on standby.
2. Stop related function tests on RPS and NSSS system.

↓

When the plant is within radius of typhoons, follow procedure 576.

Intensity / Action / Situation	Mild/ Moderate typhoon	Severe typhoon
A	The plant operates in the alert mode.	Reduce power to turbine trip bypass set point of RPS in 3 hours. (Note 2)
B	Reduce power to turbine trip bypass set point of RPS in 3 hours. (Note 2)	Reduce reactor thermal power to about 30% in 3 hours. (Note 2)
C	Reduce reactor thermal power to about 30% in 3 hours. (Note 2)	Disconnect from grid and stay in hot standby mode in 4 hours.
A+D	Disconnect from grid and stay in hot standby mode in 4 hours.	Disconnect from grid and stay in hot standby mode 4 hours, then achieve cold shutdown mode in 24 hours.
B+D	The reactors leaves hot standby in 4 hours and reach the shutdown status in the following 24 hours.	Immediately shutdown reactor and achieve cold shutdown mode as soon as possible.
E	Immediately shutdown reactor and achieve cold shutdown mode as soon as possible.	Immediately shutdown reactor and achieve cold shutdown mode as soon as possible.

→ If internal/external flooding happens, follow procedure 577 (Fig. 2).

↓

Timing for reactors to increase power and return to operation:
1. The radius of the typhoon with Beaufort Force 10 leaves the "Area on Alert" of the plant, or
2. 10/15- minute sustained winds measured on site are below Beaufort Force 9 (20.8m/s), and weather information shows the threat posed by the typhoon becomes less.

5. Loss of power and loss of ultimate heat sink

5.1 Reactor

5.1.1 Loss of off-site power (LOOP)

5.1.1.2 Design Criteria for Backup Power Supply and Power Distribution

The station power distribution systems are divided into safety related and non-safety related systems. Non-safety related power systems provide various auxiliary load power needed for unit operation. Safety-related power systems provide power to reactor protection and emergency cooling systems to ensure reactor safe shut down. The design of plant power supply and distribution systems is described as follows:

1. The source of non-safety related power system can be selected from auxiliary transformer which is connected to main generator or from startup transformer which is connected to off-site 345kV system or from emergency startup transformer which is connected to off-site 69kV system. During operation, auxiliary transformer is usually selected. If necessary, power source can be manually switched to 345 kV startup transformer or 69 kV emergency startup transformer. In cases of reactor scram, power source will be switched to 345 kV startup transformer or 69 kV emergency startup transformer automatically.

2. Safety-related power source comes from the off-site 345 kV start-up transformer and the off-site 69 kV emergency start-up transformer. Via these transformers, the 345kV/69kV off-site power is stepped down to 4.16 kV and fed to Essential bus 1(2)A3, 1(2)A4, and 1(2)A5. Each of these essential buses is also connected to an independent emergency diesel generator to provide power to the emergency cooling systems in case of loss of off-site power. During normal operation, essential bus is staggered between the 345 kV start-up transformer and the 69 kV emergency start-up transformers. If any of these off-site powers is lost, the corresponding downstream emergency diesel generator will be started and put in service automatically; the rated speed and voltage will be reached within 10 seconds. Div. I, II, and III EDG will provide power to bus 1(2) A3, 1(2) A4, and 1(2)A5 respectively.

3. Emergency diesel generator (EDG) system is divided into three divisions - Div. I, II, and III. The essential bus of each division is powered by corresponding EDG. The type and capacity of Division I EDG is with the same as that of Division II. For the essential bus downstream loads of these two divisions, Div. I & II can backup each other. As long as either of Div. I or Div the emergency diesel generator and its essential bus and the equipment for downstream emergency loads. II function normally, reactor safe shut down and cooling can be ensured. Div III EDG and its essential bus provide power to High Pressure Core Spray (HPCS) system.

4. Safety related 480V LC 1(2) B3, 1(2) B4 and MCC 1(2) C5A are powered by 1(2) A3, 1(2) A4 and 1(2) A5 respectively via a step-down transformer. 480V LC 1(2) B3, 1(2) B4 and MCC 1(2) C5A provide power to the following downstream MCCs:
   (1) Div. I: 1(2) C3A, 1(2) C3B, 1(2) C3C, 1(2) C3D, 1(2) C3E, 1(2) C3F, 1(2) C3G
   (2) Div. II: 1(2) C4A, 1(2) C4B, 1(2) C4C, 1(2) C4D, 1(2) C4E, 1(2) C4F, 1(2) C4G
   (3) Div. III: 1(2) C5B

5. The normal power supply for the Hydrogen Ignition System (HIS) is provided by 1(2) C3D19 and 1(2) C4D17, with one specific standby diesel generator as backup.
   Based on the above description, the design features for responding to loss of off-site power event is to automatically start the EDG which is attached to the Div. I / II / III 4.16kV essential bus. Rated speed and voltage will be reached within 10 seconds and the circuit breaker will be closed automatically to provide essential bus with required and sufficient power. As long as either Div. I or Div. II EDG can provide power to its essential bus, the power required for reactor safe shut down can be maintained.

5.1.1.2 Autonomy of the on-site power sources

Each station Auxiliary Boiler Oil Tank is not assessed or programmed to enhance because its capacity is very small in comparison to the capacity of the Gas Turbine Oil Storage Tank. Assessment and engineering design of the seismic-proof enhancement of the Gas Turbine Oil Storage Tank had been finished by Sino-tech Co. in December 2012. The related construction and modification is temporarily suspended because KSNPP is implementing Water-tight-doors/ waterproof enhancement measures at the building of the Fifth Diesel Generator, and the measure is scheduled to be finished before the end of October, 2013. The enhancement of the Fifth Diesel Generator makes it not urgent to upgrade the Gas Turbines.

Mobile oil tanks (with a capacity of 1250 kilo liters each) are used to transport oil from the Auxiliary Boiler Fuel Oil Tanks or Gas Turbine Fuel Tanks for makeup to the EDG Fuel Storage Tanks A & B.

5.1.1.3 Provisions to prolong the time of on-site power supply

If necessary, existing station mobile tanks can be used to transport diesel from the auxiliary boiler fuel storage tank and the gas turbine fuel storage tank to the EDG fuel storage tank to extend diesel generator’s operating time. The capacity of the gas turbine fuel storage tank is 12,336 kiloliter which is enough for six gas turbine generators for both units to run continuously for 72days at full load. The station had performed transportation exercise on September 20, 2011. Mobile tanks for testing SRC were used to transport diesel from the three auxiliary boiler fuel storage tanks to Div. I, II, III emergency diesel generators for both units. The exercise confirms the feasibility of using mobile tanks for fuel make-up.

Each station Auxiliary Boiler Oil Tank is not assessed or programmed to enhance because its capacity is very small in comparison to the capacity of the Gas Turbine Oil Storage Tank. Sino-tech Co. is committed to assess the seismic-proof enhancement of the Gas Turbine Oil Storage Tank to be implemented TPC Construction Department and the design is scheduled to complete before 2013/12/31 with construction scheduled to be completed in 12 or 18 months after completion of design.

Mobile oil tanks (with a capacity of 1250 kilo liters each) are used to transport oil from the Auxiliary Boiler Oil Tanks for makeup to the EDG Day Tank A & B.

5.1.1.4 Measures envisaged to increase robustness of the plant

1. Enhancing measures for EDG Building waterproofing:
   Because of extreme weather phenomena caused by global warming, the possibility that the plant may be flooded due to combined effects of typhoon and heavy rain has increased. In order to prevent plant area from flooding, KSNPP is planning to implement Water-tight-doors/ waterproof enhancement measures at the building of EDG. Retaining plate on personnel hatch and equipment hatch will be installed.

2. Enhancing measures for Emergency Circulating Water pump Room waterproofing:
   KSNPP has completed the retaining improvement for ECW pump structure and equipment to stop sea water from damaging the related electrical equipment. The waterproof wall was added to reach the height of 11.24 meters to the top of ceiling and the penetrations are sealed so that tsunami cannot pass through the retaining wall and flood ECW pump motor area. It means that the protection height of tsunami run-up after improvement is 12 meters, the same as that of the ground level. It can prevent the ECW from becoming inoperable due to tsunami, which in turn would cause Div. I, II, III EDGs to become inoperable due to lack of sea water for cooling.

3. In case of loss of off-site power and loss of EDGs, the station has the 5th air-cooled diesel generator and the two gas turbine generators, which can be used as diverse source to provide emergency power. The station has amended emergency plan. The details of these actions are described in emergency procedure 1451. Via the procedure described in plant procedure 1451, the 5th EDG can provide emergency power to both units' A3/A4/A5 bus simultaneously (one bus for each unit)..

5.1.2 Loss of off-site power and on-site back-up power (SBO)

There is a standard definition for SBO per 10CFR 50.63 with EDGs and off-site power as the design basis without consideration if there is the other alternative AC power. At each of TPC stations, there are dedicated Gas Turbine Generators and a Fifth Diesel Generator, etc. beyond the design basis. In order to maintain its conformity with SBO standard definitions, this chapter discusses the condition of having the Gas Turbine Generators and the Fifth Diesel Generator in case of SBO.

5.1.2.1 Design provisions

The station is designed with the 5th diesel generator and 2 sets of gas turbine generators as diverse backup power upon loss of Div. I, II, III EDGs:

1. The 5th diesel generator:
   The 5th diesel generator which can act as the backup for both unit Div. I, II emergency diesel generator is air-cooled. When the Div. I or Div. II emergency diesel generator for any unit loses its essential power supply function, the 5th diesel generator can be manually put in operation from the Control Room to substitute the malfunctioned Div. I or Div. II emergency diesel generator. Consequently, it can improve the reliability of Div. I or Div. II emergency diesel generator power supply.

2. The Gas Turbine Generators:
   The station is equipped with two sets of Gas Turbine Generators. Any one of them is enough to provide power for the loads for both units , on non-safety related buses and essential buses, to maintain the units in safe shutdown condition.

5.1.2.2 Battery capacity and duration

Because any one of the Gas Turbine Generators or the fifth diesel generator can provide power for the loads on the essential buses , including power for the essential and non-essential DC chargers .The battery has a DC power capacity for long term use.

5.1.2.3 Autonomy of the site before fuel degradation

The Gas Turbine Generators can be started and provide power to the plant non-safety related buses and essential buses in a short time. The 5th diesel generator can be started and provide power to the plant essential buses in a short time.

5.1.2.4 Actions foreseen to prevent fuel degradation

1. Station existing equipment, e.g., equipment from other unit
   The station already revised procedure 1451 to provide an operating guideline, that, in the situation that any one of the EDGs of the two units can be restored to be operable, or only one of the two units loses its on-site back up power(SBO), one set of EDG can provide power for the essential buses of both units.

2. The required operation time for above mentioned systems

(1) It takes about 20 minutes to startup the gas turbine generator and to engage to the 69 kV system.

(2) It takes about 20 minutes to startup the 5th diesel generator and to provide power to the essential buses.

(3) Any one of the available EDG can support safe operation of both units in 30 min at limited load.

3. Availability of qualified operators to perform the above actions

Operators who are responsible for the operating of above mentioned actions are well trained and exercised. They can meet the mission requirements.

4. Confirming timing for cliff edge effects

Reactor water makeup and cooling system can be re-established with power supply from the air cooled 5th diesel generator or the gas turbine generators. The timing of cliff edge effects is assessed on the basis: loss of backup power supply from the air cooled 5th diesel generator, and the diesel fuel oil supplied for the gas turbine generators as well as the mobile fuel are exhausted (The 5th diesel generator is equipped with one set of diesel fuel oil storage tank which has 7days capacity. The Gas Turbine fuel oil storage tank has 30days capacity which can provide power for the loads of both units on all non-safety related buses and essential buses).

5.1.2.5 Measures envisaged to increase robustness of the plant

Kuosheng had implemented the following enhancement measures. In case of station black out, emergency 4.16kV / 480VAC power can be provided.

1. Related procedures had been revised to instruct operator to actuate the 5th DG to provide AC power to essential bus A3/A4/A5 for both units. In case of emergency, only 1 RHR (700HP), 1 ECWP (600HP), and 1 E-chiller (400HP) are sufficient for maintaining reactor long term cooling. The total horsepower of these three pieces of equipment is 1,700HP (1,275 kW). The capacity of the 5th DG is 3,910kW. That is sufficient for running basic required loads of one division for both units. If running HPCS pump (2,500HP or 1,875 kW) is required, the 5th DG can provide power to HPCS pump of both units. Therefore, the station had lined-up the 5th DG to the essential buses A3/A4/A5 for both units as shown in Figure 5-1.

2. The station already revised procedure1451 to provide an operating guideline, that, in the situation that any one of the EDGs of the two units can be restored to be operable, or only one of the two units loses its on-site back up power(SBO), one set of EDG can provide power for the essential buses of both units.

3. The on-site support for make-up fuel for the 5th EDG and the gas turbine generators has been

planned. In the absence of external support, the fuel storage tanks for the EDGs and the auxiliary boiler, and the day tank will be the sources for makeup fuel. The capacity of the fuel storage can support station black out for up to 72 days. Details are listed on Table5-1.

5.1.3 Loss of off-site power, standby back-up power, and other diverse back-up power

5.1.3.1 Design provisions

In case of station black out along with loss of the 5th EDG and the gas turbine generators, the reactor water level can be maintained by RCIC, which requires 125 V DC power only. The design basis of 125 V DC battery capacities is 8 hours. The battery can also provide the required control power to actuate SRV.

1. Safety related DC power supply: It consists of five 125V DC power supply systems, namely A, B, C, D and G, where A and C belong to Div. I load group, B and D belong to Div. II load group, and G belongs to Div. III load group. The design feature is to ensure that any system failure does not impact RPS and the essential equipment to perform their intended functions.
2. Safety-related 120V AC instrument power 1(2)Y3 and 1(2)Y4 are provided by 1(2)C3C09 and 1(2) C4C09 buses respectively. The 120V AC UPS 1(2)YD, 1(2)YE and 1(2) YH are provided by battery sets 1(2)DD13, 1(2)DE28 and 1(2)DE53 respectively. There are two 1(2)DE battery chargers. The power of this battery chargers come from 1(2)B310 and 1(2)B410. As long as the battery sets are available, vital DC and AC (via UPS) power for operation and I&C will be available. The battery sets will be available if battery chargers are available.

5.1.3.2 Battery capacity and duration

1. KSNPP has issued DCR-K1-2855/K2-2856 to upgrade the capacity of battery sets A, B, C & D from the original design with 8 hrs capacity to 24 hrs capacity in accordance with INER proposed "KSNPP improvement benefit assessment report for response to the loss of off-site power under power operation".
2. Besides the 24 hrs power supply capacity, the operating time period of the stations enduring SBO accident can reach 24 hrs according to Taipower Nuclear Safety Department 2010/06 further assessment. For assessment report please refer to attachment 5-1. According to the assessment report, some non-essential loads have to be isolated during SBO. In order to reduce the load of the operators during SBO, DCR-K1-4179 / K2-4180 have been issued to further increase the capacity of the battery system to 24 hrs power supply capacity without isolation of loads. The modification is scheduled to be finished before February and December, 2014 for Unit 1, Unit 2 respectively. Isolation of non-essential loads during SBO will be unnecessary upon completion of the above mentioned DCRs.

5.1.3.3 Autonomy of the site before fuel degradation

In case of station black out and loss of gas turbine and 5th diesel generator, the reactor water level can be maintained by RCIC. The design DC power capacity of RCIC can last for 8 hours (The DC power capacity is enough for 24 hours if unnecessary loads are isolated or upon completion of DCR-K1-4179 / K2-4180). More time will be available for operator to restore on-site power if reactor decay heat is released to suppression pool via SRV. Furthermore, RCIC can be operated without DC power by manually operate the steam valves. Procedure for operating RCIC without DC power is included in procedure 1451.

5.1.3.4 Actions foreseen to prevent fuel degradation

1. The station existing equipment, e.g., equipment of other unit

   On SBO and loss of diverse back up power, RPV can be depressurized via SRVs, and water in the raw water reservoir uphill for fire protection system can be used through gravity for makeup water for the reactor,

2. Equipment available from off-site support in case station facilities are all damaged.

   (1) Kuosheng has signed an agreement "The agreement of fire disaster relief support between The Sixth Team of New Taipei city government Fire Bureau and Taipower KSNPP " with New Taipei city government Fire Bureau for off-site support. If the on-site equipment is all damaged, KSNPP can inform the Sixth Team of New Taipei city government Fire Bureau to provide support for emergency response and reactor water makeup, including fire engines, chemical foam trucks, and/or aerial ladder fire trucks.

   (2) Taipower Head Office already procured 6 sets of 4.16kV 1500kW mobile diesel generator power supply vehicles, delivered in April, 2012. One of them is allocated for KSNPP, and the others are allocated for CSNPP and Lungmen Project. 4.16kV 1500kW mobile diesel generators for CSNPP and Lungmen Project can be moved to support KSNPP in a few hours if necessary.

3. Dedicated power cables connected with the neighboring plants (such as hydro, gas turbine plant)

   Kuosheng NPP 345 kV system has one dedicated power cable directly connected with Chinshan NPP; and another dedicated power cable directly connected to Shieho fossil power plant.

4. The required operation time for any of the above-mentioned systems

   Water for makeup is provided via gravity from the fire system raw water reservoir on the hill. It takes about 40 minutes to open the blind plate.

5. Availability of qualified operators to perform the special line-up

   Operators who are responsible for operation of the above mentioned actions are well trained and exercised. They can meet the mission requirements.

6. Confirming timing of the cliff-edge effects

When the DC power for maintaining RCIC & SRV operation is lost, and battery power is used up, the reactor pressure relief and water makeup becomes impossible. Meanwhile, low pressure injection system can not inject water into reactor due to reactor high pressure, and eventually the reactor core will be degraded and the fuel become uncovered due to lack of water makeup.

5.1.3.5 Measures envisaged to increase robustness of the plant

In addition to considering the response capability to provide power during the Fukushima combined accident, consideration is also given to the response capability in situation when the air-cooled power supply equipment (including the gas turbine generators) all fails, KSNPP proposes the following depth-in-defense measures to strengthen KSNPP response capability in providing power in a combined accident:

1. Power supply enhancement: In case of loss of both off-site and on-site AC power, measures to provide emergency 4.16kV/480V AC power are described as follows:
   (1) Design Change Requests(DCRs) for both units were issued to modify the two auxiliary 4.16kV /1,100kW diesel generators, which are appurtenant of the Gas Turbines, to provide power to the essential bus 1(2) A3 and 1 (2) A4 as shown in Figure 5-2. The DCRs were already completed.
   (2) A plan has been completed to directly supply 4.16kV emergency power to the essential buses when the non-segregated phase bus is at fault. Based on the defense–in-depth concept, the plan includes measures implemented or to be implemented as follows (shown in Figure 5-2).
      (a) The station already revised procedure 1451 to allow the operator to manually operate a push button to close the circuit breaker in the fifth Diesel Generator Building in an emergency such that the fifth Diesel Generator can simultaneously supply 4.16kV emergency power to the essential buses on both units and not impacted by Non-segregated Phase Busduct (NPB).
      (b) DCR-4093/4094 were issued to add a disconnect switch in the rear side of the switchgear bus 1(2) A2. Power supply from the black start diesel generator or the 1500kW mobile power engine can be directly distributed to bus 1(2)A4 in case of emergency and not impacted by the faulty NPB. The medium voltage switchgear is directly fixed onto the U-shaped steel embedded on the floor, and the probability of its failure is extremely low. In case the medium voltage switchgear is at fault, the power cable in the switchgear can be jump connected in the same switchgear to the out-going power cables for the safety related equipment, such as RHR pumps. This jump connection operation, including manpower mobilization, can be completed within 8 hours because it is preceded in the same room.
   (3) Design change request to connect the two 480V/200kW diesel generators at TSC/OSC to LC 1B3/2B3 was approved. Their related wiring changes of TSC/OSC diesel generators are

shown in figure5-3-1 & figure 5-3-2, and their construction was completed in April 2012 (OSC at Unit2 EOC-21 and TSC at Unit 1 EOC-22).

(4) Four sets of 480V 200kW mobile diesel generators are added to provide power to LC1 (2) B3 and 1(2) B4 as shown in figure 5-4-1 & 5-4-2. This can provide power supply for 125VDC charger which provides power supply for the 125VDC bus and the essential 480V loads such as UPS, HIS etc. The construction for unit 2 has been completed during #2 EOC-21 and for unit1 was completed in EOC-22 in April 2012. For the load allocation, pleases refer to Tables 5-2, 5-3 & 5-4.

(5) Taipower Head Office already procured 6 sets of 4.16kV 1500kW mobile diesel generator power engines, delivered in April, 2012, and one of which is stationed at this station, Please refer to Figure 5-2.

Any one of above-mentioned AC power supply: the fifth diesel generator, or the two sets of the 1100kW Gas Turbine Generators associated 4160V Diesel Generators or the mobile 4160V 1500kW diesel generator, when put in service, it will supply power to the essential buses, which can provide the required power for the downstream 4160V/480V/120V DC / AC loads in long term. In case that the above-mentioned three kinds of 4.16kV diesel generators are all unavailable, the TSC/OSC diesel generators or the four sets of the mobile 480V 200kW diesel generators still can supply power to the 480V essential buses which can provide the required power for the downstream 480V/120V DC / AC loads in long term.

The priority sequence of the station emergency power beyond design basis is as follows:

1. The Fifth Diesel Generator (It is equipped with security doors and the elevation of its vent hole reaches as high as 17m.)
2. Gas Turbine Generators (Its elevation is 22m)。
3. Gas Turbine Generators associated 4160V Diesel Generator s(Its elevation is 22m).
4. 4160V Power Trucks(Their elevation is 31m)。
5. TSC/OSC 480V Diesel Generators.
6. 480V mobile generators (they are stored in the warehouse at the elevation of 16m).

As for response to tsunami or flooding, the former four items of 4160V backup power sources are installed or ventilated at an elevation above 17m, enough to prevent from flooding damage. The sixth item of 480V mobile generator is stored at an elevation above 16 m, enough to prevent from flooding damage.

As for response to earthquake, the Fifth Diesel Generator as mentioned in the first item is designed as category I, and its operating procedure for directly feeding power to both units via cables is clearly defined in station procedure 1451, so that it will not be impacted by earthquake.

For the 2nd item on above, assessment and engineering design of the seismic-proof enhancement of Gas Turbine had been finished by Sino-tech Co. in December 2012. The related construction and modification is temporarily suspended because KSNPP is implementing Water-tight-doors/

waterproof enhancement measures at the building of the Fifth Diesel Generator, and the measure is scheduled to be finished before the end of October, 2013. The enhancement of the Fifth Diesel Generator makes it not urgent to upgrade the Gas Turbines. For the 3rd item on above, the Gas Turbine Generators associated 4160V Diesel Generator as mentioned in the third item is a kind of mobile type diesel generator and it has a solid protective enclosure so that its earthquake surviving possibility is still high . The 4160V Power Truck as mentioned in the fourth item is laid down on the outside switchyard and it should not be impacted by earthquake.

Moreover, the station had already issued DCR-4093/4094 to install additional disconnect switches on the back of switchgear bus 1(2) A2 in order that the power from the third item of the Black start Diesel Generator or the fourth item of the 4160V Power Trucks can directly feed power to bus 1(2) A4 and it will not be impacted by earthquake in case of emergency. The medium voltage system switchgears are directly welded onto the U-shaped steel embedded on floor so that the possibility of its damage by earthquake is extremely trivial. In case switchgear bus is still damaged by earthquake, the power cables from the afore said generators shall be directly jump connected to the power receiving cable of safety related equipment such as RHR pump motor etc. by using spare cables. This jump connection can be completed within 8 hours because all the necessary actions are taken in the same room.

Besides, the 480Vmobile generator as mentioned in the sixth item is stored in two warehouses at an elevation above 16 m and it has the protection of a solid hood and a angle steel structure, and is stored in a warehouse built-up with light TBAR so that it should not be impacted by earthquake.

2. Enhancing the emergency operation capability of RCIC& SRVs:

(1) Enhancement of DC power supply:

(a) Any one of above-mentioned measures can ensure that the required DC power for RCIC & SRVs is available.

(b) Five sets of small scale 120V mobile generators and power suppliers are additionally procured to provide DC power to RCIC& SRVs and other essential instrument control power in case of emergency. One of the 120V mobile generators is stationed at the roof of the control building, and related rectifiers and cables are equipped with quick connectors, and stored in two boxes in the control room to facilitate supporting RCIC & SRV in case of emergency. The detailed instrument control power allocation is shown in Table 5-4.

(c) Procedure 1451 has been revised to provide the guideline on how to jump from 1(2) C87 panel to battery set E to supply power to RCIC& SRVs.

(2) RCIC can be manually restarted at site if its DC power supply is lost, or if RCIC is tripped. The related operation has been demonstrated to be feasible, and already been incorporated in procedure1451. (RCIC will be isolated due to equipment area high temperature resulting from loss of equipment room cooling. For this condition, the station had already stipulated in

the procedure 1451 Appendix 8 “ Reactor water level is maintained by RCIC ” to request that the door of RCIC room shall be opened, the interlock for isolation due to equipment room high temperature shall be removed, and its relevant valves can be manually opened to manually operate RCIC in order to carry out reactor water makeup function so that the cliff-edge effect shall not occur in case of loss of cooling for RCIC equipment room.)

(3) Two sets of mobile diesel driven air compressors and two sets of high pressure boosters are procured to provide the required compressed air for SRV emergency operation. Besides, DCR- K1-4034/K2-4035 was issued to install emergency nitrogen filling piping and its adapter outside the building in order to provide the required compressed air for SRV emergency use. DCR- K1-4034/K2-4035 was completed in April, 2012.

3. Enhancement of reactor water makeup capability--mobile water injection equipment:

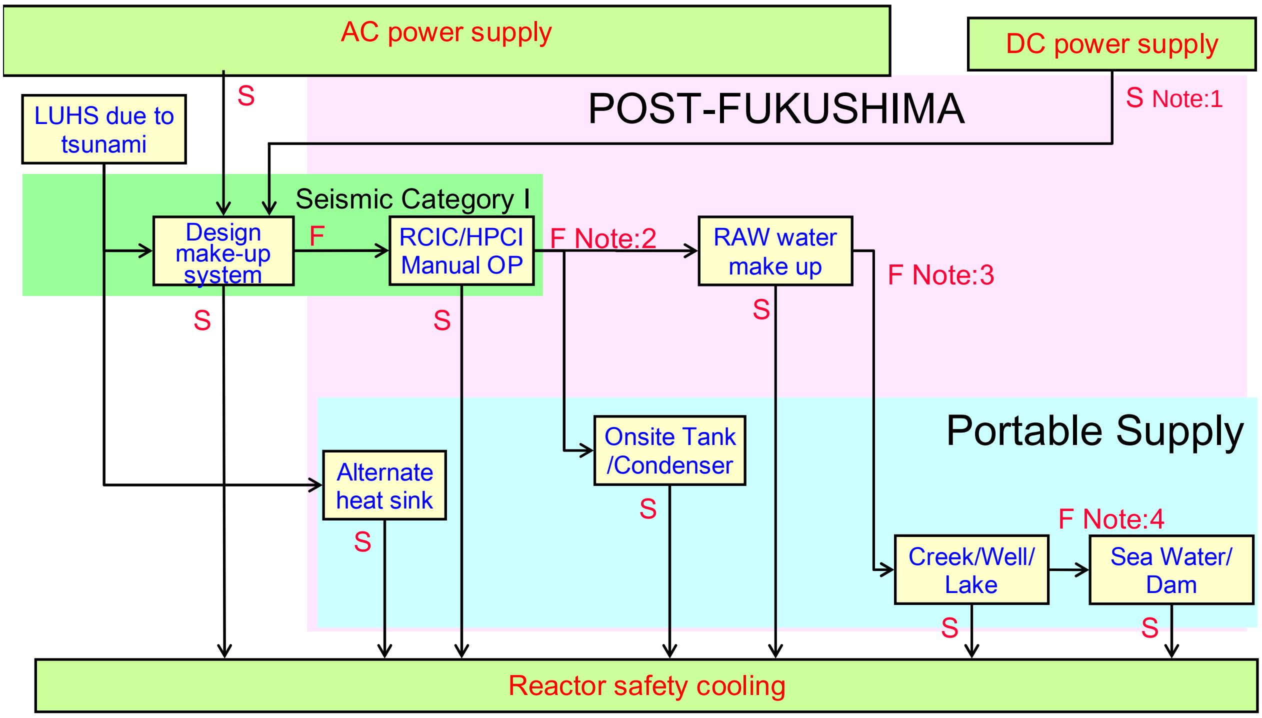
Besides the method to makeup water by gravity to reactor from the fire raw water system on the hill, the station plans to procure five sets of large scale fire pumps and one set of water tank vehicle equipped with pressure pump, to enhance the station’s mobile injection capability. The reactor water makeup can be achieved through rigorous planning (the URG in procedure 1451), and various alternative water sources (including taking water by intercepting from the discharge canal) are available with no concern for shortage.

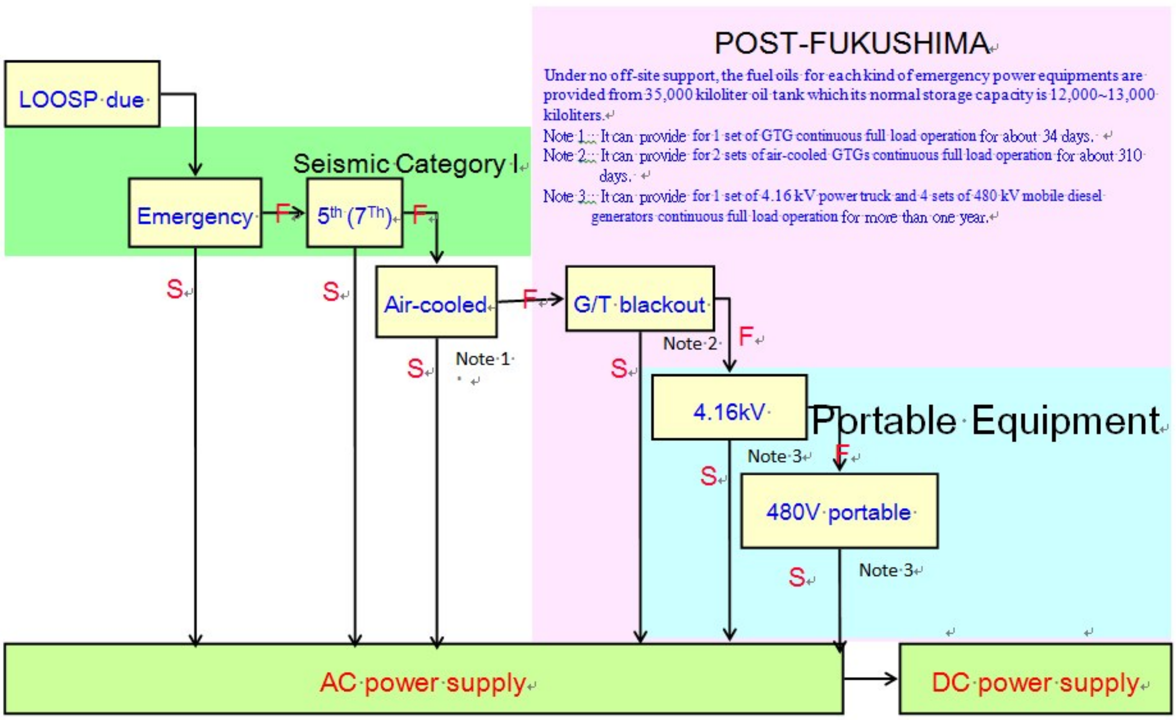
The station has signed an agreement with the Sixth Team of New Taipei city government Fire Bureau for off-site support. Based on the agreement, the Sixth Team of New Taipei city government Fire Bureau can provide fire engines, chemical foam trucks, and/or aerial ladder fire trucks for emergency response and reactor water makeup.

All of the above-mentioned emergency operating procedures have been incorporated into procedure 1451. Emergency power supply can be restored through actions of this section “Measures which can be envisaged to increase robustness of the plant”” to maintain reactor depressurization and water makeup and assure that the cliff edge effects, caused by fuel damage due to core uncover, t will not occur.

In summary, in coping with the condition of beyond design basis accident without outside support, based on the on-site safety facilities and enhanced measures, including emergency power sources and water supply equipment, durations for continuous operation of the plant are shown in detail in the following two charts.

Note1: The DC power capacity is enough for 24 hours if depending on procedure 500.15 unnecessary loads are isolated .It can sustain DC power capacity by 5kw mobile generators .
Note2: RCIC will be manually started supply water into reactor from CST (ACST,DST and ADST can supply water into CST) or suppression pool and sustain over 24 hours .
Note3: It needs 645gpm to protect fuel safe for 1 reactor unit . The total amount of raw water have about 9,732200,893 gallon , which is enough for 125 hours operation requirement for 2 reactor unit .
Note4: Water of channel is continuous water flow , which shall be utilized each kind of mobile type equipments to makeup to the reactor .





5.1.4 Loss of ultimate heat sink

5.1.4.1 Design provisional autonomy of the site before fuel degradation

The circulating water system (CW) and emergency circulating water system (ECW) are designed as the ultimate sink of Kuosheng nuclear power plant. CW is the ultimate sink when units are in normal operation and ECW is the ultimate sink for safe shutdown of the units in emergency condition. Descriptions of these two systems are as follows:

1. Circulating water system

   According to FSAR 10.4.5, the main function of the CW system is to provide cooling water to remove heat from the main condenser. It also serves as heat sink to remove the downstream heat loads (Normal Chiller and NCCCW, and TPCCW) of the External Circulating Water System. If Emergency Circulating Water System is unavailable, the CW system can provide cooling sea water to RHR in all operation modes through the External Circulating Water System and RHR Booster pump. However, this system is not designed as safety-related and its electrical power is not provided by the essential bus and its structure is designed as Seismic II class. Therefore, the reliability of CW system is relatively low.

2. Emergency circulating water system

   The Emergency Circulating Water System (ECW) serves as the ultimate heat sink to remove decay heat, by providing cooling water required by RHR heat exchanger, emergency diesel generator jacket water, emergency chillers, HPCS pump room, and Div. III switchgear room coolers, for reactor safe shutdown and in cold shutdown.

   ECW pump house is located at elevation 12 meters above sea level. In this building, the ECW pump motors and switchboards are located at an elevation of 6.6 meters. On June 30, 2011, the station has installed watertight walls at the ECW pump house to upgrade its tsunami protection capability to 12 meters, which is the same as main buildings and meets the requirement of current design bases. Therefore, based on the existing geological data and with implementation of enhanced measures, there is no concern for inundation of tsunami to the ECW pump house.

   ECW system is safety-related. The design of this system, including supporting equipment, e.g. power supply and ventilation, is all designed as safety-related Seismic Category 1. In addition, the intake structure is designed to protect against tsunami and to prevent blockage by various objects. (ECW intake structure is designed with four defense lines, including breakwater, to stop waste and debris from entering). Therefore, ECW system is highly reliable.

3. Alternative ultimate heat sink in design

   CW and ECW system serve as the ultimate heat sink to remove decay heat. They have very high reliability. However, if both systems are lost, in current design, the alternative heat sink is to inject water to reactor and to actuate SRV to discharge steam generated in reactor into suppression pool. By this way, the decay heat can be removed from reactor to suppression pool. When heat accumulated in suppression pool and containment so as to cause temperature and pressure to increase, containment shall be vented into the environment (the atmospheric) which constitutes an alternative way of ultimate heat sink.

5.1.4.2 Actions foreseen to prevent fuel degradation

1. Station existing equipment, e.g., the equipment of other unit

   In case of loss of ultimate heat sink, but AC power is still available, the support equipment from other unit is as follows:
   (1) Fire water is pumped into reactor via RHR-B.
   (2) Water evaporated from reactor is made up from the Condensate Storage Tank (CST) of the other unit.

2. Equipment available from off-site for support in case station facilities are all damaged.
   (1) Kuosheng NPP 345 kV system has one dedicated power transmission cable directly connected to Chinshan NPP; and another dedicate power transmission cable directly connected to Shieho fossil power plant.
   (2) Taipower headquarters already procured six sets of 4.16kV/1500kW mobile diesel generators power trucks. Four of them are allocated to Taiwan northern nuclear power plants, of which, one is allocated to Kuosheng Station, and three are allocated to Chinshan and Lungmen. Those at Chinshan and Lungmen can be used to support Kuosheng. These trucks were delivered in April, 2012.

3. The required operation time for any of the above-mentioned systems.
   It takes about 40 minutes to makeup water from fire water system to reactor.

4. Availability of qualified operators to perform the special line-up
   The operators, who are responsible for the operations of the above mentioned actions, are well trained and excised. They can meet the mission requirements.

5. Confirming timing of the cliff-edge effects:
   In case the ultimate heat sink is lost, but AC power is still available, based on the enhanced measures described in Section 5.1.3.5, the reactor water level can be maintained by the operation of RCIC or other ECCS systems. Steam evaporated in reactor can be discharged into the suppression pool by actuating SRVs. The decay heat is then removed from reactor to the suppression pool. By way of various actions, including water make up to suppress pool, water refresh in suppression pool, and containment venting, reactor residual heat can be continuously removed so that the cliff-edge effects of fuel degradation will not occur.

5.1.4.3 Measures envisaged to increase robustness of the plant

1. Heat removal capability of the primary containment
   (1) By removing the interlock, the containment can be vented through CTMT venting system (Power supply of VR4, which DCR is completed, has been modified to be powered from safety related power source.) or Standby Gas Treatment System (SGTS).
   (2) Makeup water to the suppression pool is initiated by manual drawdown from the Upper Pool, or provided from Condensate Water Storage Tank (CST), Auxiliary Condensate Water Storage Tank (ACST), Dematerialized Water Storage Tank (DST), Auxiliary Dematerialized Water Storage Tank (ADST) to increase the heat sink capacity of suppression pool.

2. Enhancement for ECW
   (1) In case of loss of ECW, alternative cooling water to RHR
   In case of loss of ECW, the station has established procedures (Procedure 1451, Attachment 5) to use fire water storage tank as an alternative way to provide cooling water to RHR heat exchanger to remove heat from the suppression pool or remove the decay heat from the reactor.
   (2) Replacement of ECW pump motor in an emergency:
   In response to an unexpected situation, in which ECW pump motor is damaged, it can be replaced with a spare motor immediately to restore the ultimate heat sink. The station has established the operating procedure for replacement of ECW pump motor in an emergency, and it has been demonstrated that one ECW pump for either unit can be restored to operable condition within 4 hours. The station has two spare ECW pump motors, which are enough for two units, with one each for each unit for replacement in an emergency.
   (3) Enhancing ECW capability to withstand tsunami:
   Improvements for ECW pumps and the intake structure were completed in June 30, 2011, in order to isolate and prevent sea water from damaging electrical equipment. The watertight wall is 11.24m high, top of which is at the same height of the ceiling, and all penetrations are sealed with watertight material, such that sea water can only reach the ground elevation, and cannot upraise and overflow into the pump house through the watertight wall to flood ECW motor and the auxiliary electrical components. After improvements, the ECW pump house has a height against tsunami water uprising, at elevation of 12meters, which is the same as the ground elevation.
   (4) Clean-up of wastes and debris accumulated at the ECW intake basin in emergent:
   When tsunami hits, it is very likely that large amounts of wastes and debris will be carried by sea water and accumulated at the intake basin. Even when the ECW pump is not damaged, due to blockage by wastes, the units can not take in sea water, and the ultimate heat sink is lost. Therefore, after tsunami, if there are wastes and debris accumulated at the intake basin to affect intake of sea water by the ECW pump, the intake basin shall be cleaned up

immediately,(At Kuosheng station, there are 10ton, 13.5ton, 20ton, and 30ton mobile cranes, and two large trucks that can be used to clean up the debris and wastes in front of the "first fixed traveling screen. At the same time, the station can request Military Emergency Coordination Center to support excavators and other heavy machines, and manpower to speed up the clean-up.) so as to restore the ultimate heat sink. Before the intake basin is cleaned up, and the ultimate heat sink is restored, the station will continue to inject water and vent steam to remove decay heat from the reactor until ECW system is available, and the ultimate heat sink is re-established.

The related emergency operating actions have been incorporated into procedures 747, 572, and 1451, to illustrate how to handle the above-mentioned situation.

5.1.5 Loss of the ultimate heat sink combined with station black out

5.1.5.1 Design provisional autonomy of the site before fuel degradation

If an accident far beyond design basis occurs, where ECW and all off-site and on-site AC power are lost, reactor water level can be maintained by running RCIC. The operation of RCIC relies on 125V DC power. The design basis capacity of this power source is 8 hours. However, the capacity of the DC power source had been extended to 24 hours if unnecessary loads are isolated, and will be further extended to preclude load isolation as mentioned in section 5.1.3.2. In addition, further evaluation in June 2011 by Nuclear Safety Division of Taipower showed that, without off-site power, RCIC can last for 24 hours in station black out event. The evaluation report is attached as Attachment 5-1.

5.1.5.2 External actions foreseen to prevent fuel degradation

1. Station existing equipment, e.g. equipment of other unit:

   In case of station black out combined with loss of ultimate heat sink, the following existing equipment can be used to prevent fuel degradation:

   (1) RCIC system is started and operated in station black out mode to inject water into reactor.

   (2) The 5th diesel generator and the gas turbines can be tied to the essential buses to provide power in a short time to restore the station power.

   (3) Water can be provided for makeup via gravity from the fire raw water system located on the hill.

2. Equipment available from off-site support in case station facilities are all damaged.

   (1) Kuosheng NPP 345 kV system has one dedicated power transmission cable directly connected to Chinshan NPP; and another dedicate power transmission cable directly connected to Shieho fossil power plant.

   (2) Taipower headquarters already procured six sets of 4.16kV/1500kW mobile diesel generators

power trucks. Four of them are allocated to Taiwan northern nuclear power plants, of which, one is allocated to Kuosheng Station, and three are allocated to Chinshan and Lungmen. Those at Chinshan and Lungmen can be used to support Kuosheng. These trucks were delivered in April, 2012.

3. The required operation time for the above-mentioned systems:
   (1) It takes about 20 minutes to synchronize the gas turbine into the 69 kV system for power supply.
   (2) It takes about 20 minutes to synchronize the 5th diesel generator into the essential bus for power supply.
   (3) Water is provided for makeup, via gravity, from the fire raw water system located on the hill. It will take 40 minutes to remove the blind plate.
   (4) RCIC system will inject water into reactor automatically upon receiving start signal.

4. Availability of qualified operators to perform the above actions:
   The operators, who are responsible for the operations of above mentioned actions, are well trained and excised. They can meet the mission requirements.

5. Confirm timing for the cliff-edge effects:

If an accident far beyond design basis occurs, where ECW and all off-site and on-site AC power are lost, reactor water level can be maintained by running RCIC. The operation of RCIC relies on 125V DC power. The design basis capacity of this power source is 8 hours. The battery has a capacity to provide DC power to RCIC for 24 hours continuously running (if unnecessary loads are isolated, and the battery will be further extended to preclude load isolation as mentioned in section 5.1.3.2). If DC power is lost, or the battery power is used up, reactor pressure depressurization and water makeup can not be achieved. Meanwhile, all kinds of alternative low pressure injection will not be able to inject water into reactor due to reactor high pressure. Such that reactor core will face a situation that there will be no water makeup to the reactor, resulting eventually in core degradation because fuel is uncovered.

5.1.5.3 Measures envisaged to increase robustness of the plant

1. As for the situation where a station blackout results in loss of ultimate heat sink, measures to enhance power supply are described in detail in section 5.1.2.5 “Loss of off-site power and

on-site back-up power (EDG)”and section 5.1.3.5 “Loss of off-site power, regular back-up power, and other diverse back-up power.” Item 1, and the required 4.16kV / 480V AC / DC power can be supplied to restore the ultimate heat sink capability for the spent fuel pool.

2. If the onsite power can not be restored in a short time (it means that above-mentioned power enhancement measures all fail), making it impossible to establish the ultimate heat sink based on the enhancement measures for RCIC& SRV as described in section 5.1.3.5 item 2 “Enhancement the emergency operation capability of RCIC& SRVs” and reactor water makeup enhancement measures as described in section 5.1.3.5 item 3 “Enhancement of reactor water makeup capability--mobile water injection equipment” reactor pressure control and water makeup capability can still be maintained.
3. When the ultimate heat sink can not be restored after the onsite power is restored, the response measure is described in this chapter section 5.1.4.3.
4. For response to total loss for a unit power, the station procedure 500.15 table 3 has listed the important water level indicators and pressure instruments signals monitored and described the measured loop current values with conversion to engineering units for operator reference. These relevant engineering conversion data are all placed in the tool cabinets near the wall at unit 2 Control Room back panel, and can be easily retrieved for use anytime.

The above-mentioned power enhancement measures can be followed to restore the ultimate heat sink, or various alternative water sources can be used to provide makeup water to the reactor, and exhaust the steam by means of SRV to remove the decay heat from the reactor to the suppression pool or containment, and then vent to the environment(the atmosphere), such that the cliff-edge effects, caused by of core degradation because fuel is uncovered, will not occur, and the alternative ultimate heat sink can be achieved through recirculation method.

5.2 Spent fuel pool

5.2.1 Loss of off-site power (LOOP)

5.2.1.1 Design provisions of on-site back-up power sources

The station power distribution systems are divided into the safety-related and the non-safety-related power systems. The Non-safety related power supply system (to provide power for CST transfer system, fuel pool cooling and purification system, and external circulating water system) in conjunction with the safety related essential power system(to provide power for nuclear component cooling water system, NCCW), provides the power required for the normal spent fuel cooling, while the safety-related power system(to provide power to the fuel pool emergency water makeup system, the RHR alternative fuel pool cooling system, and the emergency circulating water system) also provides the power required for the related loads of spent fuel emergency cooling in each fuel pool to assure safety of the spent fuel in the fuel pool. For the related power supply and distribution system design description, please refer to section 5.1.1.1.

The emergency diesel generators which provide the required power for the related loads of spent fuel emergency cooling and emergency water makeup are divided into two divisions, each of which is independent to supply power to its corresponding essential bus. The type and the capacity of the emergency diesel generators for both divisions are the same. As long as the emergency diesel generator, its essential bus and its downstream essential loads of one division function normally, it is sufficient to ensure safe cooling of the spent fuel pool.

5.2.1.2 Autonomy of the on-site power sources

When off-site power is lost, the EDG is designed to automatically tie-in to provide power for the essential systems. For duration that the EDG fuel oil storage tank can provide fuel for EDG operation, please refer to section 5.1.1.2.

5.2.1.3 Provisions to prolong the time of on-site power supply

Back up fuel oil supply for EDG operation can be provided from the auxiliary boiler fuel oil storage tank and the gas turbine fuel oil storage tanks to prolong the time of diesel generator operation. Please refer to section 5.1.1.3.

5.2.1.4 Measures envisaged to increase robustness of the plant

The station is designed with normal backup power and other diverse backup power (the Fifth Diesel Generator and the Gas Turbine Generators), and still has sufficient power supply by itself under the condition of loss of off-site power.

For additional enhancement measure, please refer to section 5.1.1.4.: Enhancing measures for EDG Building waterproofing and for Emergency Circulating Water pump Room waterproofing

Besides, for improvement of spent fuel pool monitoring capability, design change requests were issued to include temperature indication signal and level indication function in the main control room, and change the power supply to UPS.(unit 2 completed in EOC-21, unit 1 completed in EOC-22)

5.2.2 Loss of off-site power and on-site back-up power (EDG)

5.2.2.1 Design provisions

When the station loses off-site power and on-site backup power (Div. I/II/III EDGs), it still has diverse backup power (the Fifth Diesel Generator and the Gas Turbine Generators) to provide the required power to the essential equipment. For its design criteria, please refer to section 5.1.2.1.

5.2.2.2 Battery capacity and duration

When any of the Gas Turbine Generators or the 5th diesel generator is connected to the essential buses, power required for the essential DC Chargers can be provided continuously.

5.2.2.3 Autonomy of the site before fuel degradation

Because the 5th diesel generator as well as the Gas Turbine Generators can be connected to provide power to the non-essential and essential buses in a short time to restore station power supply, and maintain long-term cooling capability for the spent fuel pool, fuel degradation will not occur.

5.2.2.4 Actions foreseen to prevent fuel degradation

Besides the 5th diesel generator and the Gas Turbine Generators, as other diverse power supply, the emergency diesel generators for one unit can provide support for the other unit; and there is a dedicated 345 kV transmission line connected between this station and CSNPP, and between this station and SheiHo fossil plant. Please refer to section 5.1.2.4.

5.2.2.5 Measures envisaged to increase robustness of the plant

To cope with loss of off-site power and on-site backup power accident, KSNPP has prepared the enhancement program for 4.16 kV / 480V AC power supply, as described in section 5.1.2.5, and include:.

1. The fifth diesel generator is put in service to supply emergency power to the A3/A4/A5 essential buses for both units.
2. Operating procedures for the EDGs from one unit to support the other unit.
3. Plans have been completed for providing backup fuel oil for the fifth diesel generator and the mobile diesel generators.

5.2.3 Loss of off-site power, standby back-up power, and other diverse back-up power

5.2.3.1 Design provisions

The spent fuel pool cooling/make-up water pump is powered by AC source. If the off-site power, the stand-by back-up power (EDG) and other diverse back-up power are lost, water cooling and make-up capability for the spent fuel pool will be lost. Therefore, it is essential to maintain SFP cooling system in operable condition.

5.2.3.2 Battery capacity and duration

Water cooling and make-up capability for the spent fuel pool will be lost, if the off-site power, the stand-by back-up power (EDG) and other diverse back-up power are lost. The spent fuel will be cooled by the natural convection of pool water, as the operation of SFP cooling system does not rely on battery.

5.2.3.3 Autonomy of the site before fuel degradation

The spent fuel pool water will be continuously heated-up and evaporated when water cooling and make-up capability is lost. Once fuel pool water drops to a level, when fuel is uncovered, and if cooling is not provided, then fuel degradation will occur. It is especially important to assess timing of the cliff-edge effects (the shortest time for the station to initiate rescue actions).

The decay heat of the spent fuel is decreases, as shutdown time increases. On a specific fuel cycle, the decay heat of the spent fuel is the maximum at the moment: when core fuel transfer is just completed, and all the spent fuels (624 pieces) in the core are moved out, and stored in the spent fuel pool .Take unit 1 EOC-21 outage maintenance as an example, timing for the cliff-edge effects, under loss spent fuel pool cooling and makeup condition, are evaluated based on the analysis for the following three cases:

1. Prior to an outage (the total decay heat of the spent fuel pool is approximately 1.5MW) :
   - Time for SFP water temperature to rise to boiling temperature: 90.3 hrs.

   - Time for water level to drop to the level (8 feet above top of fuel), which can not maintain adequate shielding against radiation: 438.9 hr.
   - Time for water level to drop to top of fuel elements: 587.2 hrs.
   - Time for fuel to start degradation : 602.2hr [Note]

2. At the time of fuel transfer, it is assumed conservatively that the spent fuels are moved out to be stored in the spent fuel pool on the third day. (In this example, there are 160 pieces of spent fuels, and the total decay heat is estimated at 3.0MW).
   - Time for SFP water temperature to rise to boiling temperature: 45.3 hr.
   - Time for water level to drop to the level (8 feet above top of fuel), which can not maintain adequate shielding against radiation: 219.5 hr.
   - Time of for water level to drop to top of fuel elements: 293.6 hr.
   - The initiate degradation time of the fuel: 308.6 hrs. [note]
3. All core spent fuels (624 pieces)are moved out to be stored in the spent fuel pool on the 10th day after outage.(The total decay heat is estimated at 6.6 MW).
   - Time for SFP water temperature to rise to boiling temperature: 20.4 hrs.

- Time for water level to drop to the level (8 feet above top of fuel), which can not maintain adequate shielding against radiation: 99.0 hrs.
- Time of for water level to drop to top of fuel elements: 132.4 hrs.
- Time of for water level to drop to top of fuel elements: 147.4hr [note]

Note: According to CFD analysis report performed by Institute of Nuclear Energy Research, the time for fuel clad to reach degradation temperature (2200℉) (rapid oxidation to release hydrogen) is approximately 15 hours.

5.2.3.4 Actions foreseen to prevent fuel degradation

1. The station existing equipment, e.g., the equipment of other unit
   (1) The hose is pulled out from the hydrant to directly inject water to spent fuel pool(which utilize the fire raw water source on the hill, and makeup is by gravity).

   (2) The rollup door of the garage in the fuel building is opened, and mobile water pump is used to pump water from the normal or the backup water source, and directly inject water to the spent fuel pool.

   (3) The rollup door of the garage in the fuel building is opened, and fire truck is driven to the fuel building to inject water into the spent fuel pool.

2. Equipment available from Off-site support in case the station facilities are all damaged.
   As described in the section 5.1.3.4, emergency water makeup can be provided from Off-site, including the Sixth Team of New Taipei city government Fire Bureau providing fire engines, chemical foam trucks, and/or an aerial ladder fire trucks; as well as CSNPP and Lungmen providing power supply with three sets of 4.16 kV 1500kW mobile diesel generator power engines (these were delivered in April, 2012.,.

3. Power cables specially connected to the power plant (such as hydro, gas turbine plant) in the vicinity:
   Kuosheng NPP 345 kV system has one dedicated power transmission cable directly connected to Chinshan NPP; and another dedicated power transmission cable directly connected to Shieho fossil power plant.

4. The required operation time for above mentioned system.
   (1) It will take 40minutes to pull out the hose from the hydrant and inject water to the spent fuel pool directly.
   (2) It takes 60 minutes to open the rollup door in the garage of the fuel building, and to use the mobile water pump to pump water from normal or backup water source and directly inject water to the spent fuel pool.
   (3) It takes 60 minutes to open the rollup door in the garage of the fuel building, and drive fire

trucks to the fuel building to inject water into the spent fuel pool.

5. Availability of qualified operators to perform the special line-up
   The operators, who are responsible for the operations of above mentioned actions, are well trained and excised. They can meet the mission requirements.

6. Confirming timing of the cliff-edge effects
   As described in section 5.2.3.3, under the most serious condition (All spent fuels of 624 pieces are moved out and stored in the spent fuel pool at the tenth day after outage), fuels will not start to degrade approximately 147.4 hrs.(6 days) after loss of spent fuel pool cooling and water makeup.

5.2.3.5 Measures envisaged to increase robustness of the plant

In addition to considering the response capability to provide power during the Fukushima combined accident, consideration is also given to the response capability in situation when the air-cooled power supply equipment (including the gas turbine generators) all fails, KSNPP proposes the following depth-in-defense measures to strengthen KSNPP response capability to provide power in a combined accident:

1. Power enhancement measures: As described in section 5.1.3.5, the measures include the 5th diesel generator, the two sets of Gas Turbine Associated Diesel Generators, the mobile type 4.16kV 1500kW diesel generator, the TSC/OSC diesel generator power supply to 1B3/2B3 or four sets of mobile type 480V 200kW diesel generators.
2. To strengthen spent fuel pool water makeup capability:
   (1) KSNPP plans to procure 5 sets of large size fire pumps and add a water reservoir truck equipped with booster pump, in order to strengthen mobile water injection capability.
   (2) Per DCR-K1-4041 and DCR-K2-4042, installation has been completed of an additional 6 inch diameter cover plate on the movable CST manhole cover on both units, for pumping water from the CST. And DCR-K1-4068 and DCR-K2-4069 were issued to install permanent fire water piping to the plant, such that after additional spray equipment on spent fuel pool is completed, mobile engine-driven water pumps can be used to pump water from unit 1 or unit 2 CST to cool the spent fuel pool of either unit.
   (3) DCR-K1-4059 and DCR-K2-4060 were issued to install permanent fire water injection piping outside the fuel building for injecting water into the spent fuel pool,

5.2.4 Loss of ultimate heat sink

5.2.4.1 Design provisional autonomy of the site before fuel degradation

As described in section 5.1.4.1 “the design provisions of spent fuel pool water makeup and heat removal”, KSNPP is designed to have the circulating water system and the emergency circulating water system as the ultimate heat sink. The circulating water system is responsible for the ultimate heat sink of spent fuel pool when the unit is in normal operation. The emergency circulating water system is responsible for the ultimate heat sink for removing the decay heat in emergency condition. When the spent fuel pool loses its ultimate heat sink, and power is still available(or power can be supplied according to the enhancement measures as described in section 5.1.3.5),water, which is evaporated from the spent fuel pool due to decay heat, can be made-up as follows:

1. CST transfer pump can be used to regulate the water level of the fuel pool.
2. Water can be made-up by means of RHR Pump.
3. Water can be made-up by means of the emergency make-up pumps (1/2P-56A/B).

5.2.4.2 Actions foreseen to prevent fuel degradation

1. Besides the above-mentioned ways for water makeup by normal power , water makeup by way of gravity or transporting, as described in section 5.2.3.4, can be used to make up for water which is evaporated due to decay heat, and to prevent fuel from degradation.
2. As described in section 5.2.3.3, under the most serious condition (All spent fuels of 624 pieces are moved out and stored in the spent fuel pool at the tenth day after outage), fuels will not start to degrade approximately 147.4 hrs.(6 days) after loss of spent fuel pool cooling and water makeup

5.2.4.3 Measures envisaged to increase robustness of the plant

1. When the emergency circulating water system is unavailable such that the ultimate heat sink of the fuel pool is lost, KSNPP shall promptly restore the emergency circulating water system to be operable in accordance with the envisaged measures to increase robustness of the plant as described in section 5.1.4.3 item 2 “Enhancement for ECW”.
2. If the heat sink of the fuel pool still cannot be restored and the as-designed power supply is still in normal condition, water makeup can be proceeded based on the as-designed functions (including emergency water makeup). If the heat sink of the fuel pool still cannot be restored and the as-designed power supply is also lost, water makeup can be preceded based on the diverse mobile ways for water makeup, as described in section 5.2.3.4& section 5.2.3.5, to continuously make-up for water, which is evaporated; and ensure that the fuel in the spent fuel pool is covered with water and the cliff-edge effects of fuel degradation due to fuel being uncovered with water will not occur.

5.2.5 Loss of the ultimate heat sink combined with station black out

5.2.5.1 Design provisional autonomy of the site before fuel degradation

The spent fuel pool water will be continuously heated-up and evaporated when water cooling and make-up capability is lost. Once fuel pool water drops to a level, when fuel is uncovered, and if cooling is not provided, then fuel degradation will occur. In the most serious condition as described in section 5.2.3.3, the station still has sufficient time (about 6 days) to cope with the situation before fuel degradation starts.

5.2.5.2 External actions foreseen to prevent fuel degradation

For the diverse mobile ways for water makeup to prevent fuel from degradation when the ultimate heat sink is lost under the condition of SBO, please refer to the description on external support measures in section 5.2.3.4(loss of the off-site power, the standby backup power and other diverse backup power).

5.2.5.3 Measures envisaged to increase robustness of the plant

1. By power enhancement measures to deal with the situation in a station blackout resulting in loss of ultimate heat sink,, as described in detail in section 5.1.2.5 (enhancement on "Loss of off-site power and on-site power") and section 5.1.3.5 (enhancement on "Loss of off-site power, standby power(EDG) and other diverse backup power "), the required 4.16kV / 480V AC / DC emergency power can be supplied to restore the ultimate heat sink capability for the spent fuel pool.
2. If the station power can not be restored in a short time (it means that above-mentioned power enhancement measures all fail), making it impossible to establish the ultimate heat sink,; however, as long as the various mobile types water makeup and enhancement measures, as described in section 5.2.3(Loss of the ultimate heat sink), section 5.2.3.4(support from outside), and section 5.2.3.5(enhancement measures), are followed, fuel in the spent fuel pool covered with water in long term can be ensured and cliff edge effect of fuel degradation will not occur.
3. When the ultimate heat sink can not be restored after the station power is restored, the response and enhancement measures are described in section 5.2.4 (the ultimate heat sink).

Based on the above-mentioned power supply strategy to restore the ultimate heat sink, or through the various diverse mobile types water makeup, fuel in the spent fuel pool covered with water in long term can be ensured, and cliff edge- effects of fuel degradation will not occur.

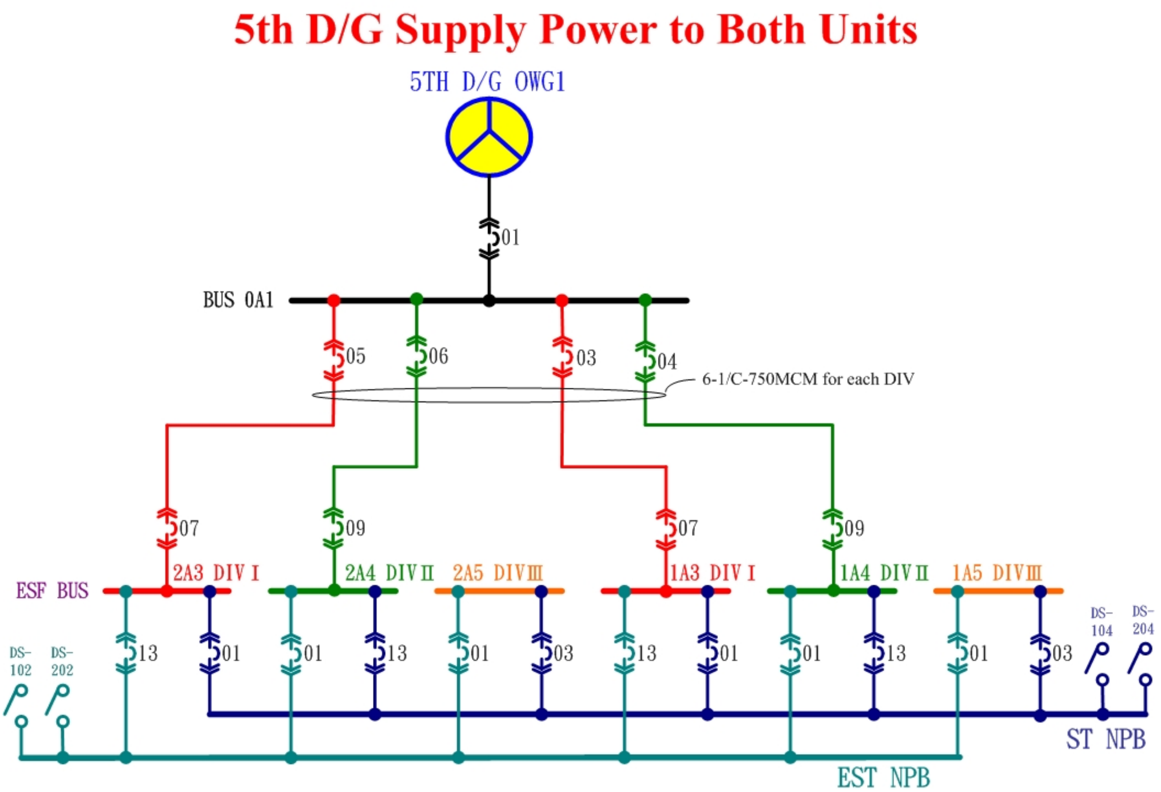


Figure 5-1 Diagram of 5th DG power supply system

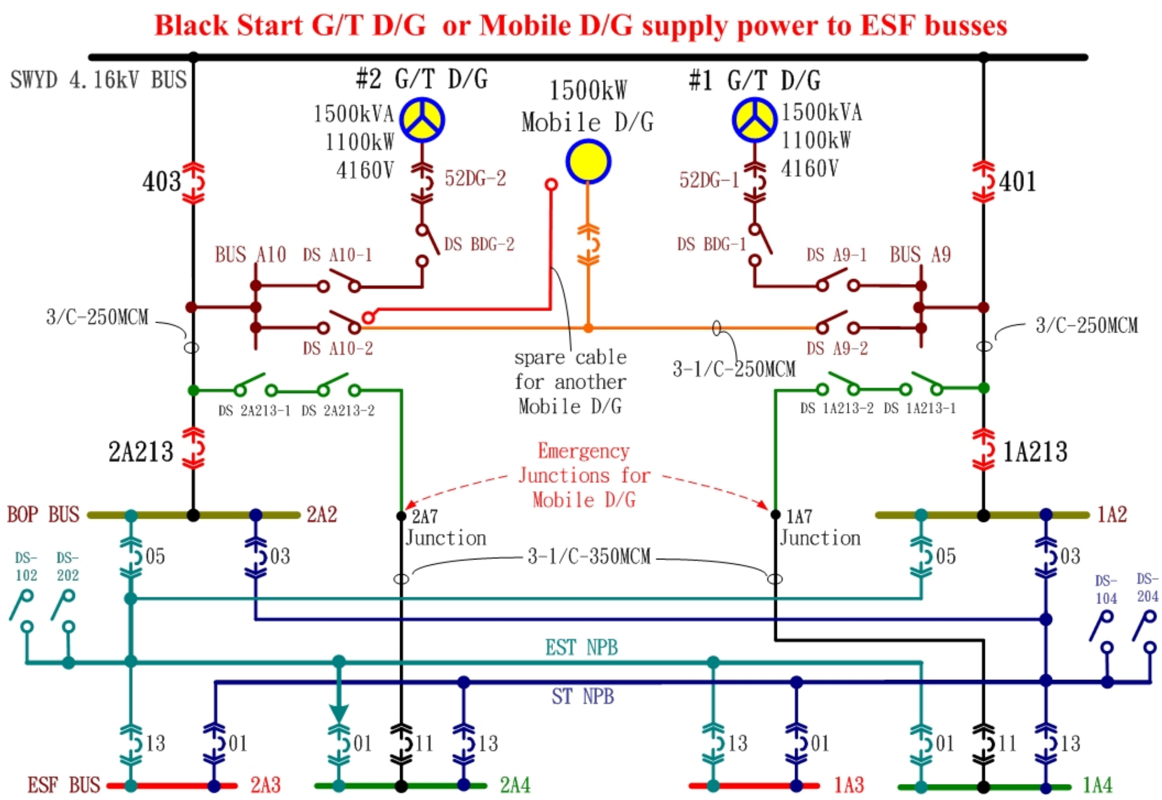


Figure 5-2 Diagram of Gas turbine associated diesel generator and mobile DG power supply system

緊急時自TSC D/G供電至1B3

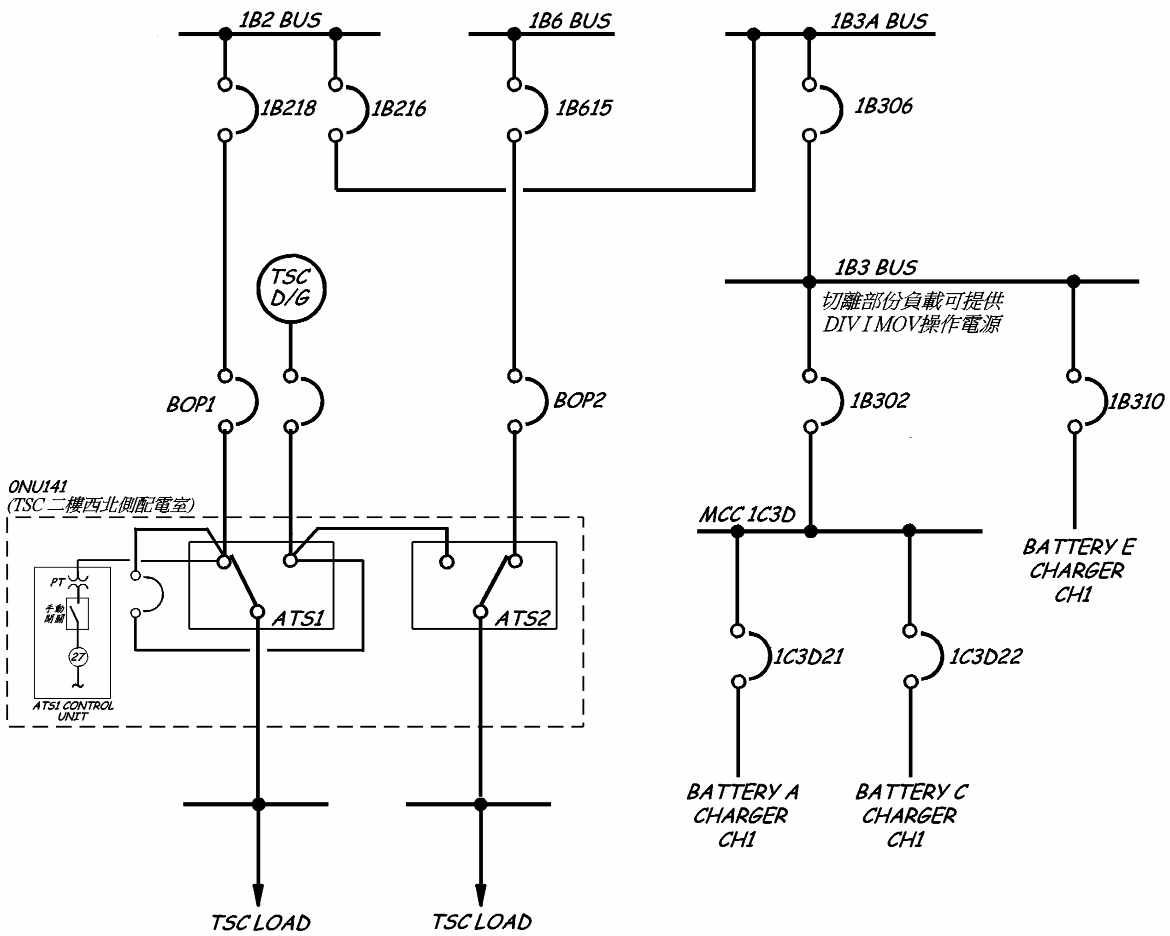


Figure 5-3-1 Diagram of using TSC DG as the emergency power source for bus 1B3

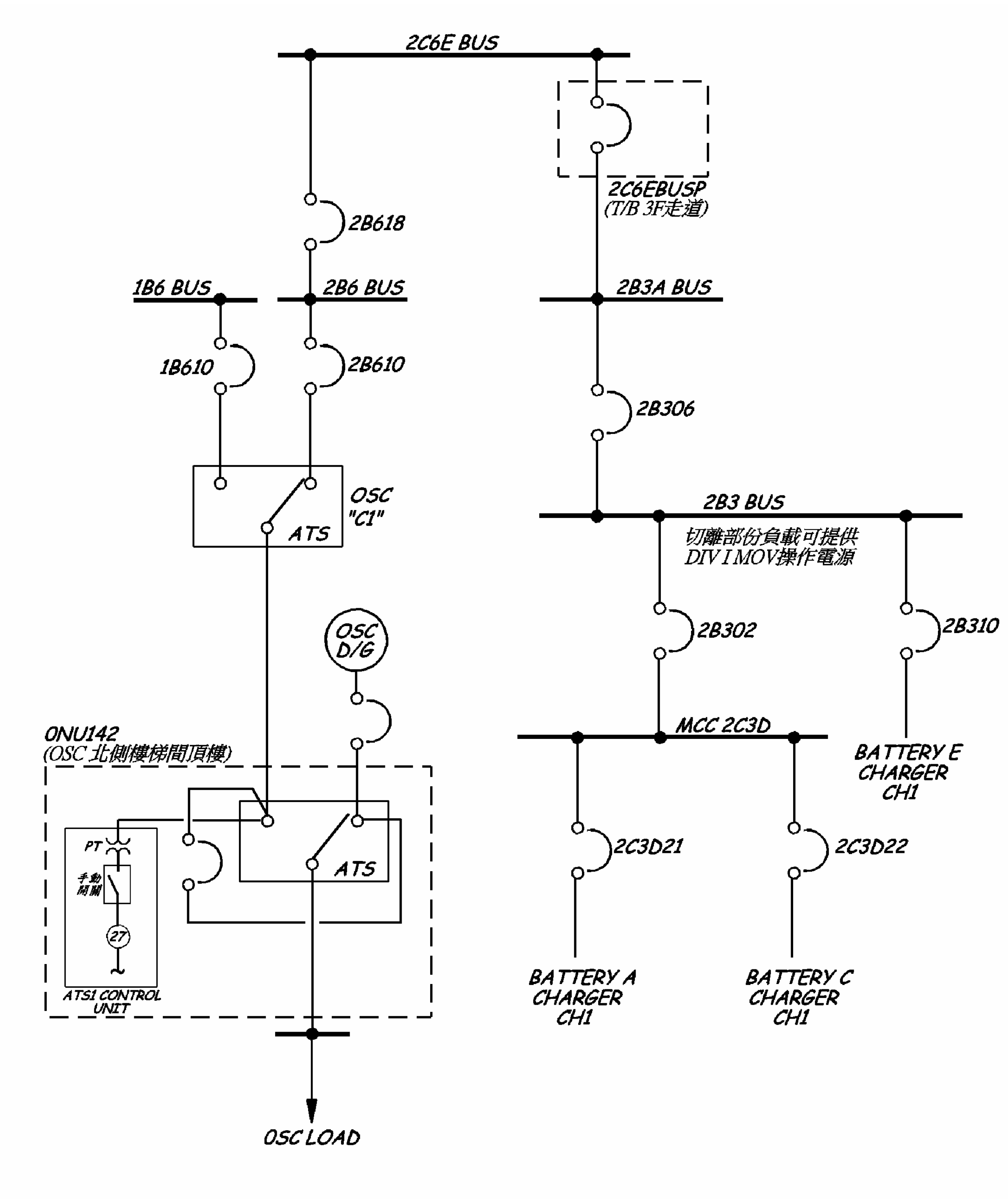


Figure 5-3-2 Diagram of using OSC DG as the emergency power source to bus 2B3

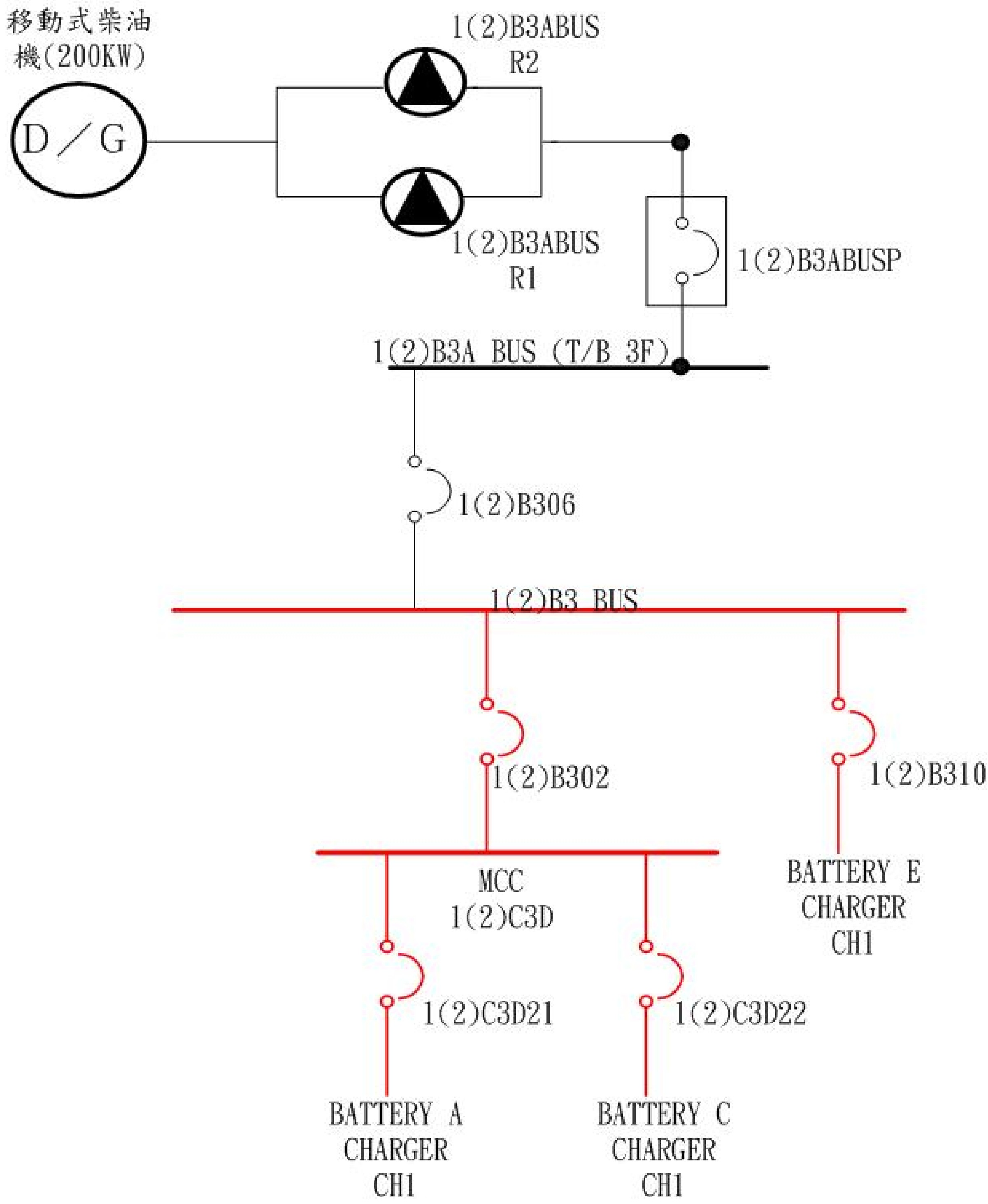


Figure 5-4-1 Diagram of using 480V/200kW mobile DG as power source to bus 1(2) B3

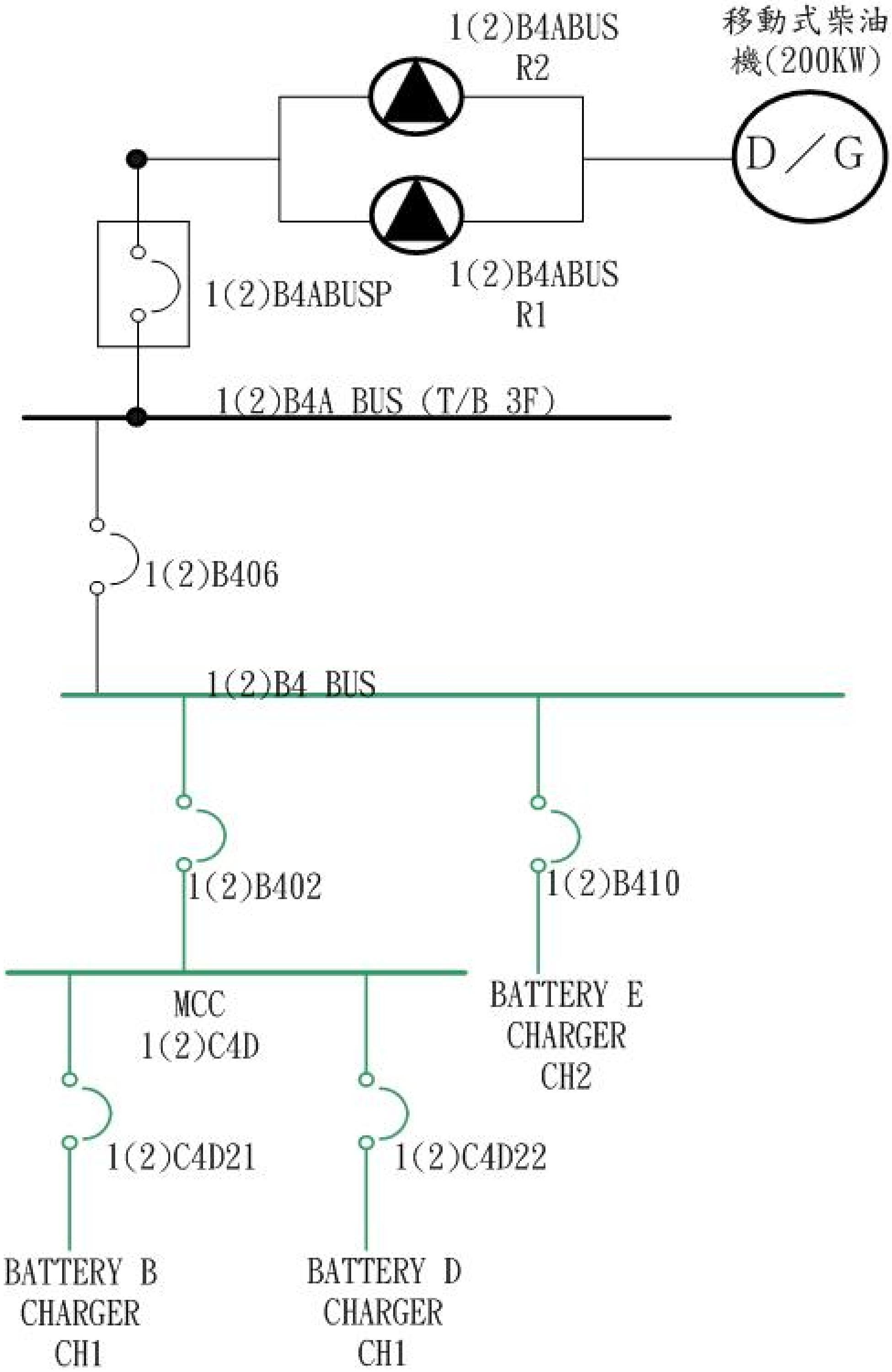


Figure 5-4-2 Diagram of using 480V/200kW mobile DG as power source to bus 1(2) B4

Table 5-1 Capacity of Fuel Storage Tanks

Tank Name	Capacity (kiloliter)	Remark
Gas Turbine 35,000 kiloliter Tank	12,336	
Gas Turbine Daily Tank A	311	Tank A, B, C are connected at bottom via valves
Gas Turbine Daily Tank B	311	Tank A, B, C are connected at bottom via valves
Gas Turbine Daily Tank C	311	Tank A, B, C are connected at bottom via valves
Unit 1 Div. I DG	208	
Unit 1 Div. II DG	212	
Unit 1 Div. III DG	114	
Unit 2 Div. I DG	209	
Unit 2 Div. II DG	208	
Unit 2 Div. III DG	113	
Aux. Boiler OT-120 Tank	600	
Aux. Boiler OT-19A Tank	50	Tank A and B are connected at bottom via valve
Aux. Boiler OT-19B Tank	50	Tank A and B are connected at bottom via valve
5th EDG	218	
Total	15,251	

Table 5-2 SBO Div. I Mobile 480V DG Load Calculation

Item	Load	2nd side current	480V Bus Side Current	Watts	Remark
1	Battery A	74	13.1	10,891	1/2C3D21(ch1),1/2C3C01(ch2)
2	Battery C	32.58	5.7	4,739	1/2C3D22(ch1),1/2C3C01(ch2)
3	Control Room ESF Essential Lighting			14,110	1/2C3C21
4	Control Room Ventilation			19,875	1/2VC1A(1/2C3A01)25HP, 1/2VC2A(1/2C3A06)1.5HP
5	SGTS 1(2) VR9A			30,000	1/2C3A11(40HP)
6	SGTS 1(2) VR9A Heater			37,600	1(2)C3A08
7	Rx Wide Range LVL (AA-LT-398):YY344(10A)	10		1,200	1/2C3C12(RPS provided from alternative source)
8	Hydrogen Ignition System			15,000	1/2C3D19
Total				133,415	

Note: Loads of Battery sets A~E are based on the required currents of steady state in calculation sheets. Battery charger efficiency is 0.9.

Table 5-3 SBO Div. II Mobile 480V DG Load Calculation

Item	Load	2nd side current	480V Bus Side Current	Watts	Remark
1	Battery B	18.3	3.2	2,660	1/2C4D21(ch1),1/2C4C01(ch2)
2	Battery D	29.34	5.2	4,323	1/2C4D22(ch1),1/2C4C02(ch2)
3	Battery E	462	81.5	67,756	1/2B410(ch2)
4	Control Room ESF Essential Lighting			14,110	1/2C4C56
5	Station 125V DC Emergency Lighting			10,275	Power Supplied from 1/2DE (Fef. Procedure 7432)
6	I&C 1/2YH Related Loads				Power Supplied from 1/2DE
7	1(2) P-56B			3,750	1(2)C4B39/5HP
8	1(2)VF-2B			11,250	1(2)C4C05/15HP
9	1(2)VF-2B Heater			15,000	1(2)C4C49
Total				129,124	

Note: Loads of Battery sets A~E are based on the required currents of steady state in calculation sheets. Battery charger efficiency is 0.9.

Table 5-4 Instruments List

Instrument (Number)	Power Source	Protection	Remark
RX Fuel Zone LVL(AA-LT-409/411)	1(2)YH03	Core Rescue	Monitoring
RX Narrow Range LVL(AA-LT-388/383/374)	1(2)YH18	Core Rescue	Monitoring
RX S/D Range LVL(AA-LT-419)	1(2)YH03	Core Rescue	Monitoring
RX Wide Range LVL(AA-LT-398)	1(2)YA08	Core Rescue	Monitoring
Abnormal following RX LVL(AA-LT-420)	1(2)YH18	Core Rescue	Monitoring
Wide Range RX PRESS(AA-PT-295/362)	1(2)YH18	Core Rescue	Monitoring
Narrow Range RX PRESS(AA-PT-361/649)	1(2)YH18	Core Rescue	Monitoring
RX Water temp (BB-TE-114/119)	1(2)YH18	Core Rescue	Monitoring
DW, Suppression Pool, and Containment Temperature	1(2)Y319/Y426	CTMT Venting /Integrity /Heat Removal	Monitoring
CTMT Narrow Range Level (EM-LT-133), CTMT Wide Range Level (EM-LT-161/162), DW pressure (AA-PT-651), CTMT Pressure (AA-PT-652/653), DW/CTMT H_2 Monitor (GN-AITS-377A/384A)	1(2)Y336, Y436 1(2)Y329, Y429	1. Core Rescue 2. CTMT Integrity /Heat Removal /Venting 3. H_2 Monitoring	Monitoring
CTMT and DW Wide Range Radiation Monitor (SD-RE-144/145)	1(2)Y347	Radiation Monitoring	Monitoring
C03 Panel, Vital Info Recorder	1(2)YH20	1. Core Rescue 2. CTMT Integrity /Heat removal /Venting 3. H_2 Monitoring	Monitoring
RCIC Instrument Power	1(2)DA10/DB17	Core Rescue	Control
SRV Instrument Power	1(2)DA09/DB12/Y302/Y413	Core Rescue	Control
SFP Temperature	1(2)YK49 C3C21L,	SFP Monitoring	Monitoring
Main Control Room Essential Lighting	1(2)C4C56L	Habitability	
NSSS Alarm Power	1(2)DE60 and YN28 (redundant)	1. Core Rescue 2. CTMT Integrity /Heat Removal /Venting 3. H_2 Monitoring	Monitoring

Attachment 5-1 Kuosheng Station SBO Duration
(Nuclear Safety Department, June, 2001)

Item	Parameters	Duration of Contributing Parameters
1	SBO scenario	Assume loss of off-site power, which is caused by switchyard failure, grid disturbance, or natural disaster, affects both units. It is also assumed that one unit lost emergency on-site AC power (AAC is not included). Conservatively, it is assumed that 5^{th} DG and gas turbine generator will not serve as alternative AC (AAC) power. Turbine governor valve (GV) will quickly open; recirculation pump will trip; and MSIV will close. Reactor will scram due to GV quick closure, and Feedwater will trip because of MSIV closure. MSIV closure will induce reactor pressure oscillation, and then SRV will be actuated. Reactor water level will decrease and suppression pool (SP) temperature will increase due to steam releasing from SRV. RCIC and HPCS will start automatically to make up water if reactor water level drops to level 2. SP temperature will continue to increase, since no RHR SP cooling is available. The preceding assumptions and operator actions will not change. These will not affect SBO duration.
2	Nuclear Steam Supply System (NSSS)	This item involves the available operating time of RCIC and HPCS. Based on the analysis by Taipower using SAFTRAN code, at 1.1hours after loss of RCIC, reactor water level will drop to top of active fuel (TAF). EBASCO has analyzed this case for Browns Ferry nuclear power plant and compared with Kuosheng condition, they decided to change 1.1 hours to 0.8hours. No matter which value is used, RCIC and/or HPCS must be available for several hours within the first 8 hours after event. This does not signify the duration of RCIC and/ or HPCS operable. The actual operating duration depends on the condition that RCIC and/or HPCS matches with reactor environment. Based on the experience learned from Fukushima Daiichi NPS Unit 2 and 3, RCIC operable time is longer than 24 hours (1 to 3 days).

Item	Parameters	Duration of Contributing Parameters
3	CST capacity for decay heat removal	Based on ANSI/ANS-5.1-1979 and assume reactor has run for 100 days, within 8 hours after SBO, the required CST water for decay heat removal is 88,647gallons. The other water consumption is 68,134gallons which is required for reactor depressurization by manipulating SRV and ADS. The total is 156,781gals. The CST water for RCIC and HPCS is only125,000 gals, which is not enough for 8 hours. However, the total amount of CST can have as much as 200,000 gallons, which is enough for 10 hours operation requirement. Conservatively assume that the decay heat at the 8th hour represents the decay heat from the 9th hour (included), the required water after 9th hour (included) is only 72% of the water required during the beginning 8 hours. Thus, After the 9th hour, the water in CST can last for: (200,000-156,781)*8/0.72/156,781＝3.1hours. The total duration will be 11.1hours. EOP500.15 requests to make up water from ACST to CST, if CST water is less than 200,000 gallons. (Note: ACST full capacity is 350x10^3 gallons. Water level of 2m indicates a water volume of 58x10^3 gallons). Therefore, the total water can last for 24hours. Based on the planned procedures for responding beyond design basis accident, the water in DST (approximate 50 x10^3 gallons) and ADST (approximate 53 x10^3 gallons) can be made up to CST(500 x10^3 gallons). If necessary, suppression pool water and CST water of the other unit can also be used as the source for making up. It is further ensured that water source can be maintained for 24 hours requirement.
4	Capability of compressed air system	The accumulator capacity of SRV and ADS is 42 gallons and 10 gallons respectively. The “relief function” of the 16 SRVs can be actuated for 5 times; and the “ADS” function of the 7 valves can also be actuated for 5 times. The total is 115 times. Within 8 hours after SBO, if no other depressurization action is taken, with only with SRV/ADS performing the auto-release function, the total actuation number is 40 times(＜115times). Considering the decay heat after 9 hours will gradually decrease, SRV actuation times during this period will be less than the beginning 8 hours. Therefore, accumulators alone can meet the requirement for 24 hours (8*115/40=23).
5	I&C system	This item considers interlock, start & control logic, and instrument power supply. The DC power source is discussed in item 6 “battery loads”. The specific controls of related system (e.g., RCIC) have been described in EOP 500.15. For example, in case of SBO, RCIC MST high temperature isolation signal must be bypassed to avoid RCIC rendered unavailable due to MST high temperature. The door of RCIC pump room and main control room control panel must be opened during event. The design of interlock and start & control logic can respond for 8 hours, and will not be affected by SBO duration.

Item	Parameters	Duration of Contributing Parameters
6	Battery loads	The design change request DCR K1-2855 and DCR K2-2856 has improved the capacity of battery set A, B, D. Together with procedure to isolate unneeded loads, those battery sets can supply DC power for more than 24 hours (The original capacity of battery set C can last for 24 hours if unneeded loads are isolated according to related procedure). Based on the plans for responding beyond design basis events, mobile generator can be used to provide AC power to the battery charger, and then to charge battery. Therefore, as long as mobile generator is continuously operable, the battery sets can continuously perform their deign function.
7	Loss of ventilation	After SBO, the areas concerned due to temperature rise include MST, RCIC RM, MCR, and electrical RM #325. Procedure 500.15 requests that the door of control panel and RCIC pump room shall be opened in case of SBO. The temperature rise in the above areas can be controlled within the limits defined in the equipment qualification (EQ) specification. The room temperature within 8 hours after SBO with door unopened versus the EQ limit temperature for the above areas are listed as follows: RCIC RM: 134°F vs. 150°F; MCR: 105°F vs. 120°F; Electrical room #325: 120°F vs. 131°F The function of EQ equipment (temperature sensor and control instrument) in MST is to close MSIVs. The MSIVs will have already been closed at the beginning stage of event. Thus, they will not be affected by MST temperature. Within 8 hours after SBO, MST temperature will increase to 205°F which is higher than the RCIC "MST High Temperature Isolation Signal Set Point 150°F". Thus, Procedure 500.15 requests to bypass this signal for RCIC continuing operation. The MST temperature 205°F is still lower than the temperature at MSLB located outside containment. This will not affect the structural integrity.
8	HPCS and RCIC	HPCS and RCIC are driven by steam and are controlled by DC power or specific diesel generator AC power. The related water source, DC source, I&C, and ventilation are discussed under other items. The effects of temperature and pressure during events are covered by related procedures, including bypassing MST high temperature (150°F) RCIC isolating signal, preventing RCIC /HPCS from taking water from SP, and isolating unneeded DC loads, etc. Therefore, RCIC can maintain long term operation. Based on the experience learned from Fukushima Daiichi NPS Unit 2 and 3, RCIC operable time is longer than 24 hours (1 to 3 days).

Item	Parameters	Duration of Contributing Parameters
9	Containment integrity	1.Containment isolation The valves, which have to be opened during SBO, are RCIC steam line isolation valve, turbine exhaust valve, and vacuum breaker. The turbine exhaust valve is operated by DC power, while the others are operated by AC power. These AC operated valves are normal-open and are kept in open if de-energized. Thus, containment isolation can be maintained as long as DC power is available. 2.Containment Structural Integrity Containment design pressure/temperature and pressure/ temperature at 8 hours after SBO are: Design pressure: Dry well Reactor Building Suppression Pool 42 psia 30 psia 30psia Pressure at 8 hours after SBO: 25.3 psia 20.8 psia 20.8psia Design Temperature: Dry well Reactor Building Suppression Pool 330°F 200°F 200°F Temperature at 8 hours after SBO: 243.2°F 145.6°F 193.5°F After SBO, containment pressure and temperature will be affected by decay heat and by the actuation of SRV/ADS (SRV/ADS actuation is caused by decay heat also). Containment pressure and temperature will gradually increase. The margin of pressure is large. Considering decay heat is decreasing, containment structural integrity should be able to be maintained for 24hours (EOP 500.14 requests to de-pressurize timely). The suppression pool temperature margin is small. Based on the EOP for primary containment control, the RPV will be depressurized in case it is necessary to control containment temperature. On the premise of "controlled release", containment integrity can be maintained for 24 hours.
10	Other systems, e.g., communication and lighting	Based on EBASCO analysis, this item includes the requirement for lighting and communication. The required lighting includes portable lighting apparatus needed for site walkdown, and temporary lighting installation at diesel room and switchgear room, etc, where it is necessary to prepare for start up of the plant. The communication can meet 8 hours requirement . Whether communication and lighting can be maintained for 24 hours will depend on the capacity of the battery set.

1. According to "Kuosheng MUR Power Uprate SBO Safety Evaluation", TITRAM/KS-SPT-MHD-02, INER, Dec. 1, 2005.
2. Reference is made in part to "Station Blackout Event Report for Kuosheng NPS Unit No1 1&2", Ebasco, Nov. 27, 1990.

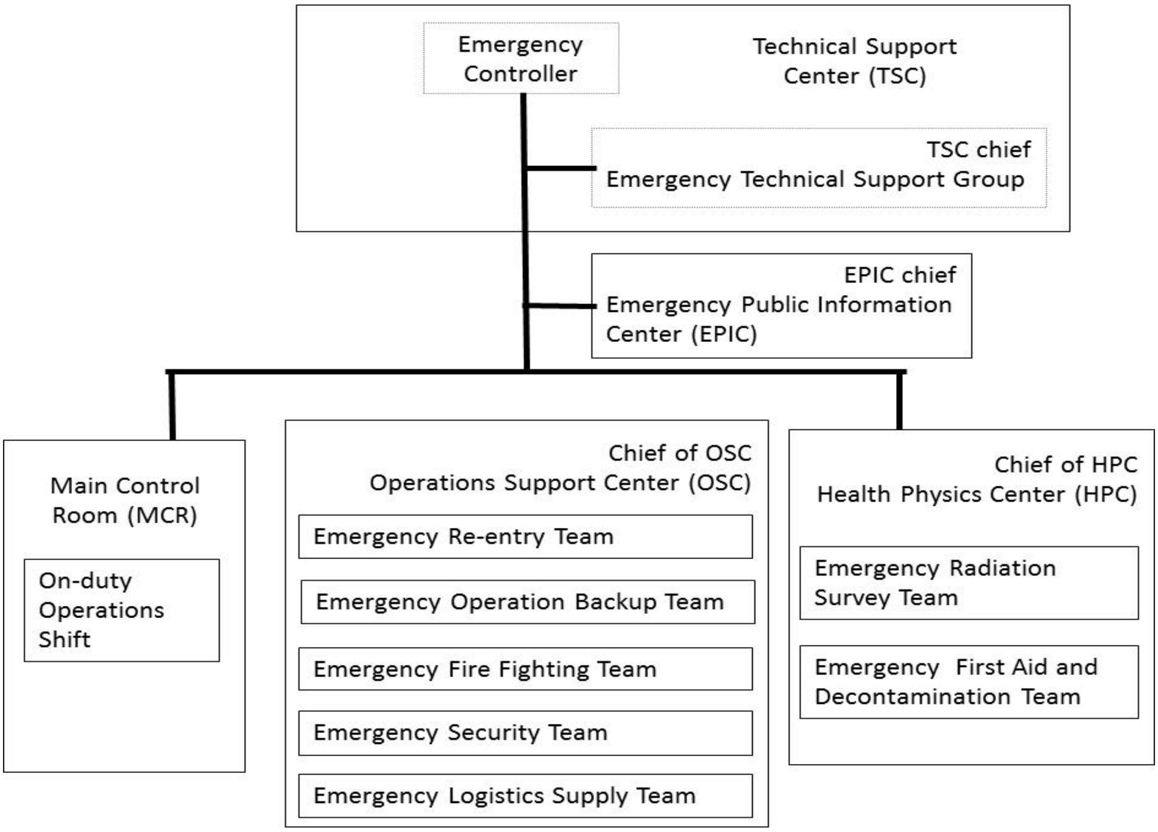
6. Severe accident management

6.1 Organization of the licensee to manage the accident

6.1.1 Organization plan

6.1.1.1 Organization structure

According to the Emergency Preparedness and Response Plan as detailed in Kuosheng procedures 1400 series, when a severe accident occurs, the Emergency Control Team is promptly organized and comprised of: Technical Support Center (TSC), Emergency Public Information Center (EPIC), Health Physic Center (HPC), Operation Support Center (OSC) and the Control Room (CR), as well as ten emergency operation divisions to carry out the different tasks. The organizational structure of Station Emergency Control Team of KSNPP is shown as follows:



Based on the Severe Accident Management Guideline developed by American BWROG, KSNPP has developed a plant -specific Severe Accident Management Guideline (SAMG, shown as Fig.6-1 and Fig.6-2) and an Accident Management Team (AMT) that functions accordingly as needed. KSNPP AMT crews are mainly comprised of TSC members. When EOP is initiated and conditions of SAG are met, or AMT leader (Operation Manager) considers necessary, TSC chief will be advised to activate AMT team work. Therefore, AMT is not a standing organization of current Emergency Preparedness Plan. According to the SAMG, AMT assists TSC to assess the accident indicators and to provide recommendations.

The members and tasks of AMT are described as follows:

1. Team leader —KSNPP's Operation Manager assumes the leadership of AMT. He is responsible for conducting assessment of timing to initiate AMT formation following SAMGs, providing adequate strategies to Station Emergency Control Team, and predicting the effectiveness of emergency operations, etc.

2. The Operation Coordination Team (abbreviated as Operation team) — Supervisor of Mobile Support Station serves as the team leader, and chief of Operation Subsection is his/her team member and the 1^{st} deputy. Based on the "Operation Coordination team member handbook" of SAMG procedure, the Operation Coordination Team takes charge of the following tasks: confirming the mission transferred according to SAGs, identifying the SAG sub-items, predicting the flooding impact on containment, the optimized rescue timing, and ranking the priority to system recovery.

3. The Nuclear Safety Evaluation Team (abbreviated as NSE team) — QA Manager serves as the team leader, and Chief of Safety Evaluation Subsection is his/her team member and the 1^{st} deputy. Based on the "System Analysis Engineer manual" of SAMG procedure, the Nuclear Safety Evaluation Team takes charge of the following tasks: controlling and analyzing the trend of safety parameters, evaluating the cooling and flow in RPV, evaluating the status of systems.

4. The Reactor Engineering Technology Assessment Team (abbreviated as Reactor team) — Manager of Nuclear Technology Section serves as the team leader, and Chief of Nuclear Engineering Subsection is his/her team member and the 1^{st} deputy. Based on the "Reactor Engineer handbook" of SAMG procedure, the Reactor Engineering Technology Assessment Team takes charge of the following tasks: confirming the reactor shutdown, identifying integrity of RPV, identifying evidence of fuel damage and requesting sampling of containment atmosphere for forecasting of radiation release rate.

5. SPDS operator —A licensed operator assigned by leader of AMT. According to the "SPDS operator manual" of SAMG procedure, the SPDS operator takes charge of the following tasks: assessing the control parameters, assessing the operability of instrumentation, and tracking the variation trend of parameters.

When severe nuclear accidents occur, before the arrival of all TSC members, the on-site shift team in Main Control Room can take actions by following the related procedure guidelines of SAG-1/2. After establishment of TSC, AMT starts to operate, the responsibility of accident management and the decision making control will be turned over to TSC together.

6.1.1.2 Possibility to use existing equipment

After Fukushima's accident in Japan, KSNPP followed the four recommendation items of WANO SOER 2011-2 to investigate and take actions. Especially regarding recommendation item 1.a "The inspections on adaptability and availability of the mitigation-equipment used in severe accident" [note], station should comprehensively check the current planned procedures for accident management, including the severe accident management guideline (SAG), the Emergency Operation Procedure (EOP; 500.1~500.16) and availability of required equipment and instrumentation for a loss of spent fuel pool water makeup. The scope of function checking comprises the Reactor water makeup, the Reactor exhaust & pressure control, the Reactivity control, the hydrogen control, the Containment exhaust, the emergency water makeup system of spent fuel pool, the emergency power supply, the Emergency Circulating Water system, the required instrumentation and indication for post-accident management (including ERF and the panel instrument meters) and so on. Besides the systems required to be regularly tested by Technical Specification, other items had been tested or inspected according to their characteristics (active or passive).

The inspection result revealed some weaknesses which had been strengthened later to meet the requirements. (Details are described in chapter 2 and chapter 3 "earthquake/flood" of this report) Afterwards, the related periodic function tests and maintenance to meet those requirements have been incorporated into KSNPP's existing test program.

[Note]: WANO SOER 2011-2 Recommendations:

1. Verify the capability to mitigate conditions that result from beyond design basis events. Include, but do not limit,

1.a Verify through test or inspection that equipment designed for severe accident mitigation is available and functional. Active equipment shall be tested and passive equipment shall be walked down and inspected.

6.1.1.3 Provisions to use mobile devices

When accidents beyond design basis occur, to deal with the loss of AC power supply or reactor coolant, KSNPP has established the procedure 1451 "KSNPP' Ultimate Response Guideline" including several alternative core-refilling approaches. The procedure 1451 "Ultimate Response Guideline" (abbreviated as URG hereafter) provides operation instructions to obtain the following purposes:

1. To maintain reactor core cooling.

2. To maintain monitoring functions in Main Control Room.

3. To assure the integrity of containment and to mitigate the release of radioactive material.

4. To maintain fuel pool cooling and the spent fuel covered with water.

5. To rebuild the rescue facilities in short time and to restore the long-term cooling capability.

The operating procedures of 1451 have been rehearsed and well verified to ensure the operability of its 18 attachments as follows.

URG Attachment 1: The Ultimate Response Process flow-chart for KSNPP. (Figure 6-3)

URG Attachment 2: The Ultimate Response executive condition process and announce & report timing flow-chart for KSNPP. (Figure 6-4)

URG Attachment 3: The Ultimate Response Process flow-chart for spent fuel pool and upper pool of KSNPP. (During plant outage period) (Figure 6-5)

URG Attachment 4: The preparation of resource adaptation for residue heat removal when heat sink loss occurs, including 'the water source, the power source, the gas source, the pipeline arrangement for fill of raw water (fire-fighting water), the fire engine preparation, the water pump driven by mobile engine and the personnel summoning

URG Attachment 5: The operating procedure for water source adaptation of residual heat removal when heat sink loss occurs.

URG Attachment 6: Water source establishment, including on-site normal water source and spare water source preparation.

URG Attachment 7: Refilling of the reactor and suppression pool by means of alternative water source and power source.

URG Attachment 8: Reactor water level control by means of Reactor Core Isolation Cooling (Including manual operation).

URG Attachment 9: Emergent reactor depressurization.

URG Attachment 10: Containment control (including exhaust, heat removal and hydrogen control).

URG Attachment 11: Increase the capacity of heat sink in suppression pool and heat removal.

URG Attachment 12: Power source establishment, Including on-site normal power source and alternative power source.

URG Attachment 13: Protection of spent fuel in the fuel pool.

URG Attachment 14: Protection of upper pool (including reactor-core) during plant outage.

URG Attachment 15: Fuel building exhaust (heat removal, hydrogen control).

URG Attachment 16: Rebuild the rescue facilities in short time and restore the long-term cooling capacity.

URG Attachment 17: Table list of the operation items and the personnel. (Attachment 6-1)

URG Attachment 18: Check list for three stages of Ultimate Response. (Attachment 6-2)

6.1.1.4 Provisions and management of supplies

When an accident occurs and the condition of "the emergency accident alert" is met, the On-Site Emergency Organization of KSNPP is then summoned to establish. According to the procedure 1411 "procedures for the backup service and equipment support", the emergency supply team will provide the backup service and equipment support.

The manager of Supply Section serves as the leader of emergency supply team; some other Subsection chiefs or senior staff will be chosen to serve as his/her 1st ~ 3rd deputy accordingly. Other people of Supply Section serve as team members of EST, and the EST leader should be responsible for the management of backup service and provisions:

- To coordinate backup man-power to support ERO.
- Responsible for the vehicles dispatch, the material supply, emergency materials preparation and purchase, and lodging arrangement for the personnel.
- To update continually the name list of on-site emergency working personnel and meeting place.
- Financial and accounting support.
- To assess the necessity of current and future manpower and equipment.
- To dispatch coordinators to the gathering and on-call spot.
- To collect information of off-site environment (for example, wind direction, adequate transportation route).

- To submit request for backup support to related government organizations.
- To provide manpower support for communicating work among Emergency Teams.

When the consequences of accident deteriorates continually, according to the Emergency Operation Procedures, TPC will establish Nuclear Emergency Preparedness Executive Committee, or it depends on the accidental severity to establish the Central Disaster Response Center by the government to provide the following necessary support and assistance.

6.1.1.5 Radiation release management and radiation confining preparation

Once severe accident occurs, the management of radiation releases and the preparation of limiting radiation of KSNPP could be divided into two portions, radioactive gas release and the radioactive liquid release, which are described as follows:

1. Gaseous release

   A. Normally, when accidents occur, the primary containment will enclose the radioactive substance to treatment system through automatic isolation function to guarantee that the off-site radiation dosage (Off Site Dose) will not exceed the requirement of 10CFR 100.

   B. According to EOP SC&RR (procedure 500.6), when plant boundary radiation level reaches 0.02 mSv/hr after an accident, the related ventilation and primary systems which release to containment and auxiliary building shall be isolated. When the conditions of severe accident set in SAG-2 “secondary containment / radiation release”, are met; the radiation level at the exhaust of auxiliary building exceeds 0.15mSv/hr (corresponding to Noble Gas channel: approximately 5.87×10^{5} CPM), confirm that HVAC has been isolated and startup SGTS (Standby Gas Treatment System).

   C. During the process of emergency operation, if containment is subject to high pressure, high hydrogen concentration, or containment is unable to withstand the RPV energy eruption so that containment might be possibly failed (capability to suppress pressure). According to EOP/SAG, primary containment exhaust must be forced to initiate (operation steps as detailed in 500.14 procedure) to guarantee the integrity of primary containment, and to prevent a massive release of the radioactive gas to outside of the containment beyond control.

   D. When the gas purge/exhaust system of containment is anticipated to fail owing to power loss after sever accidents. According to the planned URG attachment#10 “containment control (including off-gas, heat removal, and hydrogen control)”, the inner motor-driven isolation valve of primary containment will be opened in advance and the power source will be turned off before power loss. Since the outboard isolation valve of primary containment is air-driven, and it can be operated by using backup Nitrogen Gas Cylinders or manually to both maintain the integrity of primary containment and to avoid causing the massive release of radioactive gas beyond control. Due to the importance of SGTS's normal operation during accidental periods, its power source supply is the first priority to restore in order to maintain the capability of containment exhaust and filtration function. (The enhancement program of electric power is described as detailed in chapter 5 of this report).

2. Liquid release

A. There are three possible paths of radioactive liquid release as follows:

(1) Damages and leakages of Auxiliary Condensate water Storage Tank (ACST); located outdoors above ground, its maximum volume is approximately 1325 cubic meters, radioactivity concentration approximately 2.2×10^{5} Bq/m^{3}.

(2) Spent fuel pool located at the ground floor of independent fuel building, the damages and leakages could cause a drop of water level, while the leaked water would only spread within the two floors under the pool. The water makeup for the pool could be easily obtained after accidents. The radioactivity concentration of fuel pool water is approximately 1.0×10^{7} Bq/m^{3}.

(3) At the worst situation of loss of coolant, cracks could happen in primary containment, or piping penetrations could damage, or pipe breaks could lead to reactor water drainage to the first or second floor of auxiliary building. In case of a release, the emission concentration and volume of water could be reasonably assessed by observing leakage of pipeline and the radiation trend through water level variation of Sumps.

B. The possible paths of the radioactive liquid release

The accidents could cause release of the radioactive substance from its normal path. At first it could flow into sumps of plant building and then overflow afterwards. The worst case is that the water floods up the first to second floor of the building and then it further overflows outside the plant building. Moreover, it will flow into the rain-water drainage, or it will penetrate into the sea-water piping tunnel under ground, and both the above will flow into the sea.

C. Affected range

(1) The worst condition is that the release will affect the 1 ~ 2 floors underground of entire plant buildings.

(2) The rain-water drainage outlets of KSNPP (approximately 100 meters from KSNPP).

(3) The sand beach outside KSNPP (approximately 4 km wide with KSNPP in the middle).

D. Response program:

(1) To notify the Emergency Radiation Survey Team to carry out radiation detection and water-sampling and analysis for contamination verification.

(2) In case that radwaste water flows out the plant building is detected:

- To notify the re-entry team members to enclose the waste-water by sandbag.
- To dispatch the re-entry members to evacuate the contaminated water by using the fire engines/waste-water containers and transport to the plant building for handling (the storage capacity: 1000 liquid waste containers and 200 normal containers altogether may accommodate 408 cubic meters; If necessary, the bottom space of turbine building underground is estimated approximately 30,000 cubic meters, may be selected as the temporary storage space).
- To dispatch the Emergency operation backup team to investigate the source of leakage.

(3) To dispatch the Emergency re-entry members to block the leakage or repair the damage.

(4) To report to the Emergency Execution Commission and the central disaster response center, if necessary, central disaster response center should communicate with radiation detection center to consider dispatching specialists to site for further surveillance.

6.1.1.6 Communication and information systems

1. The satellite telephone set with battery standby time 48 hrs, main station located in TSC building, one handset kept in the Main Control Room and is powered by 120V AC. Regular function test is carried out every month.

2. The PA Broadcasting system with power supplied by UPS 1/2YE. When plant blackout occurs, battery bank 1/2DE will continue maintaining the function need of Pager system.

3. The internal telephone system of KSNPP comprises of the self-maintained landline system, the mobile PHS radio system, and TPC self-built long-distance microwave communication system. The base stations are all located at the first administration building. When the plant blackout occurs, self-sustained battery could last 10 hours for operating needs.

4. The external telephone system at Kuosheng is provided by telephone company CHT. No extra power source is needed for making phone calls as long as the telephone lines are well maintained

by CHT.

5. Portable walkie talkie handsets with batteries are available among TSC and each support center, the fire-fighting on-site team, the Simulation Center control room and the Main Control Room.
6. The information transmission system is mainly comprised of computer networks and soft wares to carry out data and video transmission. The network could utilize TPC self-built long-distance microwave telephone line and CHT ADSL system. The battery can support the information transmission system to operate continuously for 10 hrs.

6.1.2 Possible disruption with regard to the measures envisaged to manage accidents and associated management

As compared with Fukushima 1st plant before the accident, there are five additional designed advantage of protection for TPC's nuclear power plants as follows：

- The emergency cooling water pumps in Fukushima 1st plant are in the open area, Kuosheng has building protection for them.（emergency circulation water pump house）
- The emergency diesel generators in Fukushima 1st plant 1 ~ 4 unit are placed at the bottom level of turbine building, Kuosheng's EDGs are installed in the seismic 1 class ground level building. The flood proof capability is superior.
- There is no 5Th gas cooled diesel generator in Fukushima 1st plant, Kuosheng's is built in a ground level building. The 5Th gas cooled diesel generator can offer emergency backup electricity when cooling water is unavailable for original emergency diesel generators.
- There is no gas turbine generator in Fukushima 1st plant. Kuosheng owns two units at an altitude of 22 meters above sea level. Gas turbine generator can offer emergency backup electricity when cooling water is unavailable for emergency diesel generators.
- There is no raw water reservoir in Fukushima 1st plant. Kuosheng has two raw water reservoirs at elevation 90 meters above sea level. The capacity of raw water is around 37 thousand tons and water can be injected into reactor via gratuity.

After Fukushima's accident, TPC nuclear power plants have established procedure 1451 "Ultimate Response Guideline". The procedure utilizes extra resources including mobile power supply with vehicles, mobile diesel generators, extra water sources, etc.

6.1.2.1 Extensive destruction of infrastructure around the installation including the communication facilities

1. Countermeasures to the access difficulty of Off-site supports

KSNPP' Emergency Preparedness and Response Plan (1400 series procedures), has already precisely specified the tasks, responsibility and personnel-mobilization procedures for each unit of emergency control task-force, including on-duty shift and the Emergency operation backup team. Moreover, a further review and strengthening program on the emergent response manpower when event occurs in "normal" or "unusual" work-time interval has been carried out as follows:

A. The event occurs during the "normal office hours

(1) If the operation shift personnel are unable to arrive at the power plant to take over, there is training shift manpower in the Simulation Center, and approximately ten operators at mobile supporting shift (most of them are licensed), they can take over and assist the operation of the units.

(2) The maintenance man-powers of each department are all at site, additionally there are long-term contractors working at site, the maintenance manpower could reach around 100. This should be enough to meet the requirement of equipment maintenance under emergency case.

(3) On-site fire-fighting team consists of 8 people on-duty at daytime shift, while during theoffice hours, according to the emergency plan organization, there are 48 emergent backup fire-fighting members at site, they could assist the emergency task.

B. The event occurs during the "non- office hours":

(1) Investigation shows that there are around 48 peoples living in the off-duty dormitory at site (including operation section), and these people will be first informed to assist the reactor operation work. Besides, there are 14 people who work as shift operators living in the neighborhood area including Chin-Shan, Wan-Li districts. They can get to site relatively easily to assist operation work before the arrival of next-shift staff.

(2) Investigation shows that the number of maintenance personnel (Mechanical Section, Electrical Section, Instrumentation and Control Section, Machine Shop Section) living in off-duty dormitory at site is around 24, and they will be informed to join the emergency equipment-repairing work at the first place. The number of other

maintenance personnel living in the neighborhood including Chin-Shan, Wan-Li districts is around 23, and they will be informed as well to get to site to assist in emergency repairing work. Besides, there are many skilled maintenance subcontractors living in Chin-Shan, Wan-Li districts (the names are listed in procedure 1408 and 1409). With the emergency repairing items described in the maintenance contract, they are obliged to dispatch skilled workers to support the emergency repairing work.

(3) The current fire-fighting team are contracted workers, 8 persons per shift at site is required for off-duty hours. As all fire-fighting personnel are residents of Chin-Shan district, and they can be recalled to site when urgency occurs. Besides, the plant-resided security police officers can also assist the rescue matters.

(4) If roads surrounding the plant are obstructed, KSNPP will request for military sappers' support for recovery from government' authority "the Central Disaster Response Center", or request for helicopters to carry personnel, materials and devices for repair as well as emergent delivery of personnel for medical care.

2. To utilize external technical support for accident management

In response to the possible compound disasters, KSNPP has prepared a three-stage check list corresponding to relative on-duty shift team in URG appendix 17 & 18. At stage 1, the specified working items shall be completed by plant personnel within 1 hour, including the reactor depressurization, the alternative core-refilling source, recovering electric power of important system/instrument by using mobile power source, etc. This prevents the accident from deteriorating at the first place and gets an effective control of the damage. If the roads surrounding the plant are blocked, which hinders the access of external supports, the working team has been divided into 2~3 sub-groups according to KSNPP' Emergency Response Organization , which will work in turn to carry out emergency operation and rescue operation by standby backup resources.

The time slots for the 2nd stage and the third stage work items (the URG appendix 18) are within 8 hours and 36 hours after accidents respectively. At the two stages, members of emergency response organization have been recalled, and the fore-mentioned staff from off-duty dormitory at site, the subcontractors from Chin-Shan, Wan-Li districts arrive gradually. The comprehensive restoration and rescue operation will then continue in full scale. In addition, according to the need of rescue operation, the request for large-scale machines and tools and the manpower support will be submitted to Nuclear Emergency Preparedness Executive Committee. NEPEC will assign the skilled manpower and conduct the physical resources supported by entire company t for mitigation of the accident damage. If necessary, "the Central Disaster Response Center" will dispatch military sappers to rebuild the temporary bridges and roads or utilize helicopters to carry specialists, commodities and other resources for urgent repair work, as well as the delivery of wounded personnel to hospitals, etc. The long-term safety management from all aspects will be well under control.

3. The possibility to use the existing equipment

The design capability of the KSNPP' major safety systems are designed as seismic category 1, and they are constructed at the altitude of 12 meters above sea level to prevent against possible malfunctions induced by natural events (earthquakes, Tsunamis, heavy rains and so on). The related self-assessment and enhancement programs are detailed in other chapters of this report. Based on the Fukushima's accident, KSNPP has carried out the assessment of "Total physical examinations on nuclear power safety protection of power plant". The existing mobile disaster rescue equipment of KSNPP used for accidents has been further upgraded by the additionally prepared mobile equipment after Fukushima's accident. By following the instructions of AEC and TPC from results of "Nuclear energy comprehensive physical examination" (As detailed as Attachment 2-6 of chapter 2 "The existing disaster rescue equipment" and Attachment 2-7 "Disaster rescue equipment to purchase in response to Fukushima event"), the related facilities/equipment have been well prepared to store in places more unlikely subjected to disaster damages. When accidents beyond design basis occur, plant personnel could rapidly respond to achieve the goal of the emergency rescue operations.

4. Communication enhancement plan on-site and off-site

A. Satellite telephone main station: If plant Blackout event occurs, TSC diesel generator will start to provide power automatically. If the TSC diesel generator fails, KSNPP has prepared another small-sized gasoline generator to provide the power source of satellite telephone before the TSC diesel generator is restored.
B. PA broadcasting system: In case the electric power of battery exhausts, the additional external power source can feed into 1/2B3 or 1/2B4 to get the 1/2DE battery charger working and the 1/2DE buses can restore the function of PA broadcasting system.
C. The KSNPP's landline telephone system, PHS telephone system and TPC self -built long-distance microwave communication system: When the Plant Blackout occurs, self-sustained battery may provide 10 hours power for continual operation of the three internal telephone systems. Moreover, OSC diesel generator has been improved to be a backup of the power automatically so the continual communication could be maintained.
D. Website Network information system: In case the plant Blackout occurs, OSC diesel generator will automatically start to provide power continually to the communication system via computer network and website. Besides, the CHT ADSL is powered by external sources; the information transmission is available as long as its wiring integrity is maintained by CHT.

[Note]: The related enhancement plans on power source are described in the chapter 5.

6.1.2.2 Impairment of work performance due to high local dose rates, radioactive contamination and destruction of some facilities on site

1. The rescue operations regarding the plant facilities (including spent fuel pool) are mainly managed in Main Control Room. The functions of indicators and equipment from related safety facilities will not be affected by radiation contamination. However, if the compound disaster causes malfunctions of the normal safety system at local sites under high radiation backgrounds, and the plant personnel must get to the affected area for urgent repairing, or carry out the URG instructions and put mobile facility/equipment into service, then the radiation-protection techniques must be prepared as follows:

    A. Before carrying out the emergency repair work, the Health Physicists should survey in advance to collect information about the radiation level, contamination condition and the concentration of radioactive substances in air.
    B. To plan the radiation-protection measures according to the site radiation condition:
        (1) Evaluate the feasibility of installing the radiation shielding on site to reduce the site radiation background and the dosage absorbed by staff can be reduced.
        (2) Provide the effective radiation-protective equipment such as radiation-protective suit, breath-protective mask, and the lead clothes, etc. If necessary, instruct the repairing personnel to wear proper items of radiation-protective equipment.
        (3) Calculate the longest permitted working time of workers, and when necessary carry out the timing control process.
    C. Provide 1 dosimeter (EPD) with alarm function for each repairer, and inform them of leaving the site when alarm goes off to avoid the dosage exceeding acceptable limit.
    D. Establish the Area Radiation Monitor (ARM) at the working site to provide repairing personnel with instantaneous radiation information, and once the site radiation increased without reasons, the evacuation must be carried out immediately to protect the personnel's safety.
    E. After leaving the working area, the repairers must get to the assigned location to receive the radiation surveillance, to assure no external contamination exists.

2. When the Main Control Room is possibly contaminated, prepare plans to improve habitability in Control Room, including arrangement of personnel entrance and exit :

    A. Regularly execute the detections of radiation, contamination and radioactive air concentration in the control room.
    B. Plan the radiation-protection measures according to control room radiation condition:

(1) Evaluate the feasibility to install the radiation shielding for reducing the exposure rate of on-duty shift operators.

(2) Provide the necessary radiation-protective equipment such as radiation-protective suit, breath-protective mask, and the lead clothes, etc. When necessary, instruct on-duty personnel to dress on each item of radiation-protective equipment.

(3) Evaluate the longest working time of on-duty personnel, and when necessary carry on the time control.

C. Install the doorframe detection for personnel contamination in the proper location to assure no contamination exists on the personnel leaving after work.

3. The process procedures for off-site rescue teams entering the radioactive area/contaminated zone:

The Procedure for offsite rescue team to enter contaminated area:

A. According to KSNPP' procedure 1426 "The operating procedure of coordination supports from outside to the plant", TPC's NEPEC (Nuclear Emergency Preparedness Executive Committee) will conduct the entire company man-power, materials to support and handle the emergent accident. After NEPEC assists the resources to finish the emergency entry process to site, the command power to launch the emergency repair work is handed over to support center director. He/She will assign members to register the supporting personnel into the on-duty name-list of KSNPP' emergency work team according to their specialty so that they can join the emergency repair team to carry out the emergency repair work.

B. According to KSNPP' procedure 1419 "The re-entry procedure", the emergency re-entry team leader and emergency radiation-detection leader should work together to plan or arrange the suitable sequences of re-entry emergency repair work according to the task characteristics and the emergency status. Before the re-entry actions, emergency radiation-detection team chooses the proper detection instrument first and dispatches members to detect along the route from entrance to exit including the radiation level, air borne, and contamination status in the working area. After obtaining the radiation information of the scene, the emergency radiation-detection team should determine the work time limit for the re-entry personnel and prepare other necessary arrangements. If necessary, when the worker will receive a dose rate higher than the standard limit, it is necessary to get authorized by the plant Emergency Control Team leader, and to inform the re-entry personnel of the radiation level, air borne status, contamination conditions of the site as well as the possible exposure dose he could receive and the related radiation-protective requirements he must follow. When entering the controlled area, both the radiation detection team member and the re-entry worker should carry the auxiliary dose rate alarm, proper TLD Badge and dressed on adequate protective clothes and equipment.

C. When the radiation level of the site is too high, raise the authorized individual dose limit temporarily within the regulated value. When it is necessary, swap the workers to meet the regulation requirements.

D. Regarding the support man-powers who have never been trained with radiation-protection courses, KSNPP has already examined and proposed the related radiation-protection enhancement mechanism.

(1) If the situation permitted, it is still requested that the personnel be incorporated in KSNPP' emergency work team and carry out the emergency repair work according to duty grouping based on current procedures, .

(2) When specialists need to enter the high-radiation area to do urgent repairing, considering the emergent situation of rescue effectiveness, those who are unable to incorporate into the team have been described in the procedure 1414, which mentions the HP(Health Physics) Section assigns the HP personnel to inform them of the regulations about emergent exposure, the risks of radiation exposure and the radiation-shielding condition of the scene, etc. in place of the training class required by regulation. After obtaining agreement of the person concerned, the HP personnel should accompany with the specialists to the work site for urgent repairing, and providing support instructions about the related radiation-shielding at any time. The name-list of accompanied HP personnel has been established since June 3rd 2011. .

(3) Before the rescue teams entering the radiation-controlled area, they should bring TLD badges and the auxiliary dose meter with alarm functions under the conduction of HP personnel. For each member of rescue team, they should know the instructions about the wearing of related radiation-shielding clothes and use of related radiation-shielding equipment, etc. During the emergency accident, the spare parts and the detailed lists about inventory of the related radiation-shielding clothing, TLD badges and the dosimeters for supporting the repairing work have also been prepared since May.31, 2011.

6.1.2.3 Feasibility and effectiveness of accident management measures under the conditions of external hazards

The capability of KSNPP' major safety systems are designed as seismic category 1, and are constructed at the height of 12 meters above sea level so that it could sufficiently prevent from the cases of function loss caused by the anticipated natural disasters. (Earthquake, Tsunami, heavy rain, etc.) Based on Fukushima's accident, KSNPP has further carried out the assessment "The total physical examinations on safety protection of nuclear power plant", accomplished the self-evaluation on the events beyond the design basis, finished the corresponding improvements for the plant's insufficiencies, and also established the procedure 1451 "Ultimate Response Guideline for facility".

1. Effectiveness: Besides the strategy considered in EOP/SAG to take actions by accident indications with assessment gradually, another strategy has been applied at Kuosheng site according to “Ultimate Response Guideline for facility” is to take explicit actions and bring damages to an end in a short time, which shows the bound-and-determined mind for avoiding the accident worsened to achieve the safety protection of the general public.

2. Feasibility: As fore-mentioned “Possibility to use existing equipment”, KSNPP has been equipped with satisfactory mobile rescue equipment. With the additional mobile equipment further established to meet the potential insufficiencies discovered by “the nuclear comprehensive physical examination” after the Fukushima’s event. The related equipment/facilities have been properly stored at places where are not liable to be damaged by compound disasters. When accidents beyond design basis occur, it could be rapidly accomplished to achieve the goal of URG by the plant personnel following URG guidelines.

3. Validity: Based on all assessment results, KSNPP‘s URG has considered the idea of defense in depth as well as the strategy of diversity and redundancy (e.g. various options of water source, electric power, gas source, etc.). The validity of Kuosheng’s rescue action capability has been assured in response to compound disasters.

6.1.2.4 Unavailability of power supply

In response to the Fukushima event, KSNPP has carried out the review of power supply capability and the enhancement plan, as detailed in chapter 5 of this report ' Loss of power source and the Ultimate Heat Sink'. It is assured that KSNPP has redundant electric power supply, by which the goal of maintaining long-term core cooling could be achieved to avoid fuel damage under the situation of accidents.

6.1.2.5 Potential effects from the other neighboring unit(s) at site

Regarding the situation that both units are affected by the compound disaster at the same time, the discussions are divided into four aspects as follows:

1. The discussion on mutual supports among Equipment:

   After Fukushima accident occurred, KSNPP has carried out “The total physical examinations on safety protection of nuclear power plant”. One of those examined items is “The responding measure of mutual support between No.1 unit and No.2 unit”, with aims at the aspects of (1) condensate and the related system, (2) sea water system, (3) Essential Bus system, (4) Compressed air and the steam system, (5) others, KSNPP has already assured the associated measures about the existing mutual-support equipment, as well as the verifications of accident-mitigations and rescue-functions:

A. Condensate water and related system
   (1) The mutual support of Auxiliary Condensate Storage Tank (ACST)
   (2) The mutual support of Condensate storage Tank system (CST)
   (3) The Auxiliary Dematerialized water Storage Tank system, (DST/ADST) may provide makeup water to the CSTs of unit 1 and unit 2 by means of water pumps.

B. Sea Water system
   (1) RHR BOOSTER PUMP, pumps the water from external circulating water, and provides water to the RHR heat exchanger to remove heat.
   (2) ECW A/B LOOP, mutually support RHR heat exchanger of the other unit with cooling seawater by pipeline rearrangement.
   (3) The external circulating water (opening connection valve for use), may provide cooling water for TPCCW and NCCW.

C. Essential Bus system

   The 5th diesel generator may simultaneously supply power to A3/A4/A5 bus of two units by manual control (500.15 procedures has been revised). Moreover, it has been arranged that DIV Ⅰ/DIV Ⅱ/DIV Ⅲ EDG of two units can mutually support to each other. (Procedure 500.15, PCN has been already issued).

D. Compressed Air system
   (1) The instrument air system can be supported by the off-site air compressor.
   (2) The Compressed Air system of unit one and unit two can activate connection valve of Pressurized Air Storage Tank located at the 1st floor of control building to achieve the mutual support.

E. Others
   (1) CRD system: support another unit by connecting the outlet of water pump.
   (2) Hydrogen Recombination system: The Hydrogen Recombiner equipment can be transported for another unit’s use.

2. Regarding the equipment mentioned above, KSNPP also carries on the following enhancement plan after total physical examination:

A. KSNPP has completed the modification of DCR to drill a 6-inch hole with a removable cover on the existing manhole-cover on top of the CST of each unit. Thus, the water in CST of each unit can be collected by engine-driven pumps and delivered to CST of another unit. Other water sources can also fill into CST through the hole, and then deliver to the systems in need of water makeup.

B. Replace the Drain of ADST and DST by the quick adapter type connector which can plug into the fire hose, and deliver water from DST/ADST to the CST of each unit.

C. The power source enhancement plan, including the fifth EDG power supply for two units, the DIVⅠ/DIVⅡ/DIVⅢ EDG mutual support for two units, the essential power supply generated from two gas turbine associated 4.16kV/1100kW diesel generators , connection of two 480V/200kW diesel generators of TSC/OSC to the LC 1B3/2B3, purchase four 480V/200kW mobile diesel generators and enhancement on 4.16kV/1500kW diesel generator power supply vehicle, which are all described in details in chapter 5 of this report.

D. Compressed air system portion: KSNPP has additionally purchased a mobile diesel-engine-driven air compressor, which can movably provide high-pressured air for two units.

3. Assessment on manpower arrangement of shift operation :

A. Except for few personnel posts at local site such as pump house or switch gear room, most of the shift operators of both units stayed at the common main control room and the standby area next door to it. The manpower resources are controlled under one shift manager and the mutual support exists between the independent supervisors of 2 subsections for 2 units so that the man-power can be arranged in the most effective way.

B. The equipment of both units adopts identical layout arrangement; therefore the manpower mutual support between units is easier, especially for the most critical system's operation.

C. During the refueling outage of any unit, normally one team of shift operators is scattered to other teams and one person from each team is selected to support outage work. Therefore the shift personnel can have experiences of different posts. Once the accident occurs they can support each other for operation needs at different posts.

D. The normal training for operators of both units adopts the same standard, and the personnel of both units can support mutually without difficulty.

4. Enhancement on man-power mobilization:

KSNPP has checked the number of staff residing at site or in the neighborhood, re-inspected the emergency plan mobilization program, test and drill plan, and enhanced the effectiveness and efficiency of man-power mobilization. Besides that the procedure 1406 “the procedure of emergency organizations mobilization”, which has established the mobilization name list of emergency response center, the procedure 1408 “OSC mobilization and response procedure” and the procedure 1409 “HPC mobilization and response procedure” have also been revised and incorporated the related supporting man-power name list in response to the situation when repairing man-power is not enough and the need from off-site support is required. Besides, the name lists mentioned above are incorporated into the name lists of backup re-entry team of operation support center, health physics center and off-site subcontractor support team, and they can be requested to assist the emergency repairing work if necessary. Due to the same layout arrangement of both units, manpower resources can support mutually, and as the maintenance operation trainings include diverseness between two units, so the personnel dispatch will not be affected by unit’s differences.

6.2 Nuclear power reactors

6.2.1 Loss of core cooling: Accident management measures currently in place before occurrence of fuel damage in the reactor pressure vessel

When loss of core cooling occurs, the plant personnel will immediately carry out the reactor control to maintain the core covered with water via alternative water injection system or sub-system (including fire water system) according to the plant’s emergency operating procedures EOP (500.3~500.16). Therefore, the reactor water level L3~L8 can be maintained to avoid fuel damage. (The purpose of EOP is to avoid the accident worsened to the extent that reactor core fuel is melt.)

In case that the plant suffered from the compound disaster beyond the design basis due to earthquake and tsunami or the condition of loss of ECW and all AC powers (on-site or off-site), in accordance with the URG procedure 1451, the plant shall take prompt actions including preparation of each kind of alternative water injection path, backup power and water sources as well as to mobilize all available manpower and materials to line up all the available water sources in the shortest time. When judging that the designed core protection system and cooling functions can’t be restored in a short time, the decision will be made to inject the available backup water to reactor to ensure that core fuel is covered with water to avoid fuel damage.

6.2.1.1 Preventive actions to prevent fuel damage

When loss of core cooling occurs, besides the above-mentioned EOP actions of water injection, the plant shall simultaneously carry out reactor pressure control (RC/P) till the reactor pressure lower than 9.34 kg/cm^2 (if necessary, it can exceed the limit of 55℃ temperature step-down rate) in order to avoid fuel damage in the condition of core high pressure.

In case that the plant suffered the accident beyond design basis and any unit lost its on-site and off-site AC power or reactor water makeup function, the plant should take actions to maintain core cooling via RCIC(URG attachment 8) and to control reactor pressure (by manual operation if necessary) in order to depress the reactor pressure to 15 kg/cm^2 (if necessary, it can exceed the limit of 55℃ temperature step-down rate) in accordance with the URG attachment 9 “Emergent reactor depressurization". When the alternative water injection preparation as described in the URG attachment 7 is ready, and the pre-planned water sources shall be injected to reactor in coordination with SRV emergency pressure relief to ensure that core fuel is covered with water to avoid damages.

6.2.1.2 Risks of cliff edge effects and deadlines

In case that KSNPP lost all both on-site and off-site AC power and reactor water makeup, reactor water level can be maintained via RCIC which is designed operable with 8 hours DC power supply(24 hours operable if DC power supply with unnecessary consumption off-loaded). After the failure of RCIC, when core fuels are uncovered with water, it could lead to severe consequences of fuel degradation which is general called cliff edge effect.

The Institute of Nuclear Energy (INER) committed by TPC Safety Department assess the risks of cliff edge effects and deadlines with MAAPs. Under the conservative assumption, it is supposed that RCIC is failed after 8 hours & 24 hours so as to result in loss of core water makeup and cooling. The calculation result is described as follows:

RCIC keeps operation for 8 hours:
The time of core water level drops to TAF (top of active fuel) is 2.23 hr.

RCIC keeps operation for 24 hours:
The time of core water level drops to TAF (top of active fuel) is 3.24 hr.

After Fukushima's Accident, Kuosheng has established Ultimate Response Guide after reviewing equipment status of the plant. For the scenario mentioned above, e.g., earthquakes, tsunami, combined natural disaster beyond design basis, or loss of ECW system as well as loss of off-site power, the staff of the plant can follow URG (attachment 12) to establish normal or alternative power source (including 5^{th} DG, Gas Turbine Generation, or backup mobile diesel generators stored at a higher warehouse) and to provide long term operation power needed by RCIC. Depending on plant's actual situation, alternative makeup water source can be prepared (URG Attachment 6). When reactor is depressurized (URG Attachment 9), alternative makeup water can be injected into reactor (URG Attachment 7) to maintain water level in reactor core, cliff-edge effect could be prevented.

6.2.1.3 Adequacy of the existing management measures and possible additional provisions

Considering the experiences in the Fukushima's accident, the facilities designed for mitigation of severe accident can be inoperable at the same time or gradually. The existing plant facility/preparedness capability has been reviewed and enhanced for coping with the accident beyond design basis.

Compound disaster is a kind of full-scale impact and not limited to a single threat of the containment integrity. The timing effectiveness of management for compound disaster is very urgent and the existing judging and treatment process of EOP or SAMG isn't enough to cope with the worsening scenario of accident. In order to cope with the situation of compound disaster, TPC already prepared the ultimate response guidelines (URG) for plant to follow on the site-specific basis. All of the defense facilities or water sources may lose their functions simultaneously. Therefore, TPC programmed to incorporate all available resources and measures into URG based on the redundant, diversity and independent defense-in-depth strategy, including the mobile power, water, and air sources. Its mobility and management of timing effectiveness is emphasized to correspond with each kind of compound disaster condition.

According to the analysis results via Three Dimensional Two-Phase Thermal-Hydraulic Model(REAP5-3D), in case all water makeup system are lost and RCIC continuously control reactor pressure and water injection failed after three conditions of operation(1 hr,4hr,8hr) 【Learning from Fukushima event experience, the units which have RCIC system were all operable in initial stage（unit 2 and unit 3 had operated 40 hours and 20 hours respectively）. Based on conservative consideration, KSNPP has added 4- hour and 1-hour assessments besides original 8-hour case, and the URG successful injection water inventory is based on the worst 1-hour result. This is a very conservative assessment.】According to the analysis results via Three Dimensional Two-Phase Thermal-Hydraulic Model(REAP5-3D) and considering the reasonable process of URG, the URG water injection to reactor after reactor emergency pressure relief is sufficient for the required individual flow (645gpm(1hr), 530gpm (4hr), 475gpm (8hr)) to avoid fuel clad reaching the temperature 1500 ℉ at which hydrogen generates.

This criterion is simulated at the fire hydrant connected to the inlet of fire water pipe located at the entrance of building to measure the water injection flow via gravity from raw water reservoirs on the hill side. The flow is calculated with cross section of 4" fire pipe in consideration of reactor back pressure and friction loss. The calculation result shows that the flow can reach 808gpm that is more than the required flow 645gpm for RCIC operation only 1hr of the most conservative case.

In order for the plant to response compound disaster condition, the plant already mapped out the shift personnel arrangement and three phase check list as shown in the URG attachment 17 & 18. The related items including reactor pressure relief, alternative water injection, and the required power for essential systems and instrumentation control via mobile power source in the first stage shall be independently completed by the plant manpower within 1 hr so that the accident can be first time effectively controlled to avoid worsening. Therefore, the plant URG measures can be ready before occurrence of the cliff-edge effect of fuel damage and each kind of water sources is prepared to inject water to reactor to ensure that core fuel is covered with water and the cliff-edge effect of fuel damage will not occur.

After the execution of URGs, the fuel in reactor can be covered by water and RPV integrity can be guaranteed, containment failure and emergency evacuation of the public is not going to happen.

6.2.2 Loss of cooling: Accident management measures currently in place after occurrence of fuel damage in the reactor pressure vessel

6.2.2.1 Mitigation measures

If there is any damage found on the core fuel, the plant shall follow URG to timely restore the core water level to prevent core fuel from further damage. Meanwhile, the plant shall carry out the evaluation of each kind of contingency and proposed actions under various conditions (RC/F-1 ～ RC/F-7)in coordination with Severe Accident Management Guideline (SAMG) so as to achieve the goal for termination of fuel degradation. Moreover, the availability of containment integrity can be continuously maintained and the possibility of radioactive materials release is mitigated because the URG & SAMG cover the control measures including containment pressure, removal of hydrogen and residual heat.

Furthermore, the plant's overall program for ultimate response guideline covers all alternative water injection measures, mobility of all possible manpower and resources that can ensure that core is covered with water and possibility of fuel damage is reduced, and it can further assure the integrity of reactor pressure vessel. The plant can inject water to reactor / containment to ensure that core fuel with melt residue is long term covered with water and fuel continuous degradation is terminated.

6.2.2.2 Risks of cliff edge effects and deadlines

Under the requested of TPC Safety Department, The Institute of Nuclear Energy (INER) has assessed the risks of cliff edge effects and deadlines with MAAPs .Under the conservative assumption, it is supposed that RCIC is failed after 8 hours & 24 hours so as to result in loss of core water makeup and cooling. The calculation result is described as follows:

RCIC keeps operation for 8 hours:
The time of core water level drops to TAF (top of active fuel) is 2.23 hr.

The time of pressure vessel loss of its intended function: 9.79 hr.

RCIC keeps operation for 24 hours:

The time of core water level drops to TAF (top of active fuel) is 3.24 hr.

The time of pressure vessel loss of its intended function: 13.4 hr.

6.2.2.3 Adequacy of the existing management measures and possible additional provisions

The required DC power for RCIC operation to relieve reactor pressure and water makeup can be maintained for 24 hours after isolation of partial unnecessary loads per plant's procedure (If necessary, it can also be manually operated). Besides, water can be continuously injected to reactor by means of various water sources in a short time in accordance with URG as described in section 6.2.1.3 to ensure that core is covered with water and possibility of fuel damage is reduced.

If there is any damage found on the core fuel, the plant shall follow the programmed measures in URG to carry out the first stage water injection measures item by item per check list so as to ensure that core is covered with water again and the possibility of fuel damage is reduced. Moreover, the plant shall complete the second stage measures including setup of the required system DC & AC power supply within 8 hours. Activation and preparation shall be completed within the check time as in each stage check list so as to further ensure the integrity of RPV.

Because the containment is designed that the dissoluble radioactive substances can be purified in advance by way of suppression pool cleanup and fission product can be limited in the containment by way of the containment enclosure capability, the plant shall re-setup the system function of Standby Gas Treatment System (SGTS) to mitigate the release condition of radioactive substances via URG power restoration measures in case that the radioactive substances may be released from damaged fuel. Furthermore, the risk of hydrogen control is described in the following section in case that Zirconium water reaction occurs to produce hydrogen whenever loss of adequate cooling.

In response to the fuel damage condition, the plant shall continuously carry out the URG rescue measures and initiate severe accident management (SAG). The plant's Accident Management Team (AMT) shall take actions of optimized rescue operation to each kind of accident conditions (RCF/F-1 ～7) in order to achieve the goal of termination of fuel degradation.

6.2.3 Accident management measures and installation design features for protecting containment integrity after occurrence of fuel damage

6.2.3.1 Management of hydrogen risks (inside and outside the containment)

The plant's EOP & SAG which are programmed with the related response measures for containment hydrogen concentration control (PC/G). Besides that hydrogen igniter and hydrogen recombiner shall be started to reduce containment hydrogen concentration, containment exhaust (if necessary, it is allowed to exceed radiation release rate) or containment core spray shall be started to reduce containment pressure and hydrogen concentration depending on the plant condition so as to secure the containment integrity.

In case that accidents beyond design basis happens and it is anticipated any unit will lose its off-site and on-site AC power, the plant shall follow URG attachment 10 "Containment pressure control" to open containment exhaust system related isolation valves【to open the motor operated valve in the containment in advance (to open after power restoration in case of power loss)and then to open the air operated valve outside the containment 】 in order for containment connected to atmosphere to reduce hydrogen concentration in order not to cause hydrogen explosion by way of containment pressure relief and containment exhaust.

Besides, in order to avoid hydrogen accumulated in the secondary containment, the long shape door located in Auxiliary Building 7F and air intake shutters (GL-HV-167A/B, GL-HV-168A/B) in Auxiliary Building shall be opened to release hydrogen to outside the building in order to prevent hydrogen accumulated in the secondary containment or hydrogen explosions.

During the plant emergency rescue process, besides the reactor water makeup as per URG to avoid hydrogen continuously produce, the required power for hydrogen control system is also the first priority item in URG. Once the plant power is restored, hydrogen igniter and hydrogen re-combiner shall be started to reduce hydrogen concentration and prevent hydrogen explosion.

6.2.3.2 Prevention of containment overpressure

KSNPP containment is designed to have suppression function that the exhaust steam from SRV / RCIC is condensed by suppression pool to mitigate containment pressure rising condition. Besides, containment pressure can be effectively reduced by means of containment core spray and containment exhaust (if necessary, it is allowed to exceed radiation release rate) as per the plant's EOP and SAG "Containment pressure control measures (PC/P)"

In case that the accident beyond design basis occurs and it is anticipated that any unit will lose its off-site and on-site AC power, the plant shall follow URG attachment 10 "Containment pressure control" to open containment exhaust system related isolation valves in order for containment connected to atmosphere to exhaust containment and reduce containment pressure to prevent containment overpressure so as not to lose its enclosure capability.

During the plant emergency rescue process, the required power for SGTS is the first priority item in URG. Once the plant power is restored, SGTS shall be started to exhaust containment to effectively reduce containment pressure and radioactive substance release and further secure the containment integrity.

6.2.3.3 Prevention of re-criticality

Once reactor still has critical condition, the most important action for the plant is to confirm reactor already scram (RC/Q) and then follow procedure 500.8 to insert the alternative control rod. Boric acid liquid shall be injected into reactor via Standby Boric Liquid Control (SBLC) or via alternative boron injection measure (proc. 500.7) to maintain the reactor sub-critical condition. Boric acid shall be absolutely immediately injected into reactor in case that SAG condition achieves.

In case that the plant happen an exceed design basis accident as well as unit lost its off-site and on-site AC power that resulted in the above -mentioned boron injection failure, procedure 500.7 provides emergency boron injection measure to inject boric acid to reactor via RHR-B by way of fire water piping to prevent reactor re-critical.

Procurement of standby boric acid, borax for each nuclear power plant is according to the required quantity comparing with the required born concentration for containment water injection to TAF and for RPV safe shutdown including consideration of each plant’s storage capacity.

6.2.3.4 Prevention of base mat melted through: retention of the corium in the pressure vessel

The plant’s SAG related response measures are issued in reference to the study report【note】 issued by the Institute of Nuclear Energy Research. According to this report, there is no core melt through crisis and the integrity of containment is not menaced by core molten residue because the skirt of drywell in Mark III containment is enclosed by the dike of wet well. For this reason the plant’s SAG related first aid measures already incorporated the related study of severe accident and the plant’s major response measure for mitigation of the molten liquid falling down to core cavity is still to utilize water to mitigate the effect of reactor and its concrete melt through In order not to occur melt through condition of containment base mat.

[Note]:
This report collects all EPRI issued severe accident management Technology Basis Report (TBR) as well as the related data collected by CSARP experiment. This report which collects all severe accident phenomena, impact to NPP, and accident management application is used as the guideline for development and review of severe accident management for national nuclear power plant.

6.2.3.5 Need and supply of electrical AC and DC power and compressed air to equipment used for protecting containment integrity

During the accident response period of the plant's EOP/SAG related measures, the primary containment protections are core spray and exhaust. The containment exhaust control is the major exhaust mode by ways of those systems including SGTS, Normal purge supply/exhaust system, post LOCA purge supply/exhaust system, drywell to primary containment exhaust valve and drywell emergency vacuum relief valve as listed in EOP 500.14. If necessary, the isolation interlock can be removed. Besides, core spray is one of RHR designed functions which is provided with safety related power.

In case that the plant's Beyond Design Basis Accident occurs and loss of its related power, the plant shall follow the URG attachment 12 "power restoration measures" to setup the normal and alternative power including startup of the fifth D/G, GTG, or mobile power etc. as described in this chapter section 5 to restore the availability of each kind of first aid facilities.

In case of all power unavailable, the plant shall follow URG attachment 10 " Containment pressure control " to open containment exhaust system related isolation valves in order for containment connected to atmosphere so as to achieve the goal of containment exhaust and containment depressurized.

6.2.3.6 Risks of cliff edge effects and deadlines

The Institute of Nuclear Energy (INER) committed by TPC Safety Department assesses the risks of cliff edge effects and deadlines with MAAPs .Under the conservative assumption, it is supposed that RCIC is failed after 8 hours & 24 hours so as to result in loss of core water makeup and cooling. The calculation result is described as follows:

RCIC keeps operation for 8 hours:

The time of hydrogen combusted is 9.88 hr.

The time of RPV overpressure (in case of no reactor pressure relief and no containment exhaust gas): 9.79 hr.

RCIC keeps operation for 24 hours:

The time of hydrogen combusted is 13.4 hr.

The time of RPV overpressure (in case of no reactor pressure relief and no containment exhaust gas):

13.4 hr.

Besides that the plant shall follow the existing EOP/SA to consider how to manage the overall accident response strategies in symptom, the plant shall follow the advanced programming measures in URG for response to compound disaster accident to prepare the first phase water injection measures item by item per check list and also to complete the second phase measures including setup of the required system DC & AC power supply within 8 hours. Each kind of the first phase water injection measures shall be continuously carried out via above- mentioned hydrogen control, pressure control, and power coping etc. response measures so that the integrity of containment can be ensured before the cliff-edge effect occurs.

6.2.4 Accident management measures currently in place to mitigate the consequences of loss of containment integrity

In response to the compound disaster condition and in consideration to avoid large scale of populace evacuated under the condition that the designed safety function of existing safety system is anticipated failure, the plant already prepared the Ultimate Response Guidelines (URG), and will take decided actions that the prepared and ready water sources are injected into reactor at the first time to prevent from radioactive substances release.

Based on the above-mentioned descriptions, URG can ensure that core fuel is covered with water and fuel clad integrity is secured as well as the fission product release is limited when compound disaster happens. In case that containment integrity is fail, large amount of radioactive substance release may not occur because fuel clad integrity can be secured and large scale of populace evacuated can be avoided. Moreover, the URG programmed time, manpower, and related response measures can effectively perform its containment control to secure the containment integrity.

For loss of containment integrity condition, the plant shall take each kind of rescue action as per URG. The plant’s existing EOP / SAG procedures already specified the corresponding responses to primary containment and secondary containment radiation degree. (Please refer to section 6.1.1.5)

TPC already programmed the response measures for each kind of nuclear accidents including radioactive substances release condition as per the related codes and standards as well as「Emergency Response Program for nuclear reactor facilities」. Its response scope includes the overall emergency accident such as the conditions of core melt containment failure etc. The related programs are described as follows:

6.2.4.1 Design, operation and organization provisions

1. The Emergency Response Organization planned:

    A. Taiwan Power Company already set up the nuclear accident emergency response measures, emergency response organizations, and implementing procedures in the Head Office and each nuclear power plant. Emergency Control Team is the core unit of emergency response organizations for each nuclear power plant. Taiwan Power Company Emergency Program Executive Committee is the direct support organization and Nuclear Accident Central Disaster Response Center is the off-site support organization. (R.O.C nuclear accident emergency response organization system is shown in figure 6-6). The plant related response personnel training and the drill for Emergency Preparedness Plan of nuclear facilities is performed every year as per plant procedure.
    B. Common items of drill are technical support center operation performance and unit operation & accident management. Items of Yearly drill are first aid care & decontamination operation, building & site area radiation monitoring operation, environmental radiation monitoring operation, fire fighting operation, OSC damage control operation, emergency re-entrance rush repair operation, population information consultant operation, site area collection & on-call operation, and site area security operation.
    C. Nuclear safety drill including above-mentioned items is performed every 4 year.
    D. Ordinary and on-site drill can request support according to agreement items on the above-mentioned agreement content.

2. Agreement / contract for assistance of manage accident:

    A. The plant current support agreement:
        (1) The related fire fighting and disaster relief:
        The plant already signed an agreement of mutual support with New Taipei City Fire Bureau the Sixth Brigade. Both parties can support each other to perform fire fighting and the disaster relief as per the plant procedure 1420 if fire accident happens. The plant shall request supports including the support items if the plant is suffered from the accident such as fire, typhoon, flood, earthquake, and explosion etc. if the plant is incapable to relieve the disaster, or in case that the plant performs yearly fire fighting drill and emergency response drill. The support scopes include the scope under the jurisdiction of property areas including radiation control area (the personnel who needs to enter radiation control area shall not enter until advanced training of radiation protection and radiation monitor).
        (2) Support agreement for protection of endanger and destruction event as well as army and police manpower support for natural disasters as per the plant’s procedure 1421:
        The 21st Brigade of Coast Patrol Bureau Northern District Defense Patrol Department.

The Riding Squadron of National Army Guan-Du Command Department
The Chin-Shan Branch Police Bureau of New Taipei Police Bureau.

B. The following support contracts are signed by TPC Head Office:
   (1) An agreement for radiation Injury Prevention and Control with National Defense Medical Center of Tri-Service General Hospital,
   (2) The support contracts with GE, WH and Bechtel were included in TPC Emergency Program Executive Committee「Overseas Support Operation procedures」.

C. The domestic technical support teams often contact or co-operated with TPC:
   (1) The Institute of Nuclear Energy Research: Responsible for serious accident analysis and assessment, calculation of Emergency Preparedness Plan area.
   (2) Institute of nuclear Engineering and science in National Tsing-Hua University: Responsible for nuclear safety analysis.
   (3) Traffic And Transportation Engineering Research Institute in NCTU: Responsible for the plan of evacuate path and its pattern analysis.

6.2.4.2 Risks of cliff edge effects and deadlines

If accident is worsen to the extent of fuel damage and the integrity of containment also lost, radioactive substances may be released to off-site, and the populace nearby the plant shall be evacuated.

Because the populace evacuation command is according to the evaluation result of the populace possible dose rate, the populace evacuation command will be instructed by the Central Accident Response Center .Therefore, the failure time of containment integrity is used for the cliff-edge time based on conservative assumption

As mentioned above, the Institute of Nuclear Energy (INER) committed by TPC Safety Department assesses the risks of cliff edge effects and deadlines with MAAPs .Under the conservative assumption, it is supposed that RCIC is failed after 8 hours & 24 hours so as to result in loss of core water makeup and cooling. The calculation result is described as follows:

RCIC keeps operation for 8 hours:

The time of hydrogen combusted is 9.88 hr.

The time of RPV overpressure (in case of no reactor pressure relief and no containment exhaust gas): 9.79 hr.

RCIC keeps operation for 24 hours:

The time of hydrogen combusted is 13.4 hr.

The time of RPV overpressure (in case of no reactor pressure relief and no containment exhaust gas): 13.4 hr.

6.2.4.3 Adequacy of the existing management measures and possible additional provisions

In response to the compound disaster condition and in consideration to avoid large scale of populace evacuated under the condition that the designed safety function of existing safety system is anticipated failure, the plant already prepared the Ultimate Response Guidelines (URG), and will take decided actions that the prepared and ready water sources are injected into reactor at the first time to ensure the integrity of core fuel.

In response to the "Overall Emergency Accident" condition similar to Fukushima accident and if its endanger scope is already increased to endanger the populace safety, the activation level of Emergency Plan will be upgraded to be led by the government level. ROC Nuclear Accident Emergency Response organization as mentioned above consists of the government each department including army and police manpower to secure the safety of life and assets through the response program for the advanced planning populace protection, security, and medical care etc.

6.3 Spent fuel pool

6.3.1 Accident management measures of losses of cooling capability of the spent fuel pool

The spent fuel pool is located on the ground floor in the Fuel Building. It is normally provided for residual heat removal and water make-up by fuel pool cooling and purification system, RHR substitute fuel pool cooling system and emergency makeup water system. The detail design of its related power supply is described in the section 2 of chapter 5.

In order for the response to each kind of corresponding compound disaster condition as in the Fukushima accident, the protection of the spent fuel in the spent fuel pool is made out as described in the Ultimate Response Guideline attachment 13. The spent fuel pool cooling and water makeup in accordance with different conditions is described as follows:

- Case 1: Availability of Off-site Power in normal condition:
    1. Make sure that the cooling system of spent fuel pool of fuel building is normally available and then startup the spent fuel pool cooling system.

2. Startup normal HVAC system in the Fuel Building. When high temperature alarm or high radiation alarm appears startup emergency HVAC system (VF2A/B) to exhaust high temperature steam in the Fuel Building.

3. Startup normal makeup water system such as makeup water from condensate storage tank to spent fuel pool in case of the spent fuel water low level.

- Case 2: Loss of Off-site Power but Emergency Diesel Generator available

1. startup Emergency Diesel Generator to feed power supply into essential bus (A3/A4).

2. Use the spent fuel pool cooling mode of t Heat Removal System to reduce the spent fuel pool temperature.

3. When Fuel Building high temperature alarm or high radiation alarm appears, startup emergency HVAC system (VF2A/B) to exhaust the high temperature steam in the Fuel Building.

4. When spent fuel pool water level drops, startup its emergency makeup water pumps (P56A/B) to refill water from Condensate Storage Tank (CST) to spent fuel pool.

- Case 3: Loss of Off-site Power and Emergency Diesel Generator unavailable(Gas Turbine or the fifth diesel generator available)

1. Feed power to essential bus (A3/A4) for power supply.

2. Use the spent fuel pool cooling mode of Heat Removal System to reduce the spent fuel pool temperature. (Same as case two)

- Case 4: Loss of Off-site Power, Gas Turbine unavailable and the Fifth Diesel Generator unavailable(200KW mobile power supply available)

1. Provide power supply with pump P56B and exhaust fan VF2B from 200KW mobile diesel generator. (Only one set of 200KW mobile power source is enough to achieve spent fuel pool cooling and exhaust air purification)

2. Startup emergency fuel pool make-up water pump P56B to make up water.

3. Startup the emergency exhaust fan VF2B to exhaust the evaporated steam in the Fuel Building.

- Case 5: Use of firefighting engine or mobile water pump to inject water into spent fuel pool in case of loss of off-site power, Gas Turbine and Emergency Diesel Generator unavailable as well as 200KW mobile power supply unavailable.

1. Move the firefighting engine or the mobile water pump with water hose tie-in to outside of

the Fuel Building.

2. Connect the quick adapter and open valve EC-115A5B01/ C-115A5B02, and then inject water from the upper end of the spent fuel pool.

- Case 6: Large volume of evaporated steam inside the Fuel Building and use firefighting engine or mobile water pump to inject water into spent fuel pool in case of loss of off-site power , Gas Turbine and Emergency Diesel Generator unavailable as well as mobile power supply unavailable.

  1. Move the fire engine or the mobile water pump with water hose tie-in to outside of the Fuel Building.
  2. Connect the quick adapter and open valve EC-115A5B01/ C-115A5B02, and then inject water from the upper end of the spent fuel pool.

- Case 7: Fire water system is in normal condition in case of loss of off-site power, Gas Turbine and Emergency Diesel Generator unavailable as well as mobile power supply unavailable.

Dispatch someone to pull out water hose from fire water hose box 1/2 F-C1 next to Fuel Building HVAC system VF2A to directly inject fire water to the spent fuel pool.

- Case 8: Mobile water pump available in case of loss of off-site power, Gas Turbine, Emergency Diesel Generator and 200KW mobile power supply unavailable as well as fire water system unavailable.

The traffic access rollup door in Fuel Building is opened and then mobile water pump is used to draw water from normal water pool or backup pool to directly inject water into the spent fuel pool.

- Case 9: Firefighting engine available in case of loss of off-site power, Gas Turbine, Emergency Diesel Generator and 200KW mobile power supply unavailable as well as fire water system unavailable.

Manually open the traffic access rollup door in Fuel Building, and then drive fire engine into Fuel Building to draw water from normal water source or backup water source to directly inject water into the spent fuel pool.

Note: Please pay attention whenever to take the action of the above-mentioned cases.

1. If it is necessary to enter the Fuel Building, please understand in advance the radiation condition in Fuel Building. If necessary, please wear air mask.
2. If necessary, the traffic access rollup door in Fuel Building can be opened to exhaust the high temperature evaporated steam on the spent fuel pool.

6.3.1.1 Before and after losing adequate shielding against radiation

1. Before loss of adequate shielding against radiation:

   Judging from the condition of power supply and water supply available or not, carry out the spent fuel pool cooling or water makeup in accordance with case 1 as described in the Ultimate Response Guideline (URG) attachment 13.

2. After loss of adequate shielding against radiation:

   In case that personnel can't access to the spent fuel pool after loss of adequate shielding against radiation, but the power supply is normal or restored, carry out the spent fuel pool cooling or water makeup in accordance with cases 1~4 as described in URG attachment 13. Otherwise, carry out the spent fuel pool cooling or water makeup by means of the new added injection or spray piping located in the northern wall in Fuel Building in accordance with cases 5~6 as described in URG attachment 13.

6.3.1.2 Before and after the water level of the spent fuel pool drop to the top of fuel

1. Before the water level of the spent fuel pool drop to the top of fuel element:

   - If the change of radiation condition is not too much and the personnel can still access to the fuel pool, the management measure is same as 6.3.1.1 item 1"Before loss of adequate shielding against radiation".

   - If the radiation dose is too high and the personnel can't access to the fuel pool, the management measure is same as 6.3.1.1 item 2 "After loss of adequate shielding against radiation".

2. After the water level of the spent fuel pool drop to the top of fuel element:

   If the radiation dose is too high and the personnel can't access to the fuel pool, the management measure is same as 6.3.1.1 item 2 "After loss of adequate shielding against radiation".

6.3.1.3 Before and after severe damage of the fuel in the spent fuel pool

1. Before severe damage of the fuel in the spent fuel pool:

- If the change of radiation condition is not too much and the personnel can still access to the fuel pool, the management measure is same as 6.3.1.1 item 1"Before loss of adequate shielding against radiation".
- If the radiation dose is too high and the personnel can't access to the fuel pool, the management measure is same as 6.3.1.1 item 2 "After loss of adequate shielding against radiation".

2. After severe damage of the fuel in the spent fuel pool:

   If the radiation dose is too high and the personnel can't access to the fuel pool, the management measure is same as 6.3.1.1 item 2 "After loss of adequate shielding against radiation".

6.3.1.4 Risks of cliff edge effects and deadlines

The decay heat of the spent fuel is decreased following the increasing unit shutdown time. During the special fuel cycle, the decay heat of the spent fuel is the maximum at the moment after completion of core fuel transfer that all spent fuels (624 pieces) are pulled out to be stored in the spent fuel pool. Take unit 1 EOC-21 outage maintenance for an example, the cliff edge time of the spent fuel after loss its cooling can be evaluated based on analysis of the following three conditions:

1. The total decay heat is approximately 1.5MW in the pre-outage condition of the spent fuel pool
   - The temperature rising time till boiling: 90.3 hr
   - Time of water level drop to the level (top of active fuel 8 feet) which can't maintain adequate shielding against radiation: 438.9 hr
   - Time of water level drop to the top of active fuel elements: 587.2 hr
   - The initiate degradation time of the fuel: 602.2hr [Note]
2. During fuel transfer, it is conservatively supposed that the spent fuels are pulled out to be stored in the spent fuel pool at the third day. For this example, the total decay heat of 160 pieces of spent fuels is estimated approximately 3.0MW.
   - The temperature rising time till boiling: 45.3 hr.
   - Time of water level drop to the level (top of active fuel 8 feet) which can't maintain adequate shielding against radiation: 219.5 hr.
   - Time of water level drop to the top of active fuel elements: 293.6 hr.
   - The initiate degradation time of the fuel: 308.6 hr [note]
3. The decay heat of the spent fuel is decreased following the increasing unit shutdown time.

All spent fuels(624 pieces)are pulled out to be stored in the spent fuel pool at the tenth day after outage .The total decay heat of 160 pieces of spent fuels is estimated approximately is 6.6MW.

- The temperature rising time till boiling: 20.4 hr
- Time of water level drop to the level (top of active fuel 8 feet) which cannot maintain adequate shielding against radiation: 99.0 hr
- Time of water level drop to the top of active fuel elements: 132.4 hr
- The initiate degradation time of the fuel: 147.4hr [note]

Note: According to INER evaluation result with CFD program, the time of fuel clad of reaching degradation temperature (2200 ℉) (rapid oxidation to release hydrogen) is approximately 15 hours.

6.3.1.5 Effectiveness of the existing management measures

Based on above-mentioned analysis, fuels will not start to degrade till 147.4 hr (~6 days) after loss of spent fuel pool cooling and water makeup in the most serious condition. All spent fuels of 624 pieces are pulled out to be stored in the spent fuel pool at the tenth day after outage. Therefore, KSNPP has enough time to cope with the restoration of power supply or to prepare the alternative power supply in order to provide for the required power supply or alternative power supply for restoring spent fuel pool cooling or water makeup capability. Furthermore, because the spent fuel pool is located on the ground floor in the Fuel Building, KSNPP may dispatch someone to the site to carry out the spent fuel pool cooling or water makeup by means of fire water, water pump, fire engine as described in cases 7~9.

In case loss of adequate radiation shielding or high temperature at site, KSNPP may proceed spent fuel pool makeup or spray by means of the setup of the fire water pipes located in the northern wall in the Fuel Building to take water from miscellaneous water sources (firefighting water, CST) from outside of Fuel Building as described in cases 5~6 in order to avoid the Risks of cliff edge effects of fuel damage.

6.4 Implemented safety improvement and further work enhancing robustness

6.4.1 Adequacy and availability of the instrumentation control

The major safety related instrumentations for the plant are all seismic category 1 design. Major instrumentation may lose its monitor and control functions due to loss of power as occurred in

Fukushima compound disaster accident. However, the DC powers including uninterruptible power systems (UPS) for instrumentation and controls are designed to cope with 24 hours power supply capability at the initial stage of plant blackout condition. Various power restoration and enhance programs have been pre-planned in the attachment 12 “Setup of power supply” of URG and there shall be enough time to restore the power supply of I&C system. Please refer to Chapter 5 “Loss of power supply and ultimate heat sink” for detail.

At the situation of high building temperature or flooding (or flooding due to strategically irrigation), site severe Accident Management Team (AMT) will evaluate instrument reading from similar instruments and compare with parameter assessment table (PAT) for the effectiveness of the measured data. The evaluation result will be submitted to AMT Leader and plant Emergency Control Team brigades for them to grasp the status of the plant and to ensure the accident is under control.

Furthermore, for the enhancement of the spent fuel pool monitor and control capability, DCR is issued to improve that the temperature indication signal as well as level indication are connected to control room and power supply layout is also changed to UPS. Unit 2 was already completed in 2EOC-21. Unit 1 was already completed in 1EOC-22.

6.4.2 Availability and Habitability of Control Room

KS NPP main control room which is commonly shared for both units is design as seismic category 1. Besides that it shall be maintained operable during earthquake, tsunami accident, there are four trains of emergency ventilation system to maintain control room in positive pressure and air intake and filtration capability. It meets the habitability requirements in NRC NUREG- 0696 Functional Criteria for Emergency Response Facility. Therefore, if there is off-site radiation release condition (including Fuel building) in each kind of accident condition, main control room habitability can be maintained.

If a design basis accident (DBA) happens and it is expected that unit will loss off-site AC power, KSNPP shall restore the control room emergency ventilation system to normally operate at first priority in accordance with URG attachment 12 “Setup of normal and alternative power supply” in order to maintain Control Room long-term habitability. At the same time power coping program can assure that all related lighting and instrumentation control capability in control room can be long term maintained.

When control room has the possibility of being contaminated, KSNPP has already prepared the enhancement programs of Control Room habitability and personnel entrance control measures as follows:

A. To carry out periodically the detection of radiation, contamination and radioactive air concentration in control room.

B. To project radiation-protection countermeasures according to control room radiation condition:
   a. To assess the feasibility for installation of the radiation barrier in order to reduce on-site radiation dose rate and further reduce acceptance radiation dose rate of shift personnel.
   b. To provide with the required radiation-protective equipment such as radiation-protective cloth, absorber protection mask, lead cloth etc. If necessary, guide personnel how to wear radiation-protection equipment.
   c. To assess the longest work hours of shift personnel. If necessary, proceed with dose measurement and control.
C. To install the personnel contamination monitor in the proper place in order to assure that shift personnel will not be contaminated while leave.

According to KSNPP FSAR chapter 15.6.4.5 "Radiological Consequences" section 15.6.4.5.1, it is assumed that 100 percent of the noble gases and 50 percent of the iodine are released from an equilibrium core operating at a power level of 3039 MWt (105% of OLTP) for 1000 days prior to the accident. This assumption implies that fuel damage approaching melt condition, which is relatively conservative in dose calculation compared to that of Fukushima accident. In section 15.6.4.5.4, analysis has shown the operator exposure in control room is 1.54rem (15.4mSv) in 30 days (table 15.6-8). The regulatory dose limit for working personnel is 50mSv/yr, hence the operator in control room can sustain at least three months for emergency.

Besides, the design basis for the control room emergency ventilation system is that the control room should remain positive pressure for post-accident condition. The Control Building Ventilating and Cooling System is able to prevent any un-filtered radioactive air borne from leakage into the control room. It is also capable of maintaining adequate ventilation and temperature for personnel and equipment. It is equipped with the high efficiency charcoal absorber, and its design basis is to maintain operable for 30 days under DBA condition. If beyond DBA happens, as the charcoal absorber fails (e.g. delta pressure is too high), changing the charcoal absorber can be accomplished per KSNPP's procedure 814.1 to maintain habitability in control room.

6.4.3 Hydrogen gas possibly accumulated in the buildings other than containment building

In case that the plant happens a beyond design basis accident and it is anticipated that the loss of off-site and on-site AC power is inevitable, the site will immediately follow the procedure described in the attachment 10 of URG to reduce the concentration of hydrogen in containment to avoid hydrogen explosion.

Besides, in order to prevent hydrogen accumulation in secondary containment due to primary containment leakage, open the long shape door located in 7F of Auxiliary Building and air intake shutter (GL-HV-167A/B, GL-HV-168A/B) in Auxiliary Building to release hydrogen to outside to prevent hydrogen accumulated in the secondary containment to result in hydrogen explosion.

If the spent fuel pool cooling system is unable to operate due to power loss and above-mentioned URG water makeup measures are also all failed because of the compound disaster situation, the decay heat of spent fuel can't be removed so that it results in that fuels are uncovered and then damaged and hydrogen gas gradually produced. KSNPP can manually open both of the rollup doors in Fuel Building 3F and traffic access to naturally vent the hydrogen gas in accordance with URG attachment 15 "Fuel Building exhaust gas heat removal hydrogen control". Because KSNPP Fuel Building is independent with other buildings and its HVAC system is also separated from that in other buildings, the produced hydrogen gas will not spread out to other buildings.

Once normal power or alternative power is built-up (URG attachment 12), KSNPP shall setup power supply for spent fuel pool makeup pump to makeup water to spent fuel pool in order to avoid or reduce hydrogen generation. At the same time hydrogen gas inside Fuel Building shall be exhausted by means of Fuel Building Emergency Exhaust fan VF2A/B to reduce hydrogen concentration in Fuel Building.

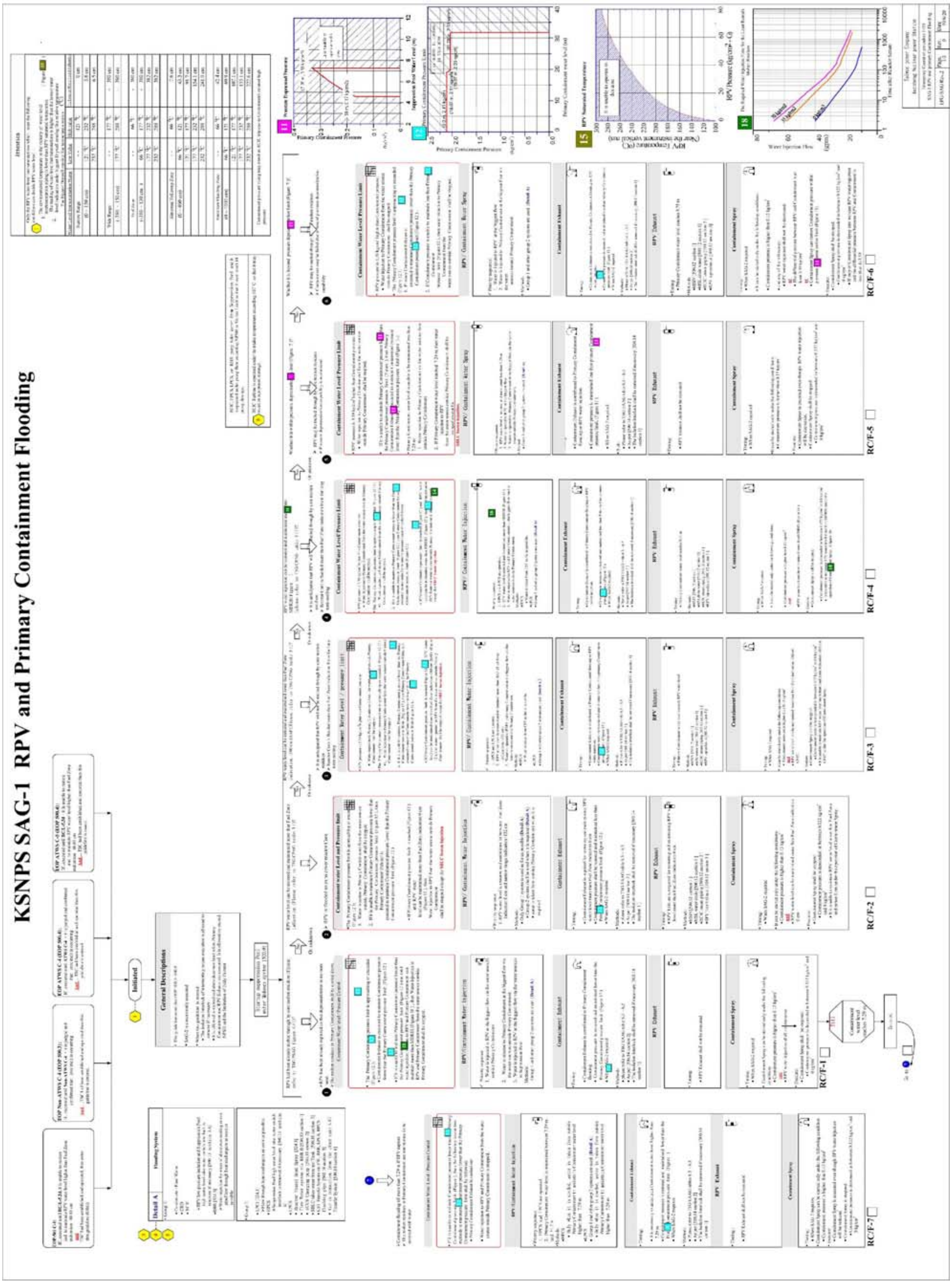


Figure 6-1 KSNPP SAG-1

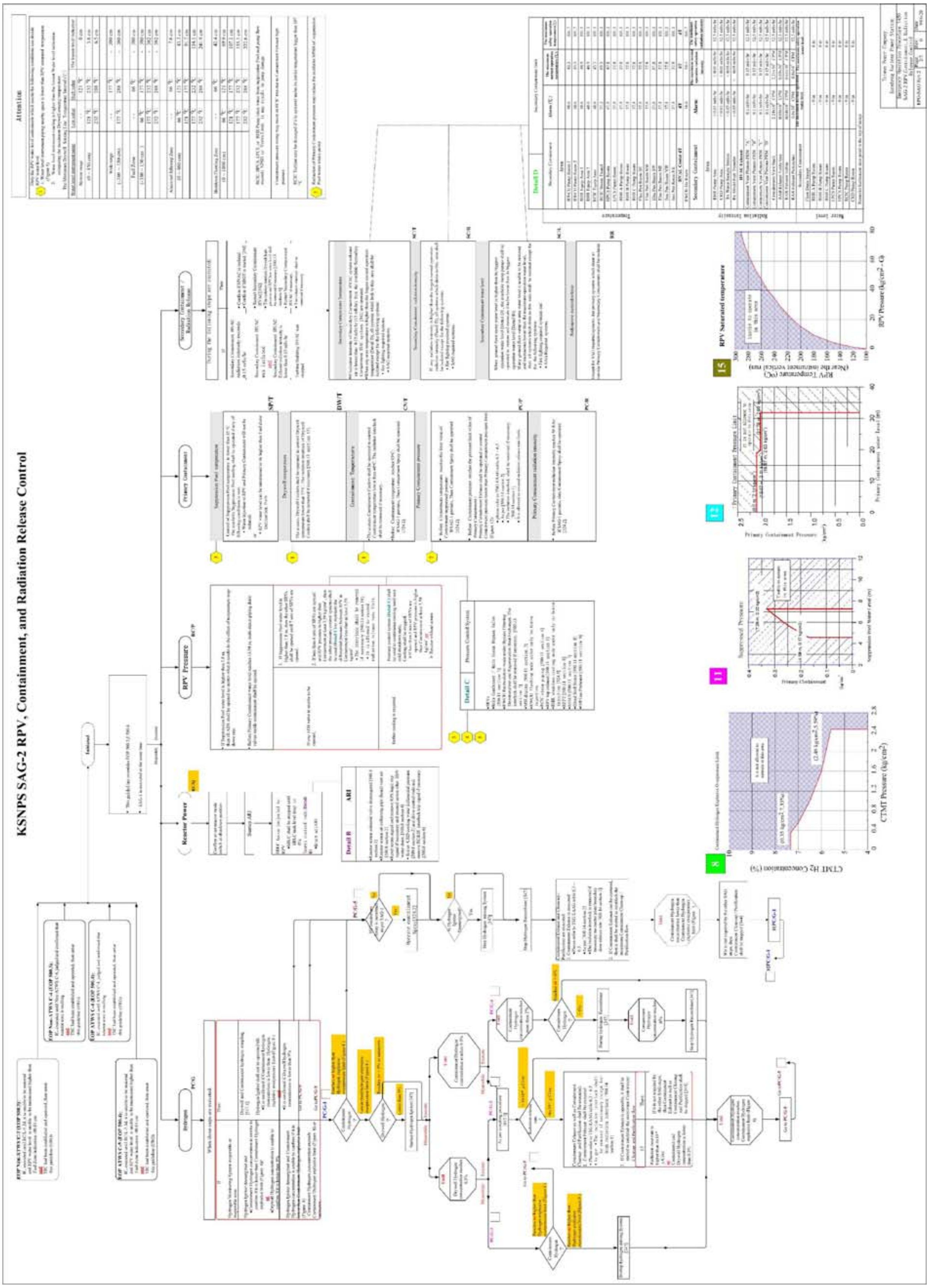


Figure 6-2 KSNPP SAG-2

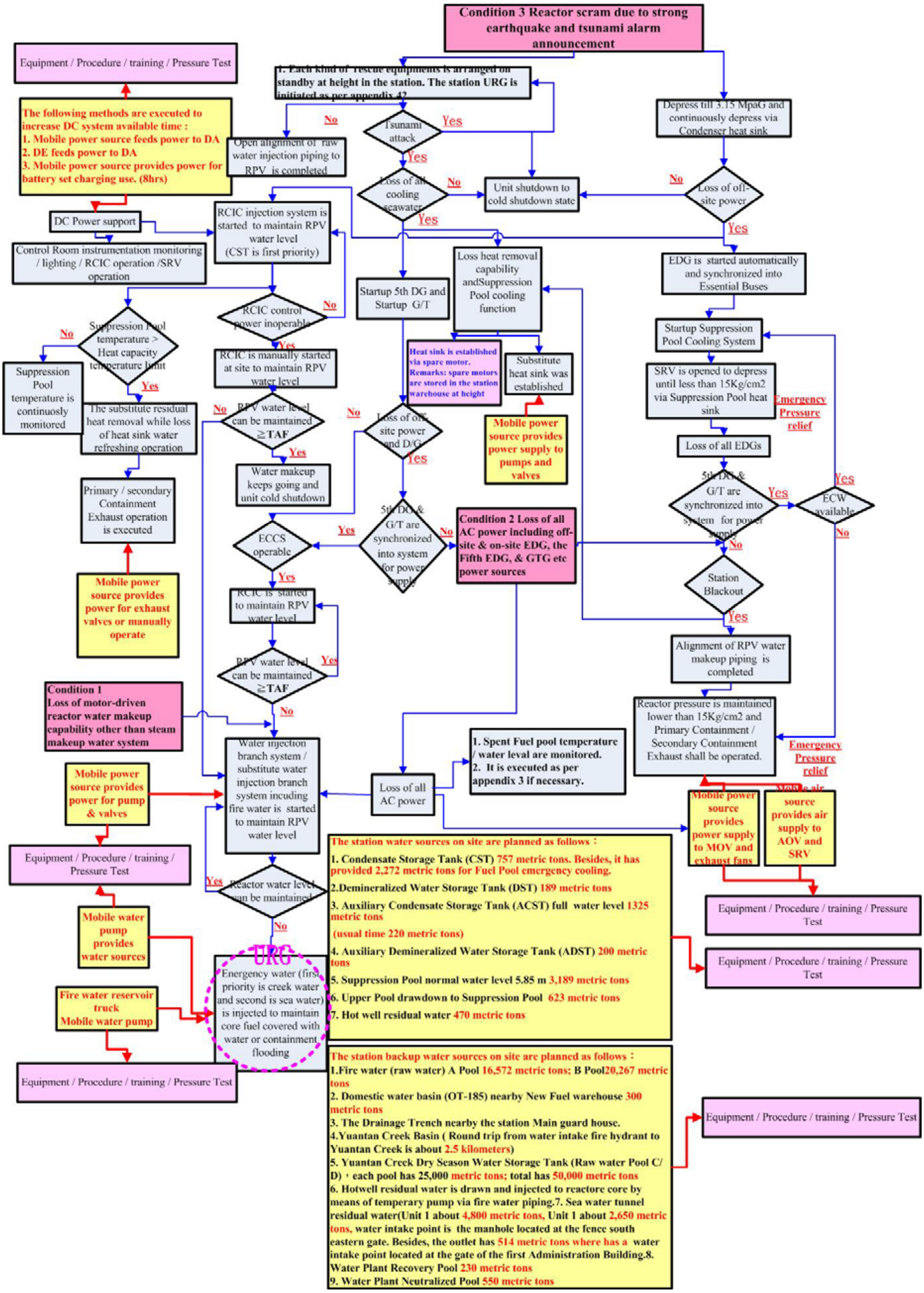


Figure 6-3 The Ultimate Response Process Flow-Chart for KSNPP

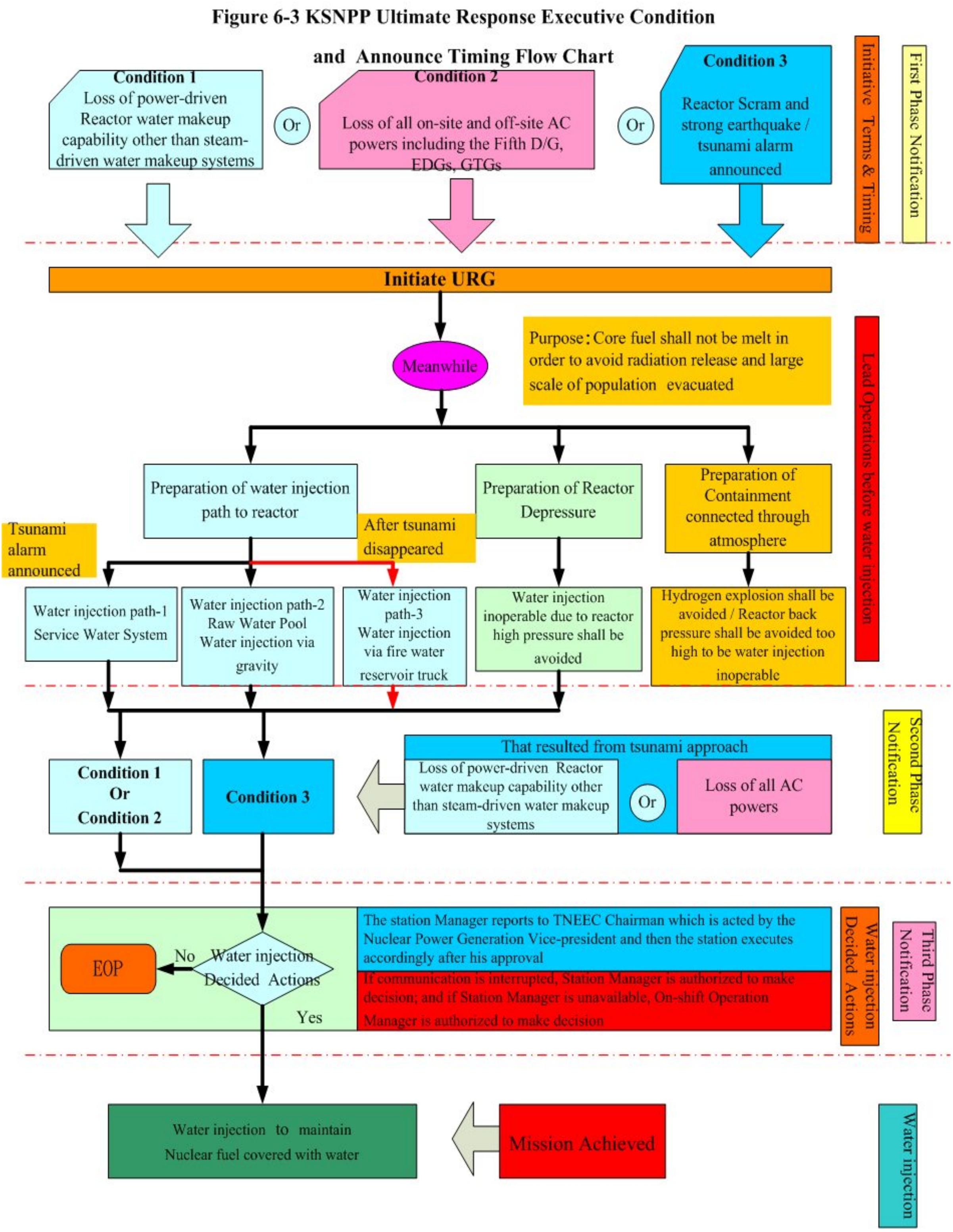


Figure 6-4 The Ultimate Response executive condition process and announce & report timing flow-chart for KSNPP

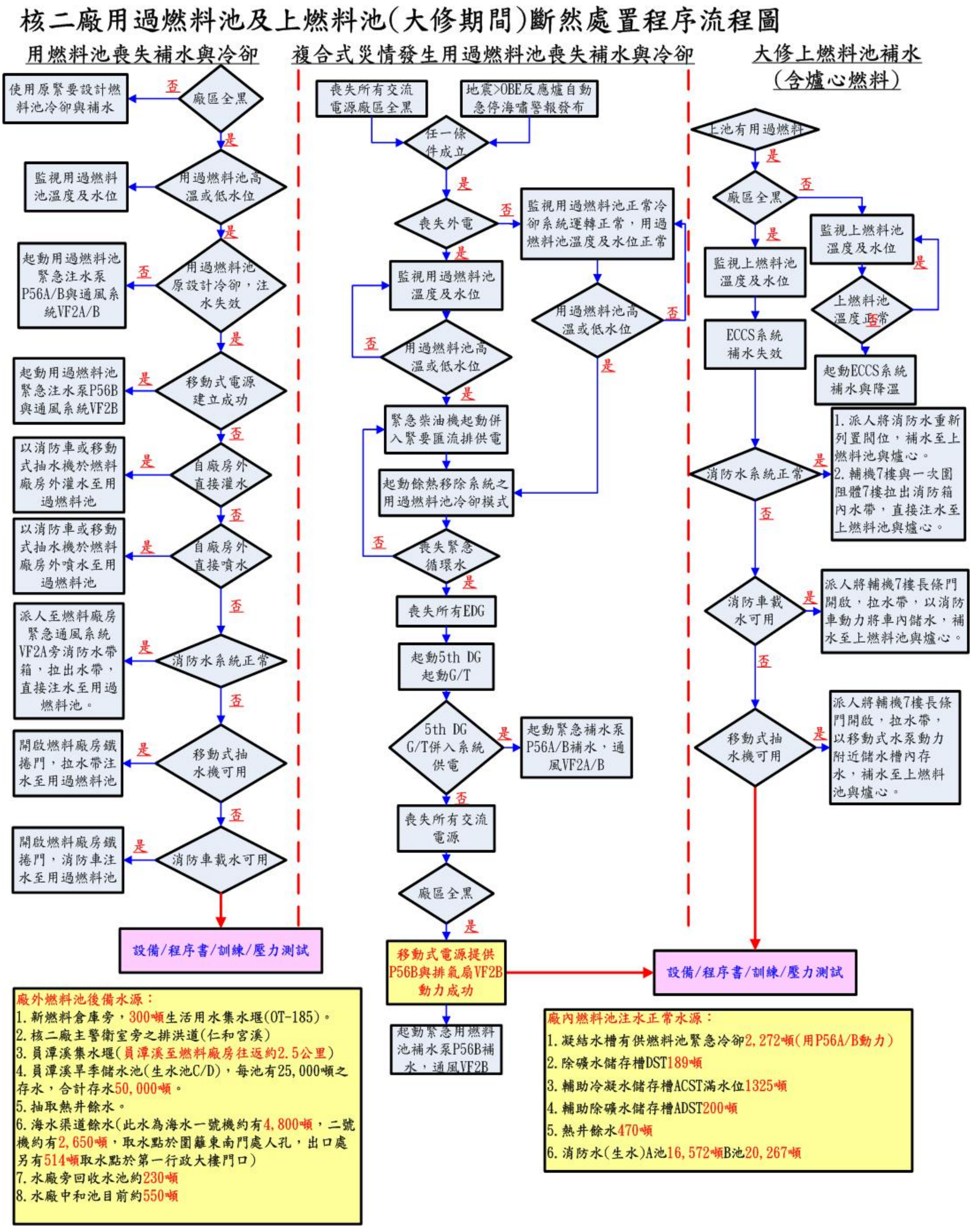


Figure 6-5 The Ultimate Response Process flow-chart for spent fuel pool and upper pool of KSNPP. (During plant outage period)

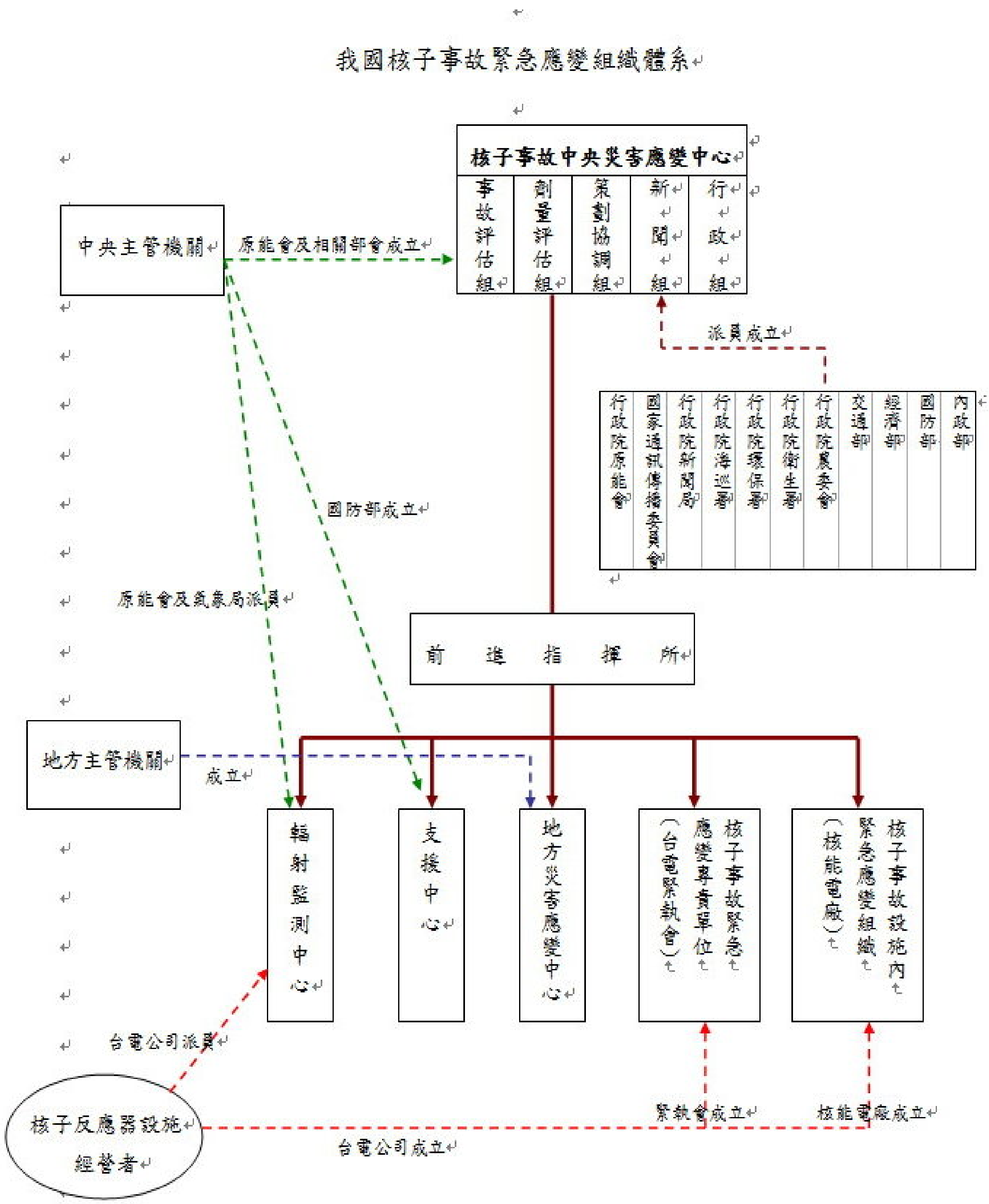


Figure 6-6 The Organizational Structure of Nuclear Accident Emergency Response Organization of R.O.C

Attachment 6-1: Operation Items and Shift Dispatch List

Operation Items	First person in response	Second person in response	Remarks
1. Operation of RHR B Blind Plate and Isolation Valve	Mechanical leader R/W Control shift Operator	R/W Control Leader Reactor Shift Operator	
2. Operation of RHR B F042B or F053B	R/W Control Leader Reactor shift Operator	Mechanical leader R/W Control shift Operator	No need to dispatch operator if it is already open before SBO
3. (1) Makeup water operation for Fire Water Engine and mobile water pump (2) Coordinate with Control Room and lead Fire Protection Shift person	(1)Fire Protection Shift person (2)Water Plant Shift Operator	(1) Fire Protection Shift person (2)Boiler Shift Operator	
4.Operation of the Fifth D/G (Control Room)	Electrical shift Director, Assistant Reactor Operator(ARO)	Unit shift Director , Reactor Operator (RO)	
5. Operation of the Fifth D/G (1) Emergency S/U Transformer Disconnect Switch(2) Startup Transformer Disconnect Switch	(1) Electrical Shift Operator (2) SWYD Shift Operator	(1) Turbine Shift Operator (2)G/T Shift Operator	
6. Emergency Diesel Generator for both unit mutual Support (Control Room)	Electrical shift Director, Assistant Reactor Operator(ARO)	Unit shift Director , Reactor Operator (RO)	
7. Emergency Diesel Generator for both unit mutual Support (1)Emergency S/U Transformer Disconnect Switch (2) Startup Transformer Disconnect Switch	(1) Electrical Shift Operator (2) SWYD Shift Operator	(1) Turbine shift Operator (2) Gas Turbine Shift Operator	
8. Cable pulling and connection from battery set E to RCIC/SRV DC power supply	Electrical shift Director, Assistant Reactor Operator(ARO)	Unit shift Director, Reactor Operator (RO)	
9.5kw D/G startup and Cable pulling to Control Room	Turbine/Mechanical Assistant, Electrical shift Operator	R/W Control Assistant, Turbine shift Operator	
10. Cable pulling and connection from 5kw D/G to RCIC/SRV DC power supply	Electrical shift Director, Assistant Reactor operator (ARO)	Unit shift Director, Reactor Operator (RO)	
11. Operation of reactor depressurization	Unit Shift Director Reactor Operator (RO)	Electrical Shift Director, Assistant Reactor	

Operation Items	First person in response	Second person in response	Remarks
		Operator(ARO)	
12. RCIC (1) Manually open F045/F046 (2) Manually open F013	(1) Mechanical leader, Turbine shift Operator (2) Reactor shift Operator, R/W Control shift Operator	(1) Reactor shift Operator, R/W Control shift Operator (2) Mechanical leader, Turbine shift Operator	
13. 4160V 1100kW interconnection from G/T to D/G (G/T Building)	G/T Shift Director G/T Shift Operator	SWYD Shift Director, SWYD Shift Operator	
14. Response process for OSC 480V 200kW Diesel Generator connect to LC 2B3	Electrical Shift Operator, Turbine / Electrical Assistant	Mechanical leader, Turbine Shift Operator	
15. Secondary Containment exhaust	HP Station shift Operator, Reactor shift Operator	HP Station Contract Operator, Mechanical leader	
16. Fuel Building exhaust	HP Station Contract Operator, Mechanical leader	HP Station shift Operator, Reactor shift Operator	
17. 4160V 1100kW interconnection from G/T to D/G (Operate in Control Room)	Electrical shift Director Assistant Reactor Operator (ARO)	Mechanical shift Director Reactor Operator (RO)	
18. Open Primary Containment Exhaust Valve	Mechanical leader R/W Control shift Operator	R/W Control Leader Reactor shift Operator	No need to dispatch operator if it is already open before SBO

Attachment 6-2: Three-Phased Check List for the Ultimate Response

Phase	Measures / Strategy	Time Limit
The first phase	Measures KS.1-01 Raw water(Fire Water)inject to reactor (Attachment 7) Measures KS.1-02 Reactor depressurization (Reactor decay heat removal)(Attachment 9) Measures KS.1-03-01Primary Containment Exhaust (Attachment 10) Measures KS.1-03-02 Secondary Containment Exhaust (Attachment 10) Measures KS.1-03-03 Fuel Building Exhaust (Attachment 15) Measures KS.1-04Inject water to reactor by means of Fire Engine or mobile (Attachment 7) Measures KS.1-05 Manually operate RCIC to inject water to reactor (Attachment 8) Measures KS.1-06 The Fifth D/G Power supply to both units (Attachment 1 of 12) Measures KS.1-07 4160V 1100kW interconnection from G/T to D/G (Attachment 38 of 12) Measures KS.1-08480V TSC/OSC Diesel Generator interconnection to 1(2)B3 (Attachment 5 of 12) Measures KS.1-09 AP-HV-203/204 fixed position in open position	Within 1hr
The second phase	Measures KS.2-01-01 Mobile Air Compressor supply air to SRV/ADS Measures KS.2-01-02 Open Nitrogen gas supply Measures KS.2-02 480V 200kW Mobile D/G interconnection (Attachment 6 of 12) Measures KS.2-03 4.16kV Power supply vehicle interconnection (Attachment 4 of 12) Measures KS.2-04-01 Extension of DC power supply time (DE to DA)(Attachment 7 of 12) Measures KS.2-04-02 Extension of DC power supply time (5KWDiesel Generator) (Attachment 8 of 12) Measures KS.2-05-01 Spent Fuel pool Cooling and water makeup by means of fire engine (Attachment 13) Measures KS.2-05-02 Spent Fuel Pool cooling and water makeup by means of mobile water pump (Attachment13) Measures KS.2-05-03 Spent Fuel Pool cooling and water makeup by means of Fuel building Fire Box Stand (Attachment15) Measures KS.2-06 Operation of Sump pump drainage Measures KS.2-07 Inject Water to CST by mobile water source	Within 8hrs
The third phase	Measures KS.3-01 Trash clean up and transportation for Emergency Water Intake Measures KS.3-02 Emergency Circulating Water (ECW)pump motor replacement Measures KS.3-03Reactor long term cooling(Attachment 16 & 17)	Within 36hrs