EU STRESS TEST FOR MS NPP
-LICENSEE REPORT
(Rev.1b)

Taiwan Power Company

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EU STRESS TEST FOR MAANSHAN NPP - LICENSEE REPORT

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1. Plant description

1.1 Location and Address of Plant

The Maanshan Nuclear Power Station (MSNPP), also known as Third Nuclear Power Plant in Taiwan, is located at Number 387, Nanwan Rd., Hengchun Township, Pingtung County. The plant occupies 329 hectare and is 5 kilometers from Hengchun, 15 kilometers north of Cape Eluanpi, and 110 kilometers south of Kaohsiung. There are not any rivers and dams in and close to the plant. The buildings of plant face Nanwan and are about 300 meters from shore. Longluan Lake is located less than 1 kilometer at north of the plant.

1.2 Major characteristics of the units

Two 3-loop pressurized water reactors (PWRs), designed and manufactured by Westinghouse, are installed on the Maanshan site. By original design, the rated thermal power/electrical output was 2775MWt/ 951 MWe for each unit. The initial criticality time for unit 1 was March 30, 1984 and for unit 2 Feb. 1, 1985. "Measurement uncertainty recapture power uprate" (MUR-PU) was successfully implemented at unit 1 on July 7, 2009 and at unit 2 on Dec. 2, 2008. As a result, each unit is capable of operating at 2822 MWt/960MWe at rated conditions. The design operation parameters of RCS are as follow:

Normal operation pressure	Psig	2235(157 kg/cm^2)
Total system volume (including pressurizer (PZR) and surge line)	ft^3	9410(266.3 m^3)
The system fluids volume at the maximum guaranteed operating power	ft^3	8833(250 m^3)
Maximum spray rate of pressurizer (PZR)	GPM	700(44.1 L/S)
Capacity of the PZR heater	KW	1400
Heat power of the primary side	MWt	2834
Heat power of the reactor	MWt	2822
Design capacity of the primary side		
The flow volume of one loop under RCP operation (thermal design flow)	GPM	97600 (unit 1) 92600 (unit 2)
Temperature at reactor outlet nozzle	^oC	327.4
Temperature at reactor inlet nozzle	^oC	290.1
Feedwater temperature of the steam generator	^oC	228.1

1.3 The safety design 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 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). All major equipment at Unit 2 is essentially a duplicate of its counterpart at Unit 1. Systems and components required for safety are not shared between Units l and 2, except the following:

1. One air-cooled 4.16 kV/ 7000 KW emergency diesel generator (5^{TH} EDG) which can be deployed as alternative to any water-cooled emergency diesel generator at units 1 & 2. The 5^{TH} EDG was initially designed as a swing EDG. That is, it could be deployed to support emergency AC power demand for either unit 1 or unit 2. After the Fukushima accident, a new SOP 1451 has been established. The 5^{TH} EDG can be deployed to provide power demand for the safety related 4.16kV buses of both unit 1 and unit 2 simultaneously, after the signals are cross over connected according to SOP 1451.
2. One NSCW building is shared by both units. However, all systems or equipment in different loops for either unit in the NSCW building are physically separated by design.

1.4 The scope and the conclusion of the probabilistic safety analysis (PSA)

The first version of MSNPP's Probabilistic Risk Assessment (PRA) report was finished in October 1987. In 1995, MSNPP completed its Living PSA. 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 MSNPP Living PSA. The MSNPP Living PSA program has developed two PRA models, one for full power conditions and the other for the refueling outage mode. Broadly, the full power PRA model analyzes 5 categories of events, namely plant internal events, earthquakes, typhoons, floods, and fires. The results of the most recent assessment are summarized as follows:

1. The total average "core damage frequency" (CDF) at full power operation is 1.8E-5/RY; the total CDF at a typical refueling outage is 2.5E-5/RY。
2. The total average "large early release frequency" (LERF) at full power operation is 1.2E-6/RY; no LERF analysis was performed for refueling outage modes.

3. For the total average CDF at full power operation, contribution from the plant internal events account for 27.2% (4.9E-6/RY), earthquakes 44.4%(8.0E-6/RY), typhoons 8.3% (1.5E-6/RY), floods 19.4% (3.5E-6/RY), and fires 0.8% (1.4E-7/RY).
4. For the total average LERF at full power operation, contribution from the plant internal events account for 56.2% (6.6E-7/RY), earthquakes 10.2% (1.2E-7/RY), typhoons 0.9% (1.1E-8/RY) , floods 31.5% (3.7E-7/RY), and fires 1.1% (1.3E-8/RY)。

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 "design basis earthquake" intensities for this plant are: (1) Safe Shutdown Earthquake (SSE): corresponding to a peak ground acceleration 0.4g, and (2) Operating Basis Earthquake (OBE): corresponding to a peak ground acceleration of 0.2g. These two values were determined according to the geological characteristics of the site and the surrounding earthquake area. Based on (1) Tectonic Province Method and (2) Geologic Structure Method, we estimated the biggest earthquakes that could happen in this region and set the SSE value to 0.4g. We set the OBE=0.2g, that is, one half SSE.

2.1.1.2 Methodology to evaluate the DBE

The DBE of the plant was evaluated in accordance with the following two methods:

1 Tectonic Province Method

(1) South Central Mountain Seismotectonic Province since MSNPP is located in the South Central Mountain Seismotectonic Province area. MSNPP should sustain the biggest earthquake ever happened in this area. According to the historical earthquake data in this area, the biggest earthquake happened on Nov. 7, 1972. Its magnitude is 5.4 (equivalent to VI~VII MM Scale). From the figures published by Neumann and Trifunac&Brady, the largest ground acceleration at MSNPP site was 0.1g.

(2) Western Taiwan Seismotectonic Province
According to the historical data, there were 3 earthquakes occurred in this area. These are:
Mar 17, 1906, magnitude＝7.1
Apr 21, 1935, magnitude＝7.1
Dec 17, 1941, magnitude＝7.1 （This one had larger effects on the MSNPP site）
Assuming the Dec 17, 1941 earthquake epicenter was just 20 kilometers away from MSNPP

site, then the site peak ground acceleration was 0.32 g according to figure 2.5-27 of MSNPP FSAR.

(3) South Eastern Taiwan-Western Philippine Sea Seismotectonic Province

According to the historical data, there were 2 big earthquakes occurred in this area. These are: （see details in the figures 2.5~22, MSNPP FSAR）

Aug 22, 1936, M＝7.1

Aug 15, 1959, M＝6.9

The boundary of the South Eastern Taiwan-Western Philippine Sea Seismotectonic Province is about 20~35 km away from MSNPP site. Regarding the importance of this seismic zone to the plant, we assumed that the largest earthquake magnitude is 7.5 (actual data is 7.1) and the distance from the seismic zone boundary to the plant is 20 km (actual distance is 20~35 km). Schnabel & Seed (1973) figured out the peak ground acceleration at the MSNPP site was 0.39 g.

(4) Other Seismotectonic Provinces

The historical biggest earthquake occurred on Jun. 5, 1920. Its seismic magnitude scale was 8.3. The seismic epicenter was in the sea outside Hualien and was 90 km away from the plant site. By the figures constructed by Schnabel & Seed (1973), the peak ground acceleration on the plant site was 0.1 g.

Conclusion: the SSE of MSNPP is 0.39 g according to Tectonic Province Method.

2. Geologic Structure Method

There are two major active geological faults within the scope of 100 km of the MSNPP, namely Taitong Rift Valley Fault and Chaozhou Fault.

(1) Taitong Rift Valley Fault (ref. MSNPP FSAR, figures 2.5-19)

According to a conservative estimation, this fault extends southward and its closest distance to MSNPP site is about 35km. The seismic magnitude scale related to this fault is M=7.3. Conservatively, we assume the historically biggest earthquake (Magnitude=8.3, occurred on Jun. 5, 1920) epicenter was 35 km away from MSNPP. Then, according to Schnabel&Seed (1973), the maximum ground acceleration at MSNPP site is ≤0.4 g.

(2) Chaozhou Fault (ref. MSNPP FSAR, figures 2.5-18）

Conservatively assume that the fault extends southward and its closest distance to MSNPP site is 20 km. According to the attenuation relationship chart by Schnabel & Seed, an earthquake of seismic magnitude scale 7.1 occurs at the fault nearest to MSNPP will cause a peak ground acceleration about 0.32 g at the site.

Conclusion: the SSE of MSNPP is 0.4 g according to the Geologic Structure Method.

Based on the above two methods, MSNPP sets the SSE to 0.4g and the OBE (which is a half of SSE) to 0.2g. For conservative strategy and design convenience, the design SSE of the rock that MSNPP sit on was set to 0.4 g.

Based on the research made by National Central University in the title of “The

Evaluation Program of the Impact of Hengchun Fault on Moving Force Characteristic of MNPP Location", in case Hengchun Fault splits to the ground surface, the PGA created on MNPP ground surface will be 0.38G.

2.1.1.3 Conclusion on the adequacy of the DBE

1. Since the construction of this plant, the site has experienced the effects of two strong earthquake events, namely the Chi-Chi Earthquake that occurred on September 21st ,1999 and the Hengchun Earthquake that occurred on December 26th , 2006. The seismic intensity at the site did not reach OBE (0.2 g) level during these two earthquakes. After September 21st , 1999 Chi-Chi Earthquake (also known as the 921 major earthquake), the Ministry of Interior had revised the Design Regulations of Seismic Resistant Building in Dec. 1999 and Jul. 2005 to enforce the seismic sustainability of all buildings. In response to these regulation revisions, we had wholly assessed the plant design in 2002 and 2004 and had proved that the plan design satisfied all the requirements of the first regulation revision (Dec. 1999). Recently, we also had proved that the original plant design satisfied the second regulation revision too. All the results showed that the plant is seismically safe.

2. During the early stage of the construction of MSNPP, the Hengchun Fault was classified as a suspicious fault in early survey. However, recently the Central Geological Survey had reclassified this fault as a category II active fault because of the results monitored by precision scientific instruments. Accordingly, MSNPP reassess the impacts of the Hengchun Fault to the design basis as follows:

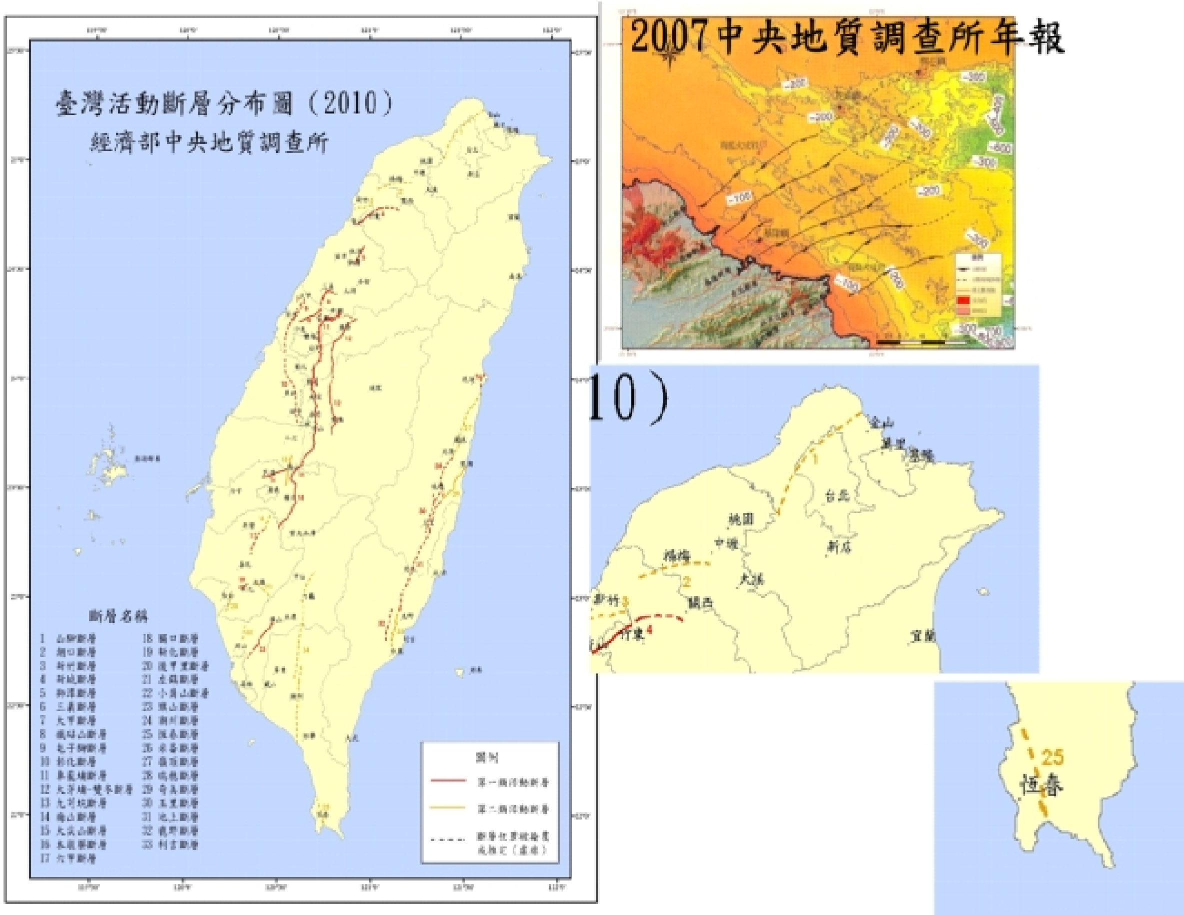
According to the Special Report 23 (December 2009) published by the Central Geological Survey, Ministry of Economy, the Hengchun Fault is a thrust fault extending in North North-West direction. It extends from the estuary near Checheng Village, Pingtung County to the South Bay of Hengchun Township. The total length of this fault is about 16 km. Hengchun Fault cutting into the late Pleistocene limestone layer was temporarily classified as category II active fault.

Based on the information and data published by the Central Geological Survey, Taipower had contracted to National Central University to study:

(1) NPP site vibration characteristics and its earthquake response (completed in May, 2009).

(2) The impacts of Hengchun Fault on the dynamic characteristics of MSNPP (completed in Nov. 2010).

The preliminary results of these studies are shown in the following tables. The base rock acceleration of MSNPP caused by Hengchun Fault induced earthquakes is about 0.22 g which is smaller than MSNPP design base earthquake SSE 0.4g.



Fault	Length in Land	Length in Ocean	Depth of Epicenter	Magnitude (ML)	Calculated ground surface acceleration
Hengchun Fault	16 km	--------	10 km	6.4	MSNPP: 0.38g

	MSNPP
Calculated ground acceleration due to Hengchun Fault	0.38 g
Calculated foundation bedrock acceleration due to Hengchun Fault	0.22 g
DBE acceleration on foundation bedrock	0.4 g

3. All the buildings in nuclear island were constructed on the mud removed clean base rock. This is mainly for reducing the seismic impacts on the plant structure.

4. Therefore, based on the current available information, it is appropriate that design bases set OBE as 0.2g and SSE as 0.4g. ）

2.1.2 Provisions of the plant to against the DBE

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

To assure that all the key SSC are operable after earthquake, we first have to survey and assure all SSC are in seismic category I. The following are the survey results:

A. Structures

1. Control building ---seismic category I
2. Auxiliary building -- seismic category I
3. Diesel generator building ------------------------------------- seismic category I
4. Containment -------------------------- --------------------------seismic category I
5. Plant ocean water pump --------------------------------------- seismic category I
6. Fuel building -- seismic category I

B. Systems and Components

1. Emergency diesel generator (KJ SYS) --------------------------seismic category I
2. Emergency core cooling system ECCS (RHR、CCP) --------seismic category I
3. Reactor cooling water system (RCS) ------------------------- -seismic category I
4. Containment spray system (BK SYS) ------------------------- seismic category I
5. Component cooling water system (CCW) ---------------------seismic category I
6. Essential chiller system (GJ SYS) -------------------------------seismic category I
7. Nuclear service cooling water system (NSCW) ----------------seismic category I
8. Chemicals and volume control system (BG SYS) ---------------seismic category I
9. Auxiliary feed water system (AL SYS) ---------------------------seismic category I

Since all items in seismic category I can sustain the earthquake up to 0.4 g acceleration on the base rock, the SSC can assure its operability to achieve safe shutdown after design base earthquake.

2.1.2.2 Main operating provisions

The operator crew will conduct SOP 582/582.1 if any or all of the following signal lamps are ON during earthquake. Those are Alarm Trigger (SG-YS001) light, OBE light and/or SSE light. SOP 582/582.1 were referred to EPRI report NP-6695 (Dec.1989) "Guideline for Nuclear plant Response to an Earthquake" which had been endorsed by NRC RG 1.166 Rev.0 "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Post Earthquake Actions" and NRC RG 1.167 Rev.0 "Restart of a Nuclear Power Plant Shutdown by earthquake".

1. Operation Procedures after Severe Earthquake AOP582

   (1). Objective: As a guideline to inspect the operability and functionality of systems and equipment after severe earthquake. Suitable actions can be taken after the inspections.

   (2). Brief descriptions: (details see appendix 1)

      a. If the earthquake at MSNPP reaches the SSE or OBE condition, the operator crew has to assure proper reactor scram**.** The operator has to conduct reactor scram manually if it is not at emergency shutdown. After that the crew will follow the emergency operating procedure EOP 570.00 to conduct all necessary actions. The emergency mobilization is according to the emergency response action basis guideline defined in the category 1401-H "Nature disasters and other reactor safety threats"**.** If the seismic scale was above SSE and a tsunami alarm was declared by the Central Weather Bureau, then SOP 1451 "Reactor Ultimate Response Guidelines" also has to be implemented.

      b. If the seismograph triggers an alarm, but the earthquake neither reaches to the SSE set point nor to the OBE warning level, then the on-shift manager /on-shift director has to follow the operating procedure to conduct inspections on reactor system and equipment and determine whether the reactor can be operate continuously or sequential shutdown or emergency manual shutdown.

      c. If the seismic epicenter is in the near sea, a tsunami may be induced. Closely watch out the information provided by Central Weather Bureau and carry out the procedure 582.2 if necessary.

      d. Carry out preliminary system evaluation to determine whether the reactor has to be cooled down to cool shutdown stage.

2. Equipment Inspection Procedure after severe earthquake AOP582.1

   (1) Objective: This procedure provides guidelines as well as details to conduct system and equipment inspection during earthquake shutdown and reactor restart period. The systems and equipment may have been damaged by the earthquake. This procedure provides the inspection items as well as their inspection contents of the equipment. If the seismic scale is above OBE, then a long term evaluation is required. To prepare for reactor restart, a special mission team will be organized to review the inspection results. The results will further be reviewed by SORC and Taipower review. The inspection report as well as the review report shall be approved by AEC before the reactor restart if AEC request. If the equipment

damage reaches to EPRI 3 level, then the long term evaluation report shall be approved before reactor restart.

(2). Brief description: (details see appendix 2)

a. The plant should organize a special mission team to perform detail system and equipment inspection. The team includes members from mechanical, electrical, instrument & control, maintenance, improvement, waste management, health physics, nuclear technology, quality assurance divisions as well as reactor operators. If real time equipment operation is required, then the on shift operator should join to operate in coordination. The team will also acquire specialists from Taipower headquarters or outside sources. The team leader is nominated by the plant director. He is responsible to summarize and evaluate the inspection results from the different divisions. He also needs to determine whether the equipment damage reaches to EPRI level. The final report is sent for SORC review.

b. After seismic shutdown, the maintenance crew should sequentially and thoroughly inspect all equipment listed in SOP. Any body or functional damage should be photo for evidence. A meeting shall be called if the damage is not apparent to judge.

c. If the maintenance division judge that the equipment damage may affect it usability. In addition to take necessary damage repair, they also need to inform the on-shift director to record the damage and to carry out actions according to the guidelines of liming conditions for operation.

d. In case the safety related equipment has tangible or functional damage, or the non-safety related equipment has the damage level larger than 1, the maintenance crew should follow the procedure to broaden the vision inspection scope.

e. If the seismic scale is above OBE, a long term evaluation should be conducted to estimate the seismic impacts on all safety related equipment/structures and to decide whether a nondestructive test (NDT) is required. It must be assured that the NPP can sustain another earthquake. Worldwide specialists should be invited if necessary.

2.1.2.3 Indirect effects of the earthquake taken into account

1. Any structures, systems, and components not related to safe shutdown but adjacent to safety related structures, systems, and components (SSC) are upgraded to an upper seismic resistance level. This is to ensure that the collapse of the non-safety related equipment would not affect the safety related ones.

2. Lost of off-site power:

   Since the off-site power grid is not built in accordance with requirements for seismic category I equipment, it is possible that the transformers related to the off-site power may be damaged during earthquake. The 345 kV, 161 kV off-site powers and the third power as well as the gas turbine generator can not supply power to the ESF Bus to support the power for safe shutdown related equipment. In this case, the ESF Bus will be supplied by train A and/or train B emergency diesel generators (EDG) which are seismic category I equipment.

Even in the case that any one of the train A or train B EDG was failed. The fifth EDG which is also seismic category I will take over to supply power to the safe shutdown related equipment.

In case all AC powers were lost, the reactor will scram and NPP will be in the SOP 570.00 stage followed by SOP 570.20 Station Blackout stage.

3. Personnel and equipment-can not reach the plant due to road blockade caused by earthquake:

(1). Use heavy machine to obviate the blockades.

(2). Use sea transportation to carry in personnel and equipment. MSNPP had built and owned a heavy duty harbor wharf.

(3). Use air transportation to carry in personnel and equipment. The Hengchun airport is only 7 km away from MSNPP. We can use civil airplanes and helicopter to carry personnel and equipment.

(4). events happen

a. If the events happen during normal office hours:

(a) The operator can not reach the plant to take over the shift, the personnel in simulator center and the mobile supporting personnel (most of them are certified licensees) take over or help the reactor operator.

(b) There are constantly about one hundred personnel including maintenance staff and long term contract personnel. It is enough to support any urgent equipment maintenance.

(c) Normally there are 10 firemen on duty. According to Station Emergency Response Organization, the plant can organize an emergency fire-fighting team up to 60 firemen.

b. If the events happen not during normal office hours:

(a) Use any available transportation to carry in all standby maintenance personnel (including mechanical, electrical, Instrumentation, and maintenance technical staffs) in Fengshan and Wuchia dormitories. We can also recruit long term contract technicians who live nearby MSNPP to support urgent maintenance.

(b) The fire-fighting team is currently contract out. During non office hours, only 6 firemen are on duty. But it is easy to collect other contract firemen during emergency since most of them live in Hengchun. In addition, the plant security policemen can also support firefighting if needed.

4. All important oil tanks have built overflow walls. The volume between the tank and overflow wall is larger than the oil tank itself. Since the oil will not overflow, the fire happens during the earthquake would not spread to threaten the safety related equipment or affect the fire-fighting activities.

5. Although the cranes in the plant buildings have no specific parking positions according to the operating procedure, every crane does have its own parking place in practice. MSNPP has inspected and assured that even if the crane falls during earthquake, it will not damage any safety related equipment nearby. Each crane parking position had redefined in related operating procedures.

6. Response to earthquake induced fire:

(1) MSNPP has completed inspections and tests on all fire protection equipment according to fire protection maintenance procedures. No abnormal events were found in automatic fire water spray system, automatic CO2 spray system, foam spray suppression system, automatic halon fire extinguish system, and fire hydrants.

(2) All fire protection equipment in safe shutdown related zone is classified as seismic category I. Even the pump, the pipe, CST are all classified as seismic category I..

(3) MSNPP is carrying on an upgrading program to make the reactor raw water fire protection underground pipes exposed and to improve the seismic resistance of the raw water tank and its related pipes.

(4) The plant has onsite a fire brigade and a number of fire trucks in readiness. They can obtain necessary fire-water from various sources.

7. Excavation and backfill

During construction period, surface accumulation layer and weathered mudrock were excavated and plant structure building is located directly on fresh mudrock layer (FSAR Appendix 2B, Fig 2B-1, 2B-7, 2B-8, 2B-9). Non-structure building is located in the backfill area to ensure structural seismic capacity. After commercial operation, the update of buried piping the excavation and backfill for the replacement of piping or new buried piping follow plant procedure 1261 “Excavation and backfill”, to ensure that the excavation and backfill will not affect plant structure and piping’s seismic capability. According to the result of long-term sinking-line measurement, no sinking or unbalance sinking of plant buildings has been observed.

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. To ensure the compliance with the licensing base, the plant usually follows the 600 and 700 series SOP to conduct the inspection, test, and maintenance of all safety related systems, structures and components.

2. Post earthquake inspection and test will follow the procedures listed below:

   a. Procedure 582—procedure for strong earthquake.

   b. If seismic scale is larger than OBE, the reactor scram or the safety cooling injection system initiates during conducting SOP 582, the crew will then follow EOP 570.00. If all AC power were lost, then follow EOP 570.20.

   c. Follows SOP 582.1 "Inspection procedures of the equipment after earthquake induced reactor scram" to conduct detail inspection.

   d. Follows SOP 700-A-001 "Inspection procedures of the structures inside and outside the plant.

2.1.3.2 Licensee's organization for mobile equipment and supplies

The plant's supporting and standby equipment and supplies are listed in the following table (category A, prepared before 6/30/2011):

No.	Item	Specifications	Power	quantity	Usage	Storage	Procurement schedule	Section	Inspection /test period
1	Oil Absorbent boom	Double layer, L=10' D=8" absorb cap = 20gal/set	NA	10 set	Oil absorb	Warehouse-D (26M)	completed	Chemical	Annually (March)
2	Hand-operated oil extractor pump	55 cm x1.5 cm 6.5 L／m	NA	5 set	Oil absorb	Warehouse-D (26M)	completed	Chemical	Annually (March)
3	Wood sawdust	powder	NA	50 kg	Oil absorb	Pump room (8M)	completed	Chemical	Annually (March)
4	naphthalene	Non-ionic surfactant	NA	50 L	Oil resolvent	Warehouse-D (26M)	completed	Chemical	Annually (March)
5	Oil Absorbent Pad	17"x19" absorb cap. = 0.38gal/set	NA	2000 set	Oil absorb	Warehouse-D (26M)	completed	Chemical	Annually (March)

6	truck	15 ton x 1 11 ton x 1 6.5 ton x 1	diesel	3 set	transportation	Garage (24M)	completed	supply	monthly
7	Gasoline-driven water pump	Flow rate: 1100LPM Lift height: 30 m Horse power: 5.5 hp (fuel consumption: 1.0 L/hr)	gasoline	12 set	Temporary water pump	Crane garage (24M)	completed	repairs	monthly (SOP 192)
8	Electrical sump pump	Flow rate: 300LPM Lift height: 10 m Horse power: 1 hp	electric	8 set	Temporary water pump	Tool warehouse (15M)	completed	repairs	monthly (SOP 192)
9	Diesel generator	Rated current: 301A@240V, 150A @480V Rated power: 125kVA Output voltage: 110V, 220V, 480V	diesel	1 set	Temporary power supply	North fence of Maintenance building (15M)	completed	repairs	weekly (SOP 193)
10	Multipurpose power supply	Rated power: 24kVA Output voltage: 110V, 220V	diesel	3 set	Temporary lighting	North and southwestern fence of Maintenance building (15M)	completed	repairs	Weekly (SOP 194)
11	Snake pipe	Adapted to sump pumps	NA	20 set	Temporary water pump	Tool room and crane garage (15/24M)	completed	repairs	monthly (SOP 192)
12	Elevation truck	Max. load: 150 kg Max. lift: 12 m Max. working radius: 7 m	diesel	1 set	High altitude operation	Crane garage (24M)	completed	repairs	Monthly (SOP 193)
13	Forklift Truck	23 ton x 1, 12 ton x1, 8 ton 1 x 1, 7.5 ton x 1, 5 ton x 1, 4 ton x 5	diesel	10 set	Material transportation	Crane garage (24M)	completed	repairs	monthly (SOP 190)
14	Tractor	35 ton x 1 60 ton x1	diesel	2 set	Material lifting and assembly	Crane garage (24M)	completed	maintenance	monthly (SOP 190)
15	Crane truck	225 ton x 1, 200 ton x 1, 90 ton x 1, 80 ton x 1, 60 ton x 1, 20 ton x 1 10 ton x 1	diesel	7 set	Material lifting and assembly	Crane garage (24M)	completed	repairs	monthly (SOP 190)
16	chain operated crane truck	0.5~3 ton	NA	50 set	Material lifting and assembly	Crane garage (24M)	completed	repairs	Annually (SOP 190)
17	Mobile generator	Output voltage: 110v/220v (model: KOSIKA KG3500)	gasoline	14 set	Fume exhaust	Buildings of unit 1 and 2 (15M)	completed	repairs	monthly (SOP 192)

		(fuel consumption:1.7 L/Hr @2.8kVA)							
18	Fume exhauster	5700 fpm	electric	14 set	Fume exhaust	Buildings of unit 1 and 2 (15M)	completed	repairs	monthly (SOP 192)
19	Fire Tanker	Capacity: 7000 L Operation pressure: 4～15 ㎏/㎝ ^{2} flow rate: 460～890 LPM equipped with mobile communication	diesel	1 set	Fire fighting	Onsite Fire station (24M)	completed	Ind. safety	Inspect on test driving
20	Chemical Fire truck	Water capacity: 3500L Bubble capacity: 500L powder capacity: 250kg operation pressure: 4～15 ㎏/㎝ ^{2} flow rate: 400～750 LPM equipped with mobile communication	diesel	1 set	Fire fighting	Fire-fighting station (24M)	completed	Ind. safety	Inspect per test driving
21	Firefighting equipment truck	Aerial flare, Fume exhauster 110V/220V generator and associated cable Destroying tools Rescue spare parts equipped with mobile communication	diesel	1 set	Fire fighting	Onsite Fire station (24M)	completed	Ind. safety	Inspect per test driving
22	Firefighting command car	Operational pressure: 4～15 ㎏/㎝ ^{2} flow rate: 460～890 LPM equipped with mobile communication	gasoline	1 set	Fire fighting	Onsite Fire station (24M)	completed	Ind. safety	Inspect per test driving
23	Mobile fire pump	Operational pressure: 4～15 ㎏/㎝ ^{2} flow rate: 460～890 LPM fuel consumption: 9.0 L/hr	gasoline	3 set	Fire fighting	Onsite Fire station (24M)	completed	Ind. safety	monthly
24	Self-contained Breathing Apparatus	Onsite Fire station: 9L/300bar/60m x 22 Plant buildings: 9L/300bar/60m x 78	NA	100 set	Fire fighting	Onsite Fire station and plant buildings	completed	Ind. safety	semi-annually
25	Mobile fire water monitor	Operational pressure: 4～15 ㎏/㎝ ^{2} flow rate: 460～891	Fire truck	6 set	Fire fighting	Onsite Fire station (24M)	completed	Ind. safety	Every 4 month

		LPM							
26	Mobile generator	110v/220v (model: KOSIKA KG3500) fuel consumption: 1.7 L/hr @2.8kVA	gasoline	3 set	Fire fighting	Onsite Fire station (24M)	completed	Ind. safety	monthly
27	Fume exhauster	5700 fpm	electric	3 set	Fire fighting	Onsite Fire station (24M)	completed	Ind. safety	monthly
28	Sand bag	20 kg/bag	NA	170 set	Fire fighting	Onsite Fire station (24M)	completed	Ind. safety	semi-annually
29	Flexible pipe	1"ψ	NA	100 m	Water drain	#1 auxiliary building 74'	completed	Waste management	semi-annually
30	Flexible pipe	1"ψ	NA	100 m	Water drain	#2 auxiliary building 74'	completed	Waste management	semi-annually
31	Flexible pipe	3/4"ψ	NA	100 m	Water drain	#1 auxiliary building 74'	completed	Waste management	semi-annually
32	Flexible pipe	3/4"ψ	NA	100 m	Water drain	#2 auxiliary building 74'	completed	Waste management	semi-annually
33	Pneumatic pump	Suction lift= 6 m	Comp. air	1 set	Water drain	#1 auxiliary building 74'	completed	Waste management	semi-annually
34	Pneumatic pump	Suction lift= 6 m		1 set	Water drain	#2 auxiliary building 74'	completed	Waste management	semi-annually
35	Pneumatic pump	Suction lift=10 m	Comp. air	1 set	Water drain	#1 auxiliary building 74'	completed	Waste management	semi-annually
36	Pneumatic pump	Suction lift=10 m	Comp. air	1 set	Water drain	#2 auxiliary building 74'	completed	Waste management	semi-annually
37	Mobile generator	Output voltage: 110V/220V (model: KOSIKA KG3000) fuel consumption: 1.5 L/hr @2.3kVA	gasoline	4 set	Standby power for Radiation Detector	#1/#2 radiation protection classroom (15M)	completed	Health physics	monthly
38	Air compressor	Capacity: 6 L Output pressure: 8 ㎏/㎝ ^{2} Horse power: 2 hp	electric	3 set	Pneumatic operation	Rescue equipment warehouse (tool warehouse) (24M)	completed	Mechanical	Every 4 month

2.1.3.3 Deviations from CLB and remedial actions in progress

1. According to SOP 192 “Procedures of rescue equipment maintenance and management”, mobile equipment including mobile diesel generators, gasoline engine water pumps, etc. must be inspected, tested, and properly maintained to operable conditions.

2. If any fixed equipment related to safety protection system was deviated from its normal condition, the following procedures must be conducted:

   (1) The crew on shift must follow SOP 1102.01 to file a maintenance request to fix the abnormal condition. He also has to judge and determine whether the abnormal condition meets the Limiting Conditions for Operation (LCO) in the reactor operation regulation guide and technical manual. If the safety system was affected, a non-operable tag and report must be announced according to SOP 113 “Procedure to report abnormal events”.

   (2). The safety team staff must issue a NCD quality nonconformance notice. If the nonconformance is related to 10CFR21, then it must be reported to responsible agency.

   (3). The maintenance request and the NCD notice must be issued or filed according to the following procedures:

   a. If the nonconformance may cause potential reactor scram or is related to critical component/environment maintenance, then follow SWP 112 “Standard Working Procedures for maintenance involving potential reactor scram/turbine trips or other risks”. (Experience feedback 1)
   b. Hang on “no operation” tag according to procedure 1114.03 “Procedure for forbidden operation control tag”.
   c. Conduct quality check according to procedure 1110.01 “Procedures for Quality Checks”.
   d. Conduct maintenance according to procedure 1115.03 “Procedure for Code Repair and Replacement during Commercial Operation”.
   e. Conduct maintenance according to procedure 1115.02 “Procedure for Temporary Non-Code Repair”.
   f. File a Design Change Request (DCR) according to procedure 1103.01 “Procedure for Plant Design Change Control”.
   g. File an EMR according to procedure 1103.04 “Procedure for Plant Equipment Modification Control”.
   h. File a request to change the equipment set points according to procedure 1102.02 “Procedures to Change the Instrument and Electrical Equipment Set Points”.
   i. File a temporary modification request according to procedure 1102.03 “Procedure for Temporary Change to Equipment Set Point or Replace It, Temporary Piping Disassembly, Temporary Jump Connection”.

2.1.3.4 Specific compliance check already initiated by the licensee

1. To response to the evidence found on Hengchun Fault, Taipower has accelerated his survey on geology and the evaluation of NPP seismic resistance. The work flowchart is shown in appendix 3 and will be executed in three phases:

(1) Planning phase

A project “A re-evaluation of the geological stability and earthquake impact on nuclear power plants” was contracted to Institute of Nuclear Energy Research (INER) on 12/30/2009. This project is mainly to plan a regional sea / land geology survey and geological specialist review program.

(2) Survey phase

A project Complementary geological survey for operating nuclear power plant was contracted to Sinotech Engineering Consultants, Ltd. on 11/10/2000. This project includes the sea and land geological survey, geophysical probing, topographic survey, and various geological testing near nuclear power plants. The project is expected to be completed ~~in~~ by Dec. 2012.

(3) Evaluation phase

a. Contract to NPP original design company, Pacific Engineers and Constructors, Ltd. (PECL), to conduct a Seismic Margin Assessment (SMA). The company will evaluate the plant equipment capability of the reactor safe shutdown and the residual heat removal if the seismic level was beyond the design basis. This contracted project will be completed by Dec. 2013. The company will conduct necessary seismic resistance reinforcement based on the evaluation results.
b. Conduct Seismic Probabilistic Risk Assessment (SPRA) according to the guideline issued by American Society of Mechanical Engineering (ASME) in2009.

2. A direct interconnection between MSNPP and the early earthquake and tsunami warning system of Central Weather Bureau has been established. The warning and maintenance mechanism has also been implanted to collect the information from Central weather Bureau. This mechanism will help to further improve the earthquake response of MSNPP.

3. Taipower Company has invited the Central Weather Bureau to help MSNPP to set up ~~an~~ earthquake monitoring instruments in underground ~~the~~ wells on the plant site. This monitoring instruments will help monitoring the plant basis seismic scale more effectively.

4. The following actions will be executed after MSNPP lost of its offsite power:

(1) If both emergency diesel generators (EDG) of train A and train B failed, then after disconnecting the electrical interlock the 5th EDG will supply power to one ESF Bus of both

unit 1 and unit 2 simultaneously. If one of the EDG of train A or B is functional, the functional DSG can also supply power to the ESF Bus of the other unit after disconnecting the electrical interlock.

(2) If all the AC power supply can not recovered and would not be recovered in a short term, then following SOP 1451 “Reactor Ultimate Response Guideline”, the mobile diesel generators will be applied to the equipment that need AC or DC emergency power.

5. The following actions will be executed if the offsite roads were blocked due to earthquake and it was not normal office time. (1) Mobilize the registered 103 personnel with special skill (include operators) in Hengchun area to help plant operation. (2) Mobilize contract vendors’ workforce to help the plant equipment maintenance. The contract vendors’ workforces are also registered in the list according to their expertise.

6. All cranes in essential plant buildings must be parked at their specific positions defined in the related SOP. MSNPP has also installed locking devices between the crane and the horizontal trail to avoid its movement during earthquake.

7. After a comprehensive review of potential accompanied accidents after earthquake, MSNPP will purchase the following equipment and materials to mitigate the accident effects (category B, procured after 6/30/2011).

Equipment, materials and tools procurement planning schedule response to Fukushima Accident (revised 12/16/2011)

No	item	Specification	Power	Quantity	Usage	Storage	Schedule	Division	Inspection /test period
1	Mobile generator	Output: 110v/220v (Model KOSIKA KG3000) Fuel consumption: 1.5 L/hr @2.3kVA	gasoline	2	standby power supply for radiation detectors	#1/#2 Radiation protection classroom (15M)	8/19/2011	Health physics	monthly
2	Sand bag	20 kg/bag	NA	430	Fire fighting	Onsite fire station (24M)	11/30/2011	Ind. safety	semiannual
3	Fire Tanker	Volume Capacity: 12000 L Operational pressure: 10 kg/cm ^{2} Flow rate: 4000LPM Equipped with mobile communication	diesel	1	Fire fighting	Onsite fire station (24M)	6/30/2012	Ind. safety	Inspect per test drive

4	Foam Tender Fire truck	Water capacity: 7000 L Condensed Bubble capacity: 3000 L Operational pressure: 4~15 ㎏/㎝ ^{2} Flow rate: 750~1500 LPM Equipped with mobile communication	diese l	1	Fire fighting	Onsite fire station (24M)	12/26/2011	Ind. safety	Inspect per test drive
5	4.16kV diesel generator	Rated power: 1500KW	diese l	2	temporary Power supply	Rescue equipment warehouse (tool warehouse) (24M)	6/30/2012	electricity	Every 4 month
6	Diesel engine water pump	Flow rate: 600 LPM Lift height: 15 m Suction height: 7m	diese l	30	temporary water pump	Rescue equipment warehouse (tool warehouse) (24M)	10/25/2011	maintenance	Monthly (SOP 192)
7	Diesel engine water pump	Flow rate: 600 LPM Lift height: 65m	diese l	3	standby pump for CST	Rescue equipment warehouse (tool warehouse) (24M)	11/17/2011	maintenance	Monthly (SOP192)
8	Diesel engine water pump	Flow rate: 1600 LPM Lift height: 30m	diese l	2	Fire hydrant pressure boosting	Rescue equipment warehouse (tool warehouse) (24M))	11/17/2011	maintenance	Monthly (SOP 192)
9	Diesel engine water pump	Flow rate: 1000 LPM Lift height: 56 m	diese l	2	Temporary water injection to raw water reservoir	Rescue equipment warehouse (tool warehouse) (24M)	11/17/2011	maintenance	Monthly (SOP 192)
10	diesel generator	Rated power: 370kVA Output voltage: 110V/220V/480V	diese l	10	temporary Power supply	Rescue equipment warehouse (tool warehouse) (24M)	11/17/2011	maintenance	Monthly (SOP 192)

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

1. Taipower utilizes the earthquake damage curve and the seismic resistance analysis results to calculate the earthquake impacts on various safety related systems. The calculation is referred to the analysis of NPP living probabilistic safety evaluation report (Taipower living PRA 1995). The analyst will discuss with NPP senior reactor operators (SRO) to find out the most possible

structures and equipment that would be damaged by earthquake. It is not feasible to conduct failure mode and effect analysis on all equipment since there are too many items in the NPP and the personnel resource is really limited. The followings are the equipment screening rules for failure mode and effects analysis:

(1) Structures or equipment with median seismic resistance equal or less than 0.3 g. (Because the probability of having a seismic 3.0 g scale earthquake is rare.)

(2) Structures or equipment with HCLPF (High-Confidence-of-Low-Probability of Failure) value less than reasonable peak ground acceleration. (HCLPF means, under this ground acceleration, we have 95% confidence that the structures or equipment failure rate is less than 5 %.)

The selected structures and equipment according to the above two screening rules are:

ID number	Structure/equipment	Failure mode	Median seismic resistance (g)
S_{01}	Gas turbine	Coupling cap screw	0.30
S_{02}	Offsite power	General failure	0.40
S_{31}	5^{th} Diesel Generator	Support failure	1.20
S_{05}	Component cooling water pump	Foundation anchor Bolts	1.39
S_{06}	125-V DC distribution panel	Structural	1.48
S_{07}	480-V motor control center	Structural	1.55
S_{08}	Diesel fuel-oil storage tank	Pipe failure due to tank sliding	1.90
S_{09}	480-V load center chatter	Chatter	1.96
S_{10}	Auxiliary/control building	Shear wall failure	2.00
S_{11}	Interposing-logic cabinets	Generic structure	2.01
S_{12}	Component cooling water heat exchanger	Mid support anchor bolts	2.11
S_{13}	125-V DC batteries and racks	Bay connection bolts	2.13
S_{14}	Diesel generator auxiliaries	Tank anchorage	2.17
S_{15}	Refueling water storage tank	Shear failure of tank wall	2.20
S_{16}	Diesel generator	Frame structure	2.23
S_{19}	480-V load centers	Structural	2.40
S_{20}	Diesel engines	Governor Function	2.49
S_{21}	Diesel generator Cabinet chatter	Chatter	2.49

S_{22}	Component cooling water building	Shear wall failure	2.50
S_{23}	4.16 kV switchgear chatter	Chatter	2.60
S_{24}	Essential chilled water pump	Pump hold-down bolts	2.69
S_{26}	Diesel generator building	Shear wall failure	2.80
S_{27}	120-V AC distribution panel	Structural	2.86
S_{29}	Containment fan cooler	Structure column flange	3.00

2. The results of MSNPP PRA event tree due to earthquake is shown in Figure ~~1~~ 2-1. The earthquake derived event trees are shown in the table below. Except the last two trees that can not generate success path because of their low RCS cliff edges, the success path and cliff edge of all other trees have been considered.

MSNPP Earthquake Event Tree Table

Event trees derived from earthquake	Illustrations (AND)	Considered in the success path of the earthquake stress test event tree?
EO	Earthquake Loss of offsite power	YES
EOR	Earthquake Loss of offsite power Loss of RWST integrity	YES
EO5	Earthquake Loss of offsite power 5th EDG damaged	YES
EO5R	Earthquake Loss of offsite power 5th EDG damaged Loss of RWST integrity	YES
EOD	Earthquake Loss of offsite power 1A、1B EDG damaged	YES
EODR	Earthquake Loss of offsite power 1A、1B EDG damaged Loss of RWST integrity	YES
EOQ	Earthquake Loss of offsite power Loss of RCS pressure boundary integrity	NO Since the cliff edge of RCS crack is very low, no new success path can be generated.
EO5Q	Earthquake Loss of offsite power	NO Since the cliff edge of

	1A、1B EDG damaged Loss of RCS pressure boundary integrity	RCS crack is very low, no new success path can be generated.

Analyzing the PRA event tree in Figure 2-1, there are four success paths:

(1) If offsite power was lost due to earthquake → reactor scram → use DC controlled gas turbine to drive auxiliary feed water pump to remove heat → If on site AC power was established (DC power can continue to supply power) → Successful Cool down.

(2) If on site AC power was established → use AC motor to drive auxiliary feed water pump to remove heat → Successful Cool down.

(3) If the heat sink of the secondary loop was lost → use primary loop high pressure water injection and turn on PZR PORV to remove heat (must coordinate with high pressure water injection/recycling mode and containment heat removal mode)→ Successful Cool down.

(4) If the SG standby water makeup (diesel engine fire hydrant) was successful → Successful Cool down.

From the PRA event tree analysis method shown on the figure, based on the definition of cliff edge, the cliff edge level is represented as the lowest item number of the maximal safety margin of all the successful cooling paths, i.e., the 1.48g of success path (1) or (2).

In summary, from the success paths of the event tree along with the safety margin of associated event and Cliff Edge, the following two enhancements will be implemented.

(1) Enhance the strength of the coupling cap screws of G/T to upgrade the seismic resistance of initial events.

(2) Enhance the strength of water pipe between S/G and fire hydrant to the safety margin of path 4.

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

In order to enhance the defense and rescue capability facing various compound disasters, MSNPP has revised and improve related procedures and hardware equipment-shown in the following:

(1) Add 1451 Unit URG which require AC/DC power used for a variety of rescue equipment including steam generator backup replenishment, mobile diesel generator as well as maintaining monitoring function of control room. Meanwhile, evaluate the containment ventilation to prevent from deflagration caused by accumulation of oxygen and containment overpressure. Continue monitoring of spent fuel pool water level and temperature. Take urgent measure replenishment when necessary. Maintain the spent fuel pool cooling. And implement unit cooling capacity guidelines for long-term recovery to prevent power plant from endangered effect.

(2) Proceed the following tables improvement projects, to strengthen compound disasters defense and

rescue ability.

No.		Contents
DCR	M1-4256 M2-4257	Connect fire hose from BL-V023 downstream blind plate to RCS for water makeup. The work was completed on Mar. 12, 2012.
	M1-4258 M2-4259	Connect fire hose from AP-V020 upstream blind plate to CST for water makeup. The work was completed on Dec. 14, 2011.
	M1-4261 M2-4262	Connect fire hose from BN-V005 downstream wash blind plate to CTMT for water makeup. The work was completed on Nov. 8, 2011.
	M1-4273 M2-4274	Add pipes from spent fuel pool to the outside of the fuel building door (of 100 ft size). The work was completed on Mar. 19, 2012
	M1-4304 M2-4305	Add manifolds on the upstream and downstream of AP-P100, 101 I/O isolation valves. The work was completed on Dec. 14, 2012.
	M1-4372 M2-4373	Add spray pipes above the spent fuel pool. The work was completed on Dec. 14, 2012.
	M1-4145 M2-4146	Displace AL-P020 fuel tank (N-AL-T021) and add fuel pipe to make its fuel supplied by auxiliary boiler feasible. The work was completed on Mar. 6, 2013.
	M1-4286 M2-4287	Add hydrogen concentration monitor in the fuel pool building. The design work has been completed and the installation work is in process.
	M0-4285	Add water shield wall and water tight door to the pump building of NSCW. The work was completed on Nov. 9, 2011.
MMR	M0-0683	Add cover board on the intake pool of sea water. The work was completed on Jun. 24, 2011.
	M1-0712 M2-0713	Add fixing stands for fire spray nozzle in spent fuel pool building to allow emergency water makeup from the fire protection system. The work was completed on Feb. 29, 2012.

MNPP intends to add one meter high water proof facilities at the gates of Unit 1 & 2 buildings and other critical equipment. Their location and door number are as follows:

Unit 1:

Sequence No.	Building/Elevation	Door Number	Type (single-leaf or double leaf)	Remark	MMR Number
Emergency Diesel Generator Building (ZD)					
1	D/G, EL.100’	338	Single-leaf	Emergency exit	M1-0735
2	D/G, EL.100’	347	Double-leaf	Anti-flying object door	

3	D/G, EL.100’	337A	Single-leaf	Emergency exit	
4	D/G, EL.100’	339A	Single-leaf	Emergency exit	
5	D/G, EL.100’	340	Single-leaf	Emergency exit	
6	D/G, EL.100’	348	Double-leaf	Anti-flying object door	
Control Building (ZA)					
7	C/B, EL.100’	98	Double-leaf	Anti-flying object door	M1-0737
8	C/B, EL.100’	115	Single-leaf	Emergency exit	
Auxiliary Building (ZA)					
9	A/B, EL. 100’	226	Single-leaf	Emergency exit	M1-0733
10	A/B, EL. 100’	238	Double-leaf	Anti-flying object door	
11	A/B, EL. 100’	255	Single-leaf	West Emergency exit	
12	A/B, EL. 100’	251	Double-leaf	Equipment entrance/exit	
NSCW Building (ZA)					
13	CCW, EL.100’	317	Double-leaf	Equipment entrance/exit	Planning in process
Fuel Building (ZF)					
14	F/B, EL.100’	321	Single-leaf	Inner door	M1-0733
15	F/B, EL.100’	322	Single-leaf	Inner door	
16	F/B, EL.100’	323	Single-leaf	Inner door	
CST Building (ZY)					
17	CST Building 98.5’	10	Single-leaf 3-C-ZY-810	General entrance/exit	Besides M1-0739 2-foot water-proof weir, additional one -foot waterproof facilities are planned to add.(The planned MMR is in process)
18	CST Building 98.5’	11	Single-leaf 3-C-ZY-810	General entrance/exit	

RWST					
19	Refueling Water Storage Tank	12	Single-leaf 3-C-ZY-810	General entrance/exit	Planning in process
Administration Access Control Building (ZG)					
20	Access Control Building EL.100’	1-1	Double-leaf	Frequent use entrance/exit	M1-0737
Radwaste Building (ZR)					
21	R/B, EL.100’	369	Single-leaf	General entrance/exit	M0-0732
22	R/B, EL.100’	371	Double-leaf	General entrance/exit	
23	R/B, EL.100’	372	Single-leaf	General entrance/exit	
24	R/B, EL.100’	379	Double-leaf	General entrance/exit rolling door	
25	R/B, EL.100’	421	Double-leaf	General entrance/exit	
26	R/B, EL.100’	SD1	Single-leaf	Inner rolling door	
New Rdwaste Building					
27	New Fuel Building EL. 100’	Add waterproof gate for the entrance of waste repository tunnel			M0-0889
The 5th Diesel Generator Building (ZD)					
NSCW					
28		NSCW external opening			M0-0853

Unit 2:

Sequence No.	Building/Elevation	Door Number	Type (single-leaf or double leaf)	Remark	MMR Number
Emergency Diesel Generator Building (ZD)					
1	D/G, E. 100’	338	Single-leaf	Emergency exit	M2-0736
2	D/G, E. 100’	347	Double-leaf	Anti-flying object door	
3	D/G, E. 100’	337A	Single-leaf	Emergency exit	
4	D/G, E. 100’	339A	Single-leaf	Emergency	

				exit	
5	D/G, E. 100’	340	Single-leaf	Emergency exit	
6	D/G, E. 100’	348	Double-leaf	Anti-flying object door	
Control Building (ZA)					
7	C/B, EL. 100’	98	Double-leaf	Anti-flying object door	M2-0738
8	C/B, EL. 100’	115	Single-leaf	Emergency exit	
Auxiliary Building (ZA)					
9	A/B, EL. 100’	226	Single-leaf	Emergency exit	M2-0734
10	A/B, EL. 100’	238	Double-leaf	Anti-flying object door	
11	A/B, EL. 100’	255	Single-leaf	West emergency exit	
12	A/B, EL. 100’	251	Double-leaf	Equipment entrance/exit	
NSCW Building (ZA)					
13	CCW, EL. 100’	317	Double-leaf	Equipment entrance/exit	Planning in process
Fuel Building (ZF)					
14	F/B, EL. 100’	321	Single-leaf	Inner door	M2-0734
15	F/B, EL. 100’	322	Single-leaf	Inner door	
16	F/B, EL. 100’	323	Single-leaf	Inner door	
CST Building (ZY)					
17	CST Building 98.5’	10	Single-leaf 3-C-ZY-810	General entrance/exit	Besides M2-0740 2-foot water-proof weir, additional one -foot waterproof facilities are planned to add.(The planned MMR is in process)
18	CST Building 98.5’	11	Single-leaf 3-C-ZY-810	General entrance/exit	
RWST					
19	Refueling Water Storage Tank	12	Single-leaf 3-C-ZY-810	General entrance/exit	Planning in process

Administration Access Control Building (ZG)					
20	Access Control Building EL.100’	1-1	Double-leaf	Frequent use entrance/exit	M2-0738

(3) MSNPP has contracted Sinotech Engineering Consultants, Ltd. to evaluate the seismic resistance of gas turbine generator and the thereafter enhancement. After the enhancement, MSNPP can upgrade his overall seismic resistance of initial events.

(4) MNPP has set up Rescue Strategy MS.1-01 “Actuate Auxiliary Feedwater Pumps by Manual Operated Turbine Generator or Diesel Engine” in Procedure 1451 “Ultimate Response Guidelines”. In case of an emergency DC power loss, auxiliary pumps can be actuated by manual operated turbine generator, to inject water into steam generator. Since the rescue measure is not restricted by DC power seismic capability of 1.48g, cliff edge can be raised to a seismic capability of 1.90g. Hence, the safety margin of success paths (1) and (2) is increased.

2.2.2 Range of earthquake leading to loss of containment integrity

According to the report “The seismic safety margin evaluation of NPP2 and MSNPP at power operation, report-1”, the result is shown in the table below:

Structure	Median ground acceleration
Containment Exterior Shell	5.8g
Concrete Internal Structure	3.3g
Auxiliary/Control Building	2.0g
Diesel Generator Building	2.8g
Component Cooling Water Building	2.5 g
NSCW Pump House	4.4 g

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

1. There is no creek, no water dam, and no potential mudflow inside plant site. Although the highest water level of Lungluan pond is 16.5 m which is 1.5 m higher than the site altitude 15 m, it would not overflow to NPP site because of high mountain separation in between. Therefore

there is no concern of water overflow or mudflow from Lungluan Pond during earthquake.

2. Here are two 50,000 ton raw water reservoirs on the northwest side of the site. The altitude of the two ponds is about 51 m and is 36 m higher than the site. However, it is shielded and separated by high lands from the site. Furthermore, the west side of the storage pools is lower than the pond base. There is no concern of water overflow or mudflow from the raw water reservoirs during earthquake.

3. On the east side of the site, there is a fire water tank with a 5000 ton capacity. However, it is 500 m away from NPP, there is no concern of flood due to its collapse during earthquake.

In conclusion, no above DBF flood will occur even the seismic scale is above DBE.

2.2.3.2 Weak points and cliff edge effects

As stated above, there will be no condition beyond DBF but DBE due to no flooding source existed. There is no weak point and cliff edge effects due to earthquake induced flood in this plant.

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

Although MSNPP has on concern on earthquake induced flood, we will, following the suggestions proposed in the report "Seismic resistance evaluation and structure enhancement of the raw water storage tanks of NPP1,2,3" issued by Sinotech Engineering Consultants Ltd., enhance the structures of the two 50,000 ton raw water reservoir, the 5000 ton fire water tank, and the 2000 ton raw water reservoir to upgrade their seismic resistance.

References

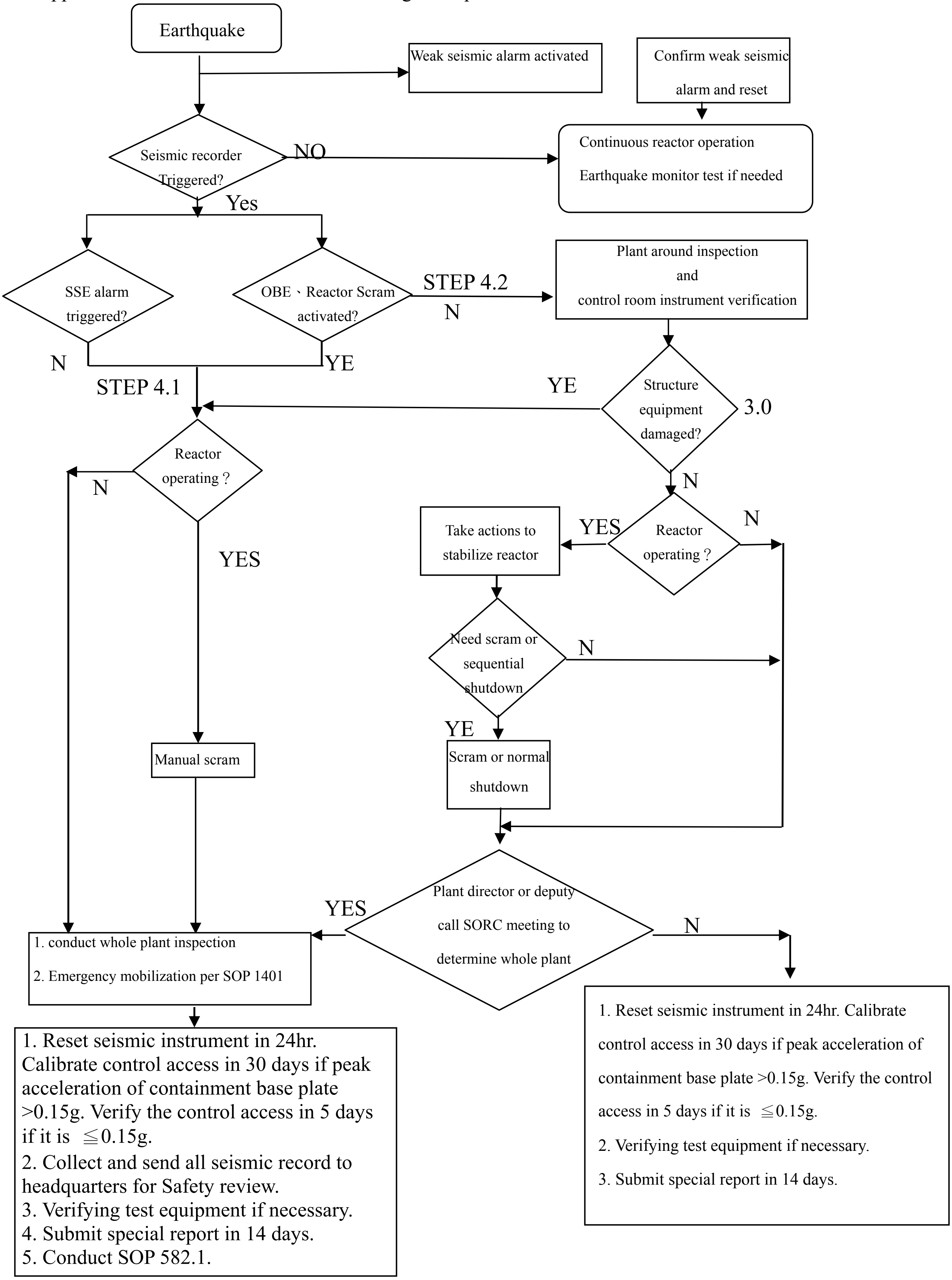
1. 經濟部中央地質調查所特刊第二十三號（2009年12月），中央地質調查所

2. 核能三廠功率運轉活態安全度評估（84年12月），核研所

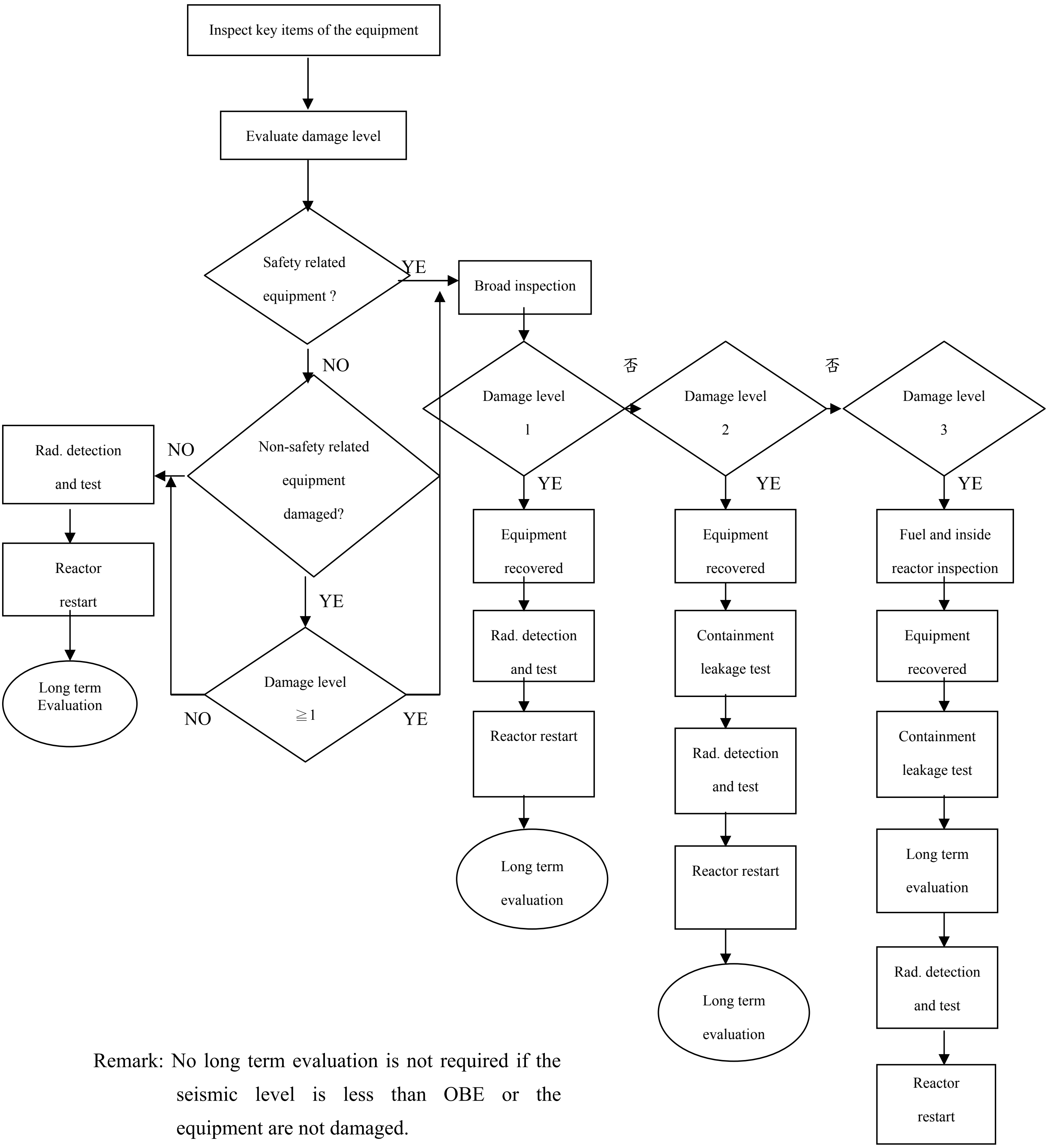
3. 台灣電力公司核三廠期終安全分析報告（FSAR），台灣電力公司

4. 核三廠地震評估PRA事件樹分析，台灣電力公司

Appendix 1: Procedure flowchart after strong earthquake

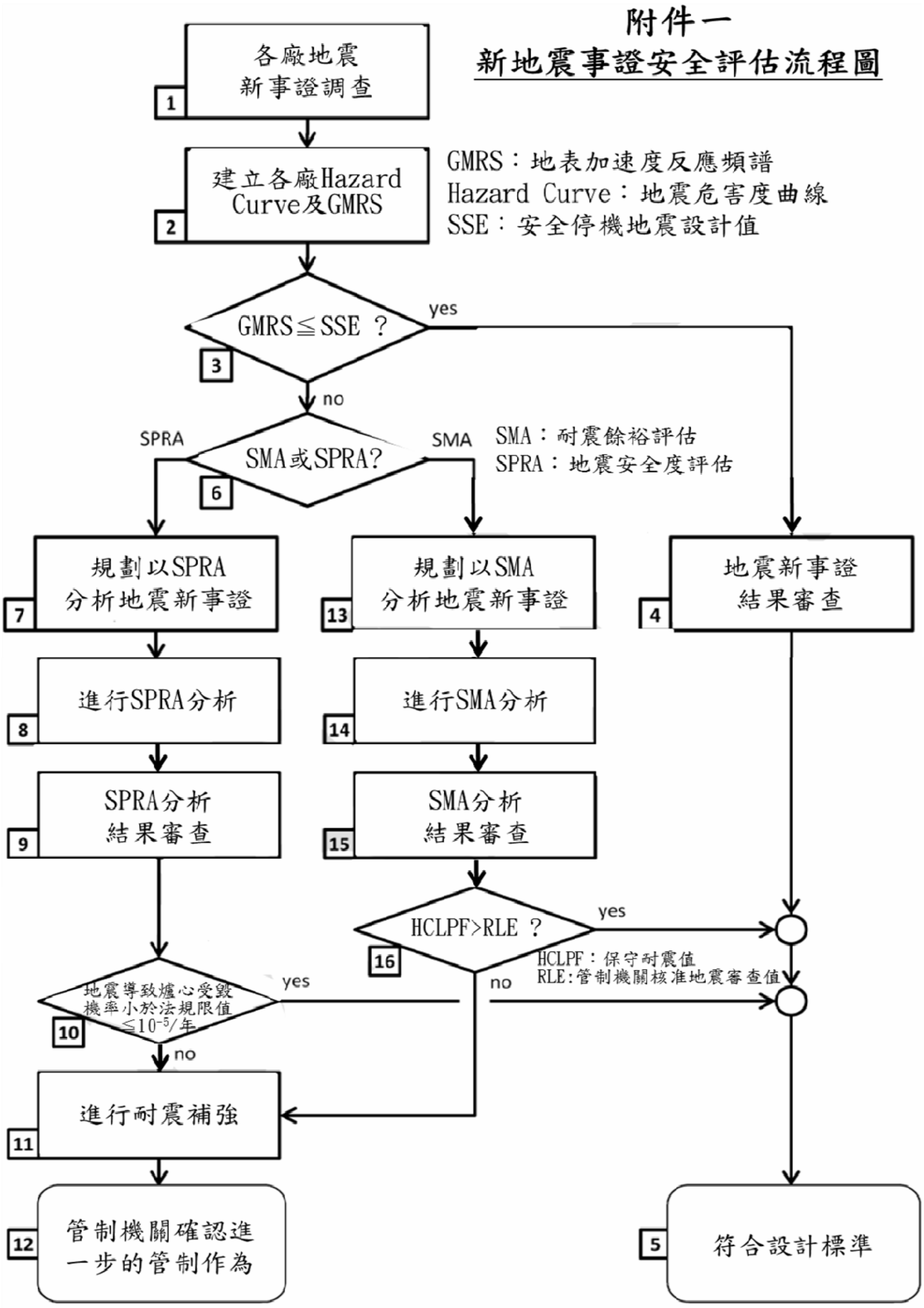


Appendix 2: The evaluation flowchart of earthquake caused reactor shutdown inspection, Testing and reactor restart



Remark: No long term evaluation is not required if the seismic level is less than OBE or the equipment are not damaged.

Appendix 3: The flowchart of seismic safety evaluation process responding to new earthquake evidence.



2B.3 DESCRIPTION OF EXCAVATIONS

Figures 2B-1 through 2B-4 illustrate the yard area excavation along with the deeper power block structural excavations. The original ground surface in the yard area varied from about 15 meters to 34 meters above mean sea level. The general yard area was cut down to approximately elevation 15 meters with enough variation to promote surface drainage over the area. The deeper power block structural excavations were made within the large yard area and extend down to various elevations depending upon the particular structure they are designed to contain. The deepest power block excavations are those for the circulating water discharge tunnels where they exit from the turbine buildings of both units. These extend down to an elevation of 4.9 meters below sea level.

It should be noted that for convenience of design, plant elevations have been converted to the English system with absolute elevation 15.00 meters equalling plant elevation 100 feet 0 inches. Plant elevations are usually expressed in this manner and therefore do not reflect the true elevation (based on the mean sea level datum). In this appendix, elevations expressed in meters are true elevations.

The perimeter slopes of the yard area were made at a gradient of approximately 1:1 (one horizontal to one vertical) with intervening drainage terraces. Power block excavation slopes were generally cut at a gradient of one-half horizontal to one vertical. Several slopes were modified to flatter gradients because of instability. This is discussed in subsection 2B.5.1.

Standard earthmoving equipment accomplished the excavation work. Backhoes performed the final trimming of cut slopes.

2B.4 GEOLOGIC CONDITIONS

2B.4.1 POWER BLOCK AREA

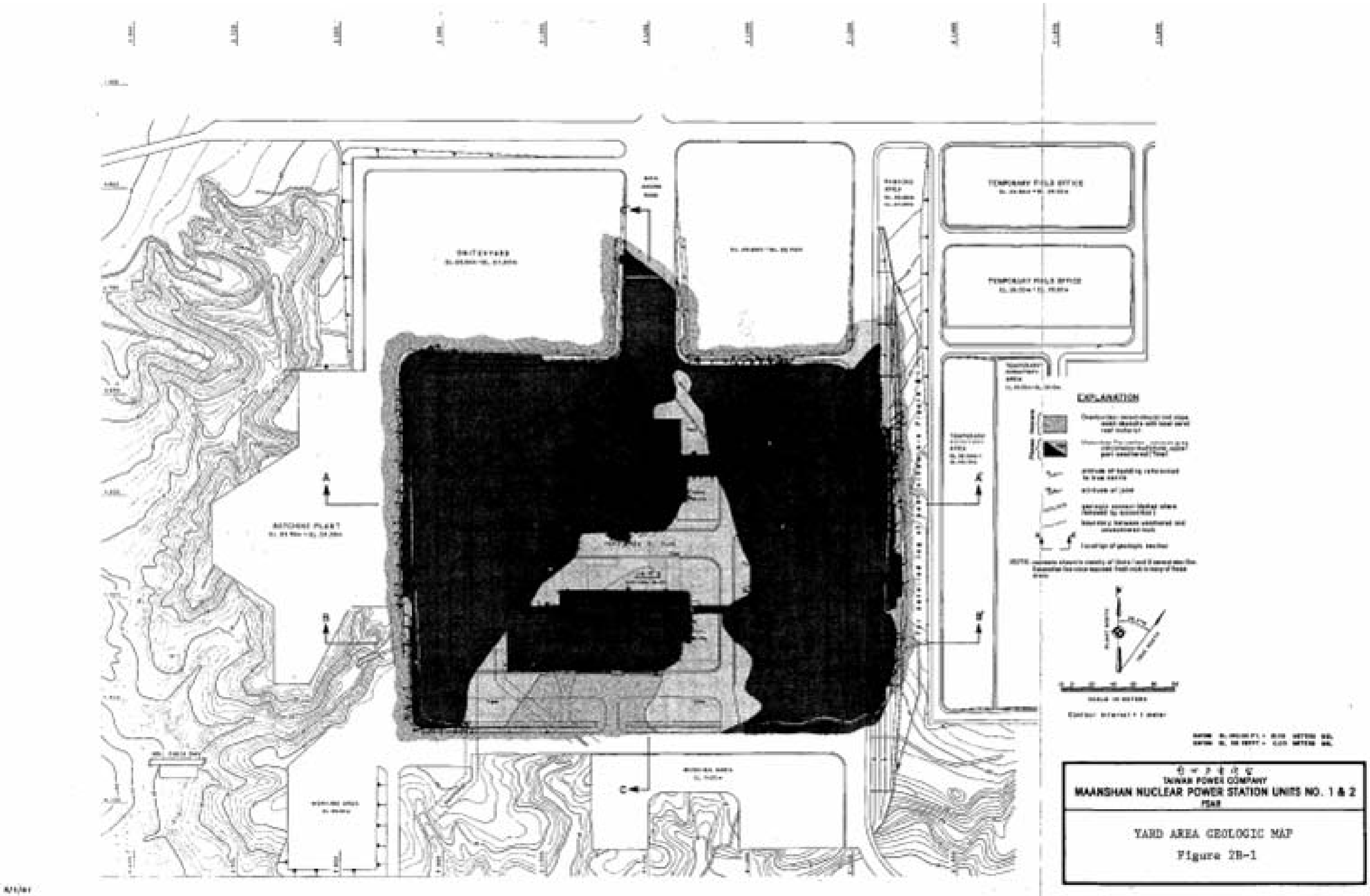
This subsection presents geologic conditions as exposed in yard area and power block excavations. Descriptions of regional geology are found in section 2.5, Report of Hengchun Fault Investigation( ), and Site Selection Report(?).

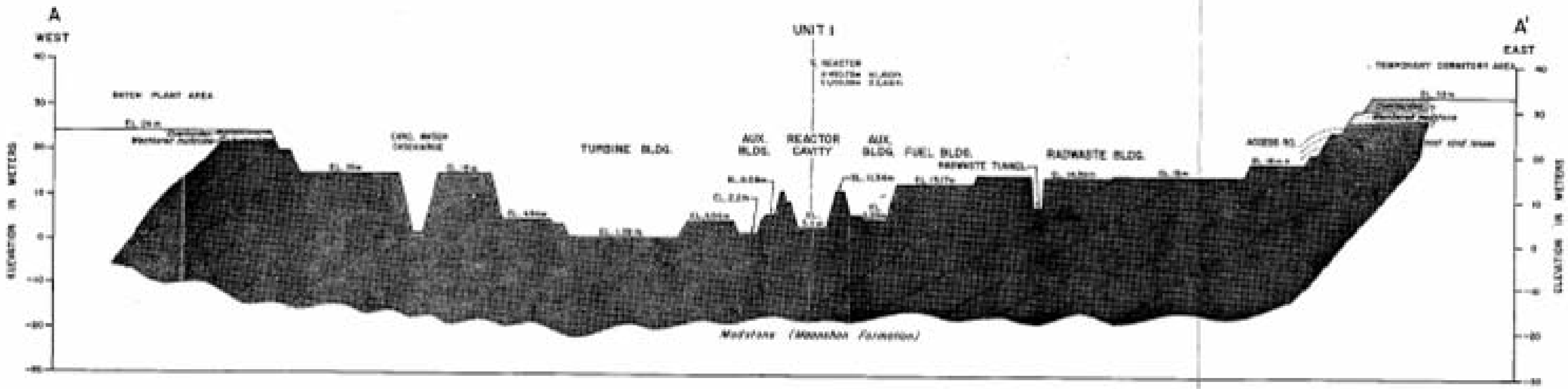
The general surface geology of the yard area is shown in figure 2B-1. Geologic conditions in power block excavations are illustrated by figures 2B-2, 2B-3, 2B-4, and 2B-5. A detailed geologic log of the east slope of the yard area is shown in figure 2B-6 (4 sheets). Subsurface conditions are illustrated by geologic sections, figures 2B-7, 2B-8, and 2B-9.

The power block area excavations exposed gray mudstone covered by a layer of overburden. The upper part of the mudstone is weathered. Figure 2B-1 shown the locations of contacts between overburden, weathered mudstone, and fresh mudstone at elevation 15 meters in the yard area.

Prior to excavation, the overburden in the power block consisted of deposits of brown sandy clay with coral fragments. a layer of well-rounded pebbles and cobbles was locally present at the base. Scattered large coral reef fragments were also present. The clay was generally well consolidated and stiff. Free ground water was present in small amounts in the overburden. Prior to site grading, the overburden in the power block area varied from 0 to slightly over 7 meters in thickness. Much of this has since been removed by the excavation work. Areas where overburden deposits remain are indicated on figure 2B-1.

Fresh unweathered mudstone is the foundation for all major power block structures. The mudstone is a consolidated but uncemented sedimentary rock, has a gray color, and consists primarily of clay and silt with minor amounts of sand. The thickness of the mudstone has not been determined but the rock has been cored to a depth of over 200 meters in the power block area. The mudstone is massive to finely laminated and has abundant joints, most of which are healed or tightly closed. Some joints are filled with black clay.

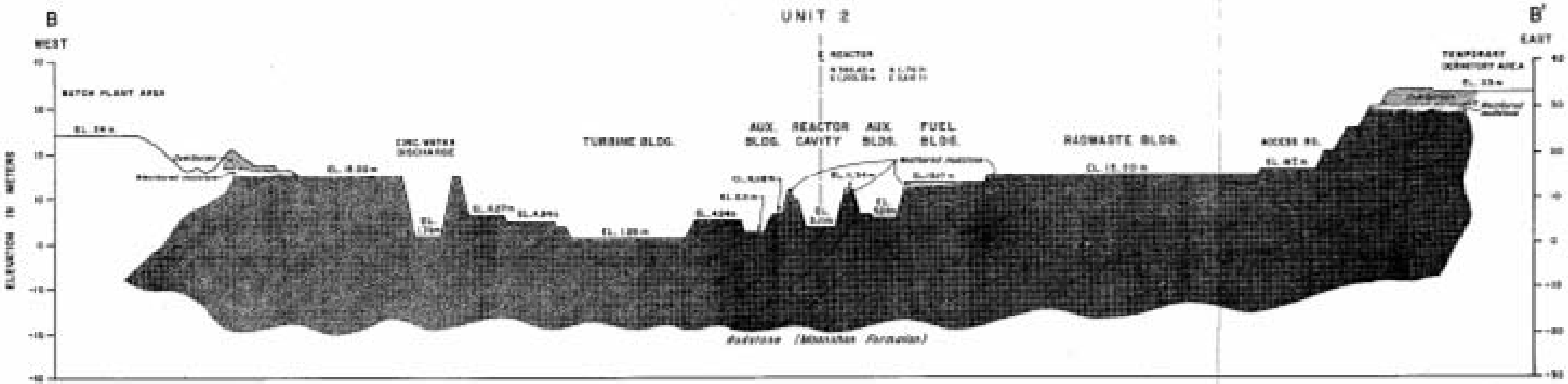

EXPLANATION
TAIWAN POWER COMPANY
MAANSHAN NUCLEAR POWER STATION UNITS NO. 1 & 2
FSAR
YARD AREA GEOLOGIC MAP
Figure 2B-1



MAANSHAN NUCLEAR POWER STATION UNITS NO. 1 & 2

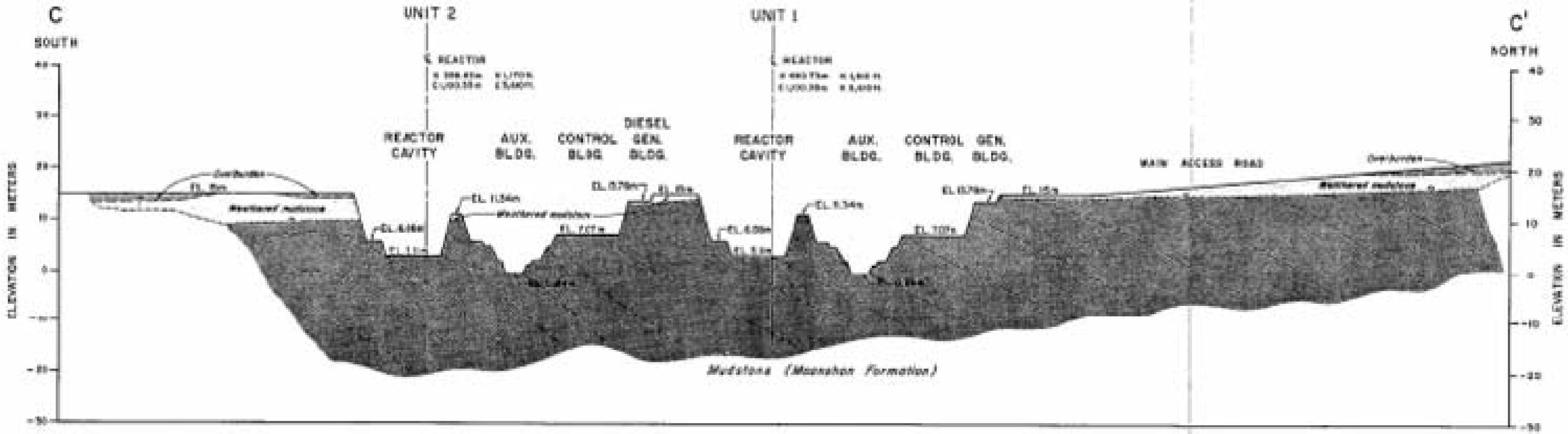
GEOLOGIC SECTION A-A'

Figure 2B-7



TAIWAN POWER COMPANY
MAANSHAN NUCLEAR POWER STATION UNITS NO. 1 & 2

GEOLOGIC SECTION B-B'



NOTE:

GEOLOGIC SECTION C-C'

Figure 2B-9

TAIWAN POWER COMPANY
MAANSHAN NUCLEAR POWER STATION UNITS NO. 1 & 2
FSAR

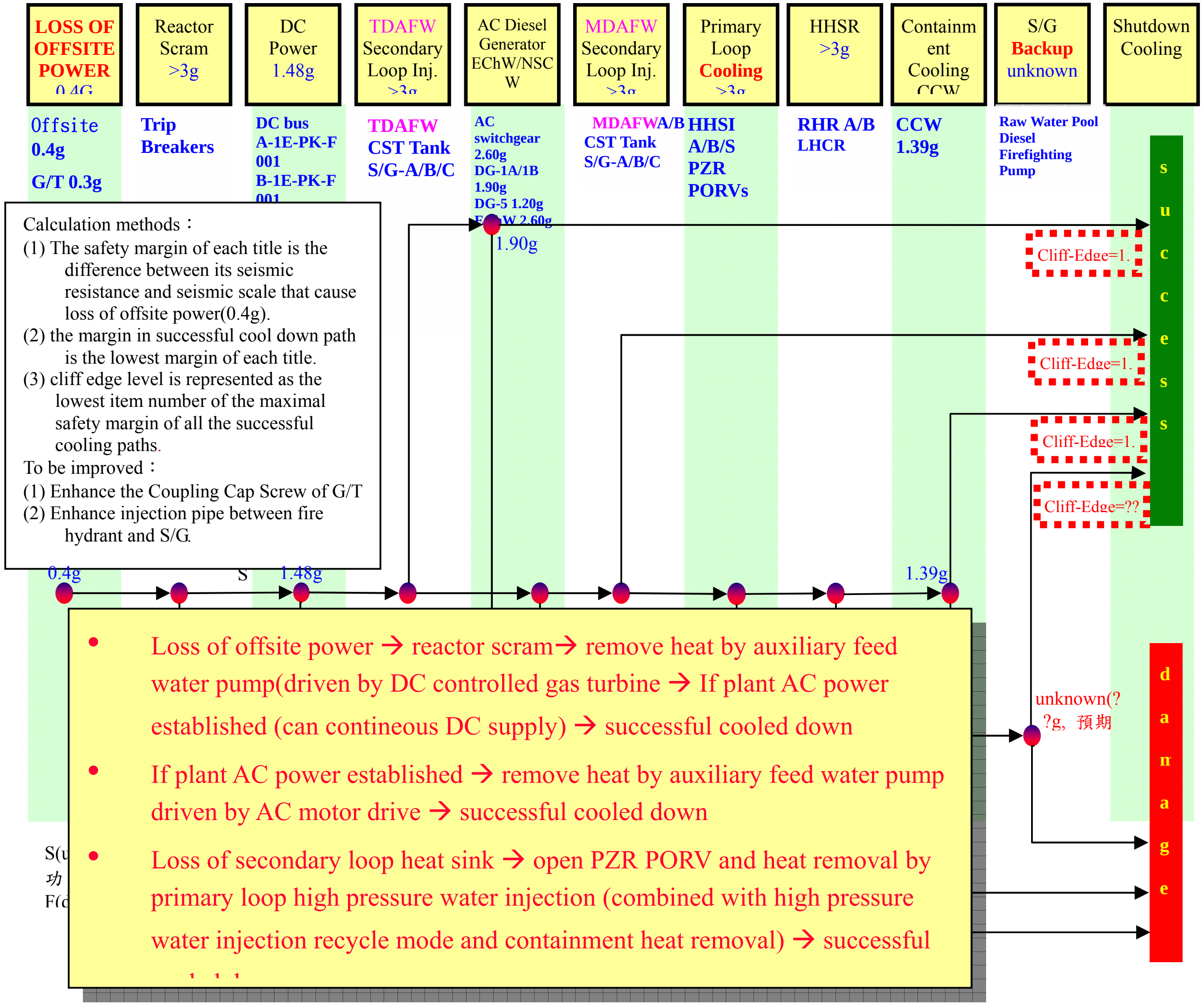


Figure 2-1 Event Tree for MSNPP Seismic Evaluation

3. Flooding

3.1Design basis

3.1.1 Flooding against which the plant is designed

3.1.1.1 Characteristics of the DBF

According to the FSAR of the plant, flooding at the site may happen due to tsunamis or extremely heavy rain and the description of the design basis flood (DBF) the power station should be prepared to fight against is as below:

1. Tsunami:

   The elevation of the plant is 15m above sea water level. Tidal ranges at different locations are different and the maximum tidal range in the historic record of the neighboring oceanic area is 4.03m, which happened at Kaohsiung Port before. Based on the tsunamis run-up height record of the neighboring oceanic region as well as the oceanic stratum structure near the plant, it is estimated that the maximum tsunamis run-up height near the plant is 12.53m. Therefore, there is no concern of tsunamis-induced flooding at the plant.

2. Flooding induced by extremely heavy rain:

   Rainfall records at the Maanshan site are inadequate as a basis for estimating probable maximum precipitation (PMP). However, within the region there are four weather stations which are part of the Central Weather Bureau (figure 2.4-4). These stations, Tawu, Taitang, Kaohsiung and Hengchun, were chosen for estimation of the probable maximum precipitation.

   The maximum hourly rainfall for various return periods of these four stations as calculated by the Gumbel Method is as follows:

Maximum Hourly Rainfall (mm/hr)

Return Period	2.33	10	50	100	200	500	1000	10000	Observation Period
Tawu	61	93	125	139	152	170	184	228	'40-'75
Taitung	51	72	93	101	110	122	131	160	'42-'75
Kaohsiung	54	82	110	122	133	149	160	199	'42-'75
Hengchun	62	85	109	118	128	140	151	183	'42-'75

A comparison of the greatest observed point rainfall in Taiwan and in the region near the site is shown in table 2.4-3 and plotted in figure 2.4-5, the envelope curve of the world's greatest point rainfall. The greatest hourly rainfall of 176 mm in Taiwan is very close to the 10000 year rainfall at Hengchun Station and the envelope curve of short duration in Taiwan, $R=9.9D^{0.6}$, is much lower than the world's envelope curve. Therefore, we recommend using the maximum hourly rainfall of 10000 year return period, R_1 =228mm, as the probable maximum precipitation for the Maanshan site.

3. Flooding induced by tsunamis:

According to the origination, there are three kinds of tsunami which may strike the Maanshan coast: those arising in the eastern or northern Pacific ocean such as the Chile Tsunami and the Alaska Tsunami; those originating in Pashi Channel or Luzon Strait; and those originating in the south China Sea. Tsunamis arising in the Pacific Ocean have no destructive effect on the coast of Taiwan. Because the site is in Nan Wan Bay which has two arms (peninsulas) on either side of the site , the site is protected against tsunamis approaching from the Pacific Ocean. The tsunami record of the Central Weather Bureau, Republic of China, showed that the maximum sea water levels induced by the Chile Tsunami on May 1960, and the Alaska Tsunami on March 1964, were 0.6m and 0.15m respectively. Both of these were due to the recent largest earthquakes having a magnitude (Richter scale) of 8.5. Because this is a severe earthquake, and the water surface elevations raised are small, no further consideration will be given to tsunamis arising in the Pacific Ocean. Attention will be given to the tsunamis generated in the Pashi Channel, Luzon Strait, and in the South China Sea.

Since Nan Wan Bay is open to the south, the site could be affected by tsunamis generated in the Pashi Channel, Luzon strait, and South China Sea. The tsunami-generating mechanism is the shallow earthquake (focal center depth less than 60 km) with high Richter scale. Shallow earthquakes offer the greatest potential for tsunami damage. According to the records of the Central Weather Bureau, no significant tsunami damage in this region has been reported in the past 100 years.

The earthquakes with focal depth greater than 60 km or of magnitude smaller than 6.0 are not considered because they could not cause a tsunami

The refraction diagram of waves propagated from W, SW, and SE directions shows that there is little convergence of wave rate; i.e., there is not much wave height increase in Nan Wan Bay..

To provide the maximum safety to the area, an earthquake magnitude of 8.0 is chosen for tsunami wave study. According to Wilson (1969), the tsunami height near the source could be obtained with given magnitude (M) by equation (1),

$$\text{Log } H = 0.75M - 5.0 \qquad (1)$$

Hence, the tsunami height is 10m with a magnitude of 8.0. Also, from Wilson (1969), the period of tsunami could be determined by equation (2) with given magnitude,

$$\text{Log}T = 0.625M - 3.31 \qquad (2)$$

Then, the period of tsunami with magnitude of 8.0 is 49 minutes where H, T, and M are, respectively, wave height, period, and magnitude of earthquake (Richter Scale).

The wave crest above still water level of tsunami propagating from epicenter to shallow water could be estimated by equation (3),

$$\frac{d}{d_o} = \left(\frac{\sqrt{1 + \frac{h_o}{d_o}} - 1}{\sqrt{1 + \frac{h}{d}} - 1} \right)^{\frac{4}{5}} \left(\frac{\sqrt[6]{1 + \frac{h_o}{d_o}} - 1}{\sqrt[6]{1 + \frac{h}{d}} - 1} \right)^{\frac{6}{5}} \qquad (3)$$

Where, d_o and h_o are the water depth and wave crest, respectively, above the still water level at epicenter. h is the wave crest above still water where the water depth is d. Submarine earthquakes frequently occur at a water depth of 3000m. The tsunami height at epicenter in this case is 5m. Then, the wave crest at water depth of 50m. along the Maanshan coast, calculated by equation (3) is 12.5m. According to the refraction diagrams, however, the energy of tsunami will diverge, and the wave height will reduce about 95%. Consequently, wave height in front of the Maanshan coast will be about 11m.

From Iida (1963) (3) the relationship between earthquake magnitude (M) and tsunami magnitude is given by equation (4).

$$m = 2.61M - 18.44 \qquad (4)$$

The probable maximum run-up elevation for given m can be predicted by Iida`s statistical data. Here, M is taken for 8.0; then the probable maximum run-up is about 6-8m. According to the records of some 100 years, however, not any tsunami disaster has been reported. Wave levels in Kaohsiung Harbor were normal even though a considerable earthquake occurred in Pashi Channel or South China Sea. Hence, Iida`s empirical estimation would be adopted.

The calculated results show that the run-up will be 5.5m and 8.0m for typhoon and tsunami waves respectively.

The elevation of maximum wave run-up on a 1:7 sea dike is determined by the sum of the spring tide rise (4.03m), the storm surge (1.53m) and the typhoon wave run-up (5.5m) or the sum of spring tide rise (4.03m) and tsunami wave run-up (8.0m).

The latter results in higher run-up and is used for determining the elevation of the crest of sea dike. Assuming a 0.5m freeboard, the crest of the sea dike will be 12.53m CDL.

Consequently, when deciding the design basis flood (DBF), only the pump room of the nuclear service cooling system (NSCW) near the coast need to consider the influence of tsunamis and other areas just consider flooding triggered by extremely heavy rain. The plant’s DBF is （1）120mm/hr precipitation intensity once every 100 year, and（2） 228mm/hr precipitation intensity once every 10,000 year .

3.1.1.2 Methodology used to evaluate the design basis flood

Using the Final Safety Analysis Report (FSAR) of the plant as a basis, the description about the methodology used to evaluate the two types of design basis flood, respectively induced by tsunamis and extremely heavy rain is as follows:

1. Design basis tsunamis:

   Because the plant faces toward south, its threat of tsunamis is from Bashi Channel, Luson Strait, and South China Sea, which are induced by superficial epicenters of big massive earthquakes. Thus, if an earthquake that measures 8.0 on Richter magnitude scale induces tsunamis and the tsunamis wave height at the epicenter location is 5m, then the tsunamis wave height at the coast of Maanshan would be approximately 11m, causing the tsunamis run-up height near the plant to be approximately 8m. Conservatively, if the tsunamis run-up height is added with 4.03m of typhoon surge water level and 0.5m of safety margin, then the maximum tsunamis run-up water level at the plant is 12.53m. Consequently, the ground elevation of the main building area at Maanshan Power Station is set to be 15m to prevent the seizure of tsunamis.

2. Design basis flood:

(1) The elevation of the building area (namely the area outside of the plant buildings) is 15m above sea water level, higher than the original potential maximum tsunamis run-up height, 12.53m, evaluated prior the construction of the plant. Hence, there is no concern of tsunamis-triggered onsite flooding.

(2) There are no streams or dams near the plant.

(3) All though the highest water level of Lungrung Lake, 16.5m, is 1.5m higher than the ground of the building area (namely the area outside of plant buildings) in the plant, 15m, there is a natural high land barrier at an elevation of 30m between the lake and the plant. For this reason, there is no concern of the lake water flowing into the plant.

(4) The plant has two 50,000 ton fresh water reservoirs, whose ground elevation is 51.5m. Even though these two reservoirs are 36.5m higher than the ground elevation of the plant building area, 15m, a natural high land barrier separates the pools and the building area. So, there is no concern of the fresh water flowing into the plant.

(5) High elevation around the building area, except the southern part that is near the seas and higher than the ground of the buildings, serves as a natural flood barrier barrier. Accordingly, the drainage system for outside of plant buildings only needs to deal with the precipitation in the building area, and the system is designed to make the precipitation flow into the seas in south by gravity. The building area covers approximately 220,000m^2.

In that existing information indicates that tsunamis do not cause external flooding, the design basis flood (DBF) of the plant mainly focuses on the probable maximum precipitation (PMP) intensity. As previously described, the PMP intensity of the plant is 228mm/hr, resulting in 14 cms of volume flow rate. Its calculation is explained as below:

$$Q = CIA \quad (C=1.0,\ I=228\text{mm/hr},\ A \fallingdotseq 220{,}000\text{m}^2)$$
$$\fallingdotseq 1.0*(228*0.001/3600)*220{,}000$$
$$\fallingdotseq 14\text{cms}\ (\text{m}^3/\text{sec})$$

Hence, the drainage capability of the drainage system for outside of plant buildings is 20cms, equal to the precipitation intensity, 325mm/hr, so the system is capable of responding to the PMP in the building area.

3.1.1.3 Conclusion on the adequacy of the design basis for flooding

Storms, earthquakes and tsunamis happen frequently in the recent years. In response to these global climate changes, the plant has gathered related information from the recent years to be used to estimate and review the adequacy of the original design DBF. The result of the review shows that the original design DBF of the plant is still adequate. The following is the explanation:

1. Consideration regarding tsunamis :

According to the existing analyses and investigation which include "Influence of Tsunamis Induced by Potential Massive Scale of Earthquakes on the Nuclear Power Station in Taiwan" published by NSC(National Science Council) Tsunamis Simulation Team on Aug. 19 in 2011, the potential tsunamis run-up height at Maanshan Power Station is lower than the design basis for tsunamis run-up elevation in the FSAR of the plant. The comparison among the related design basis tsunamis run-up elevations and the actual elevation of the plant is shown in the chart:

NSC simulation result (Note 1)	Tsunamis run-up height analyzed in FSAR (Note 2)	Ground elevation of plant buildings
10.0m	12.53m	15.0m
Note 1: The simulation programming adopts COMCOT; oceanic landscape uses information from a national database. Note 2: This result is analyzed by **Tainan Hydraulics Lab.** in related fields.		

From above table, the ground elevation of the buildings in the plant is higher than the tsunamis run-up height in the NSC simulation result, so tsunamis would not cause flooding at the plant. The exterior entrances/exits at the NSCW pump room is at an elevation of 12.6m. At NSCW Pump House external entrance/exit, MNPP has completed Design MMR-M0-0853 to add 3.5 meters high water-proof facilities which include cement cofferdam wall, water-tight door and top rain covers. In addition, the exterior wall and rooftop exit of NSCW Pump House has been included in the work scope of anti-tsunami embankment construction project which is under evaluation and design process by TPC Construction Department.

2. Consideration regarding flooding:

In response to the climate change in the recent years, the plant uses totally 32 historic records of the maximum daily precipitation measured in each of the past 30 years by Henchun Weather Station of Central Weather Bureau to again estimate the once every100 year and once every 10,000 year storms. The estimate result is that once every 100 year storm is 169.36mm/hr and once every-10,000 year storms is 303.32mm/hr. Both of these two figures are smaller than the PMP, 325 mm/hr, the trenches A and B in the drainage system of the plant can cope with. Besides, since the main drainage channel capacity of MNPP is 20cms, equals to the runoff of rainfall intensity of 325 mm/hr., an emergency scupper with drainage capacity of 20cms has been designed and built at the southwest corner of the plant area (emergency scuppers capacity checking is shown as below). As a result, the safety margin has reached 100% which justifies the adequacy of original designed DBF.

CAPACITY CHECKING FOR THE EMERGENCY SCUPPERS UNDER THE SAFETY FENCE AT THE SOUTH CORNER OF MNPP

The thickness of the safety fence emergency scupper wall is 40cm, depth 70cm and width 235cm. There are six scuppers in total. The slope of the ground is greater than 0.01. Its flow capacity is simplified and conservatively calculated based on the assumption of open channel. (The elevation of the north sidewalk crest is 97.35'. Refer to detailed drawing 301-P-002, SECT.D)

$A = 2.35\times0.7 = 1.645m^2$ (Cross-section)

$P=2.35+0.7\times2= 3.75m$ (Wetted perimeter)

$R= A/P = 1.645/3.75 = 0.4387M$ (Hydraulic radius)

$N = 0.014$ (Roughness coefficient)

$S = 0.01$ (Slope)

$v = 1/n\times R^{2/3}\times S^{1/2}= (1.645\times0.4387^{2/3} \times0.01^{1/2} = 4.12$ m/sec

$Q = A \times v = 1.645\times4.12\times6$ (hole) = 40.66 m3/sec

Based on conservative strategy, the designed drainage capacity is halved as: 0.5×40.66≒20 m3/sec. The total drainage capacity below the south safety fence scuppers will be greater than 20cms.

According to the analysis, the drainage trenches of the power station can still sustain extremely heavy rainfall resulting from climate changes, so there is no concern of the flooding inside the plant site.

A emergency scuppers with drainage capacity of 20cms is build under the security fence at the southwest corner of the power block，in order to drain the run off on ground surface through low-lying lands into the sea. Such method can increase drainage margin. The drainage capacity is equal to the total capacity of two channels at both sides of the power block.

3.1.2 Provisions to protect against the DBF

3.1.2.1 Key SSC required to achieve safe shutdown state after the flooding

In order to confirm that the critical structures, systems, and components (SSC) required for safe shutdown can be operated after flooding, the plant needs to verify that the designed elevation for the SSC is higher than the maximum tsunamis run-up height at the plant, 12.53m. Also, it is necessary to make sure that the design basis for the maximum precipitation intensity would not cause flooding to enter any onsite buildings, so SSC can still be available for sure. The explanation is as follows:

(Structure)

Building	Located areas	Bottom floor elevation
1. Control buildings	--building area EL.15m	EL.9m
2. Auxiliary buildings	--building area EL.15m	EL.7.2m
3. Diesel generators buildings	--building area EL.15m	EL.15m
4. Containments	--building area EL.15m	EL.15m
5. NSCW pump room	--pump room area EL.12.6m	EL.7.6m (control floor)
6. Fuel buildings	--building area EL.15m	EL.15m

(System and component)

System and components	Located areas		Bottom floor elevation
1.Emergency diesel generators (KJ SYS)	--building area	EL.15m	EL.15m
2.Emergency reactor core cooling system ECCS (RHR, CCP)	--building area	EL.15m	EL.7.2m
3.Reactor cooling water system (RCS)	---building area	EL.15m	EL.7.2m
4.Containment spray system (BK SYS)	--building area	EL.15m	EL.7.2m
5.Component cooling water system (CCW)	--building area	EL.15m	EL.15m
6.Emergency chiller water system (GJ SYS)	-building area	EL.15m	EL.9m
7.Nuclear service cooling water system (NSCW)	--pump room area	EL.12.6m	EL.7.6m
8.Chemistry and volume control system (BG SYS)	--building area	EL.15m	EL.7.2m
9.Auxiliary feedwater system (AL SYS)	--building area	EL.15m	EL.15m

According to the chart above, except the SSC of Nuclear service cooling water system is outside of the pump rooms (The elevation of the entrances/exits is 12.6m.), the SSC of other systems are all in the building area of the plant at an elevation of 15m. Even though some of the bottom floor of these buildings is lower than 15m, only particular type of tsunamis or storms would cause flooding to enter buildings, making these SSC to suffer from the impact of flooding due to the incapability of the drainage system in the area to respond. These tsunamis are those that are beyond the design basis and higher than 15m or the storms that bring beyond the design basis of the maximum precipitation intensity and whose volume flow rate is higher than 20 cms. Similarly, the SSC of the nuclear service cooling water system would suffer from the impact of flooding only when tsunamis beyond design basis and higher than 12.6m.

No equipment, cable tunnel or culvert is connected directly to seashore. All cables are installed inside conduits which are connected to numerous manholes. (The manhole covers are double-decked water tight cast iron.) It is unnecessary to consider that seawater will invade into plant area through the above said channel. Nevertheless, in order to improve protection, the seals at conduit exit will be enhanced. Due to no reservoir or stream existed around the site, it is not expected that the reservoir/stream water will inundate the plant area.

Moreover, after the lesson learned, the plant immediately complies with the Recommendation 3 of WANO SOER 2011-2, "Verify the capability to mitigate internal and external flooding events required by station design" to conduct an walkdown inspection to finish verifying the adequacy of the material and equipment needed by Maanshan Power station to mitigate internal and external flooding events. The range of the inspection consists of:

1. Seal of the penetrators on and under the ground floor of buildings.
2. The sump drainage pumps and water-proof doors in the area of buildings for emergency equipment.
3. Fire-proof doors, doors at emergency exits, and roller shutter doors that connect to outside of buildings.
4. Onsite drainage routes.

There are no deviation situations in this verification result or the existing plant facilities respond to design basis flood, so they can meet the original design requirement and as a result demonstrate their functions. The detail is shown in Appendix 3-1.

All water-proof sealing method applied to pipelines are tested and meets spec. requirements. The sealings of underground pipeline penetrations will be visually inspected inside plant buildings. The inspection will identify whether the sealings are damaged, whether the glue is deteriorated or whether the sump pumps are operable. If the answer is yes, then the function column on a check list will be marked with "Y".

3.1.2.2 Main associated design/construction provisions

The main consideration the plant has for the design that protects the plant against the DBF focuses on the flooding in the 220,000m² of building area induced by storms. The consideration about the protection design of the plant can be divided into two parts: inside of buildings and outside of buildings (namely the building area); the detailed description is provided as below:

1. Inside of buildings:

(1) All penetrators on exterior walls and the penetrators underground are designed to be water-proof and sealed.

(2) Base and walls of buildings that are underground are installed with water-proof synthetic rubber tapes at expansion joints and structure gaps. Base of buildings and exterior walls underground are enhanced to be water-proof.

(3) Install door curbs or water-seal doors at emergency equipment rooms to prevent water from entering or flowing out of these rooms.

(4) Accumulated water on all floor ground is gathered by drainage holes on the floor and delivered to the sumps in the buildings. Then, the water is sent to different liquid waste treatment systems via sump drainage pumps for treatment and drainage toward outside of buildings.

2. Outside of buildings (namely the building area):

(1) The entrance and exit of the NSCW pump room is at an elevation of 12.6m, higher than the potential maximum tsunamis run-up height. This is to ensure the NSCW pumps would not become out of order due to flooding.

(2) The first floor elevation of onsite buildings is 15m. All doors at exterior walls or openings on the ground are at least 6 inches above the ground (as stated in FSAR 3.4.1.1.2) to prevent accumulated flooding from entering buildings. The ground elevation outside of building rooms is 14.85m above sea water level.

(3) The design for the area outside of plant buildings has a ground drainage system that is capable of dealing with probable maximum precipitation intensity (PMP); its ground surface has enough slope rate to ensure no water accumulation and the capability to drain the water from roof pipes during maximum precipitation intensity. Drainage trenches outside of plant buildings has drainage capability of 20cms, bigger than the volume flow rate of 14cms resulting from the probable maximum precipitation intensity, 228mm/hr.

(4) East, north, and west of the building area have high lands isolating the building area as well as independent drainage systems, so surface flow in these regions would not enter the building area of the plant.

(5) Under the safe fence on the south side of the building area is installed with 6 emergency drainage outlets, 70 cm (height) x 235 cm (width), whose bottom elevation is 14m. Their drainage capability is 20cms, equal to the total drainage capability of both the east and west sides of drainage systems. This can further ensure that there is no concern for external flooding induced by extremely heavy rain due to climate change.

3.1.2.3 Main operating provision

Low-lands in the important buildings and ESF equipment rooms of the plant are installed with sumps and equipped with water level detective instruments; high water level warning panels are installed in the control rooms. When high water level warnings are released, operators comply with response procedure for the corresponding warning panels to assign workers to conduct walkdown inspection to find out the causes as well as adopt adequate correction measures to solve the problems. The detail is listed below:

Item	Name	Alarm panel	procedure	Item	Name	Alarm panel	procedure
1	High sump water level at charging pump rooms	JP004 C-33	595.1.3	14	High high sump water level at control buildings	JP009 B-55	595.6.2
2	High sump water level at RHR pump rooms	JP004 C-27	595.1.3	15	High high sump water level at control buildings	JP009 B-63	595.6.2
3	High／high high water level at containment sump B,	JP004 D-05	595.1.4	16	Waste treatment buildings sump water level High high	JP009 B-64	595.6.2
4	High／high high water level at containment sump A,	JP004 B-02	595.1.2	17	High sump water level at component cooling water buildings	JP009 B-65	595.6.2
5	High sump water level at containment spray pump rooms	JP004 C-29	595.1.3	18	High sump water level at waste decontaminating buildings	JP009 B-74	595.6.2
6	Containment dry well sump water level increases quickly.	JP004 D-22	595.1.4	19	High high general sump water level at waste treatment buildings	JP009 B-75	595.6.2
7	Containment west sump water level increases quickly.	JP004 D-23	595.1.4	20	High high sump water level at auxiliary buildings	JP009 B-84	595.6.2
8	Containment normal east sump water level increases quickly.	JP004 D-24	595.1.4	21	High sump water level at auxiliary buildings	JP009 B-73	595.6.2
9	High sump water level at boric acid tank rooms	JP005 B-35	595.2.2	22	Containment is normal; high high water level at dry well ／RCDT sumps	JP013 B-41	595.9.2
10	High sump water level at emergency diesel generators buildings	JP009 B-43	595.6.2	23	High sump water level at containment buildings	JP013 B-42	595.9.2
11	High sump water level at decontamination tanks in fuel buildings	JP009 B-44	595.6.2	24	High sump water level at refilling water storage tanks／NSCW valve rooms	JP004 C-03	595.1.3
12	FB general sump water level High High	JP009 B-45	595.6.2	25	High oil level at the oil leakage collecting sump for the oil fuel storage tanks of emergency diesel generators	JP018 A-21	595.12
13	TB drainage sump water	JP009	595.6.2				

	level High High	B-54					

If operators discover abnormal intake or other abnormal situations at these sumps, comply with procedure 583—"Emergency flooding procedure" to respond to and solve these abnormal situations. This description of the operating procedure is as follows:

1. Confirm the sump drainage pumps are operation normally and immediately trace origins of leaking.
2. Watch for any flooding signs at low lands of all buildings, monitor water level of all sumps, and inspect operation situations of all equipment and accumulation situations at all low lands.
3. Increase the number of temporary drainage pumps to increase drainage capability.
4. Find out flooding origins and isolate them.
5. If extremely heavy rain, flooding, typhoon surges, and tsunamis that are close to or beyond design basis happen, the plant should comply with procedure 1401-- "Event category judgment procedure" to decide whether the plant is in an emergency event.
6. If flooding events can not be controlled, stop using motors and components that are damaged and cut off their power sources.
7. If operation safety of the plant is affected, shut down the reactors and stay in the cold shutdown mode till flooding events are solved or under control.
8. Prior to flooding components back to operation, safety inspection needs to be done well.
9. Prior to electric components back to operation, confirm their insulation is normal.
10. Inspect and repair ruptured pipes/trenches and equipment.
11. Notify maintenance workers to clean previously flooded sites.

3.1.2.4 Other effects of the flooding taken into account

1. Consider synergistic effect of lost of offsite power:

   If the plant loses all AC power sources, the plant trip the reactors and follow procedure 570.00 as well as 570.20 afterwards. If all AC power sources can not be recovered, the plant also needs to comply with procedure 1451 -- "Unit ultimate response guideline" to arrange and place the 5th diesel generator and provide it with 2 emergency buses at the same time in order to maintain the supply of emergency power source. However, if the plant also loses the 5th diesel generator, mobile diesel generators can replace as the emergency power sources to supply AC and DC power.
2. If offsite situations hinder/delay workers and equipment to arrive at the plant:

   If offsite flooding situations hinder/delay workers and equipment to arrive and enter the plant, utilize the following methods to solve traffic and manpower problems:

   (1) Use mechanical equipment to remove road barriers.

(2) The plant has a harbor for heavy machinery, so rescue and support workers and equipment needed to mitigate events can be transported to the plant by sea.

(3) Rescue and support workers and equipment needed to mitigate events can be transported to the plant or Henchun Airport, or use helicopters to transport workers or hang the equipment needed directly to the plant.

(4) Events can occur during office hours and off-duty hours:

a. If events happen during plant office hours:

i. If operation personnel on call can not arrive at the station due to flooding, those who are intraining shift at the simulator center and standby support shift personnel (mostly licensees), can be on duty and assist with operation and handling of the units.

ii. All workers from the maintenance department and long-term contractors are onsite during office hours. Therefore, maintenance manpower can reach around a hundred people, which is enough for meeting the demand of equipment maintenance during emergency.

iii. There are 10 fire-fighting workers in every day-shift period. Emergency response team would organize 60 people into standby emergency fire-fighting manpower.

b. If events happen during off-duty hours:

i. The plant has the registration of 103 workers of all different specialties living in Henchun area (including operation personnel), so they can be notified to enter the plant to assist unit operation work. The plant has also listed supporting contractors of all different specialties and had their agreement about their entering the plant to assist maintenance during events.

ii. Considering the traffic situation at the time of emergency, transport the maintenance (mechanics, electricity, instruments, and maintenance) workers living in the standby dormitory in Fongshan and Wujia to the plant to perform maintenance work. They can also mobilize to help with equipment repair work. Also, the maintenance supporting contractors have almost technicians who live in Fongshan and Wujia. In the maintenance contracts signed by both the power station 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.

iii. Presently fire-fighting shift manpower is acquired via outsourcing. 6 fire-fighting workers remain onsite during off-duty hours. All the fire-fighting workers are local residents of Henchun, so they get to the site quickly once there is an emergency. Furthermore, security guards working onsite can join to assist with emergency related tasks.

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

3.1.3.1 Licensee's organization to ensure compliance

1. Periodically inspect, maintain, and test safety related systems and structures under the guidance of

procedure 600 and 700 series to ensure licensing basis.

2. In regard to protection against external flooding for exteriors of buildings, the plant enhances seal of penetrators on exterior walls of buildings (630-S-015) and maintains necessary openings of building, such as doors /windows (650-S-006), to help their functions stay normal.
3. To help the building area to reach the goal of fighting against external flooding, it is attained by installing drainage pipes/trenches in and around the building area and maintaining their intact and unclogged status.
4. To enhance the protection for the plant from internal flooding, it is fulfilled by sealing drainage holes on building floors (700-M-263), water-seal doors (shift periodically walkdown inspection) at ESF pump rooms, and penetrators on walls (630-S-015).
5. In respect of drainage inside of buildings, it is completed by sumps of buildings, sump pumps (700-M-039), and related pipe with check valves and valves.
6. After flooding events or tsunamis, the plant abides by the following procedure to conduct inspections and tests:
   (1) Procedure 582.2 -- "Tsunamis emergency response procedure."
   (2) Where there are internal flooding warnings, comply with procedure 583 – "Emergency flooding procedure." During the process, if reactors need to trip and/or feedwater automatically starts, comply with EOP 570.00. If the plant loses all AC power sources, abide by procedure 570.20.
   (3) Adhere to procedure 700-A-001 – "Onsite and offsite structure inspection procedure" to inspect structures, including the unclogged status as well as the structures of drainage trenches and pipes, and to examine the retaining structures around the plant to prevent occurrence of mudslides. This procedure requires periodical inspections of structures, including that of the plant drainage systems every year in June (before the flooding season), before and after typhoons, and after earthquakes with magnitude 4 and above.

3.1.3.2 Licensee's organization for mobile equipment and supplies

Guided by procedure 192 – "Maintenance and management procedure for disaster mitigation equipment," the plant inspects, tests and maintains mobile equipment, including mobile diesel generators, diesel (gasoline) engine drainage pumps, and etc. once a week or once a month to verify operability.

For detailed information about the standby rescue and support equipment, resources, their maintenance cycles, and the divisions that are in charge of, please refer to the charts in 2.1.3.2.

3.1.3.3 Deviations from CLB and remedial actions in progress

The plant presently does not have any deviation situations. If any of them occur, the plant conduct safety evaluation and adopt correction measures using related procedure as a guideline. The detail is referred to Section 2.1.3.3. Additionally, the sealings of the pipeline penetrations in NSCW pumps room will be changed to steel plate with silicon glue, to ensure the commitment is achieved.

3.1.3.4 Specific compliance check already initiated by the licensee

1. The improvement programs and simple improvement programs the plant has established and are undertaking are as follows:

Enhance program		Content
DCR	M0-4275	Waterproof walls and water-tight doors are added to NSCW Pump House. The related electrical and instrument & control equipment are required to shift position to cope with the modification. The work was completed on Dec. 26, 2011.
	M0-4276	To cope with the added anti-tsunami walls and water-tight doors, the inlet ventilation pipes are installed in NSCW Pump House and the relevant ventilation pipes are modified. The work was completed on Feb. 3, 2012.
	M0-4277	To cope with the added anti-tsunami walls and water-tight doors, the relevant fire pipelines is modified. The work was completed on Nov.16, 2012.
	M0-4285	The added waterproof walls and water-tight doors for NSCW Pump House were completed on Nov. 9, 2011.
	M0-4350	The penetrations at the north wall of NSCW Pump House are reinforced and the manhole cover on the floor is replaced with the floating type. The work was completed on Jan. 8, 2013.
MMR	M0-0672	The steel screen on drainage holes at the safety fences on the south side of the protection area of the plant is modified to be able to be opened outward. The work was completed on Aug. 9, 2011.
	M0-0683	Install debris prevention covers at NSCW. The work was completed on June 24, 2011.

Per detailed design, the scuppers cover in NSCW pump room is changed to water-proof steel plate attached with floating board at the bottom. In case of tsunami flooding, the water-proof steel plate with floating board will be floated by buoyant force to seal the opening.

2. MNPP intends to add one meter high water proof facilities at the gates of Unit 1 & 2 buildings and other critical equipment. Their location and door number are as follows:

Unit 1:

Sequence	Building/Elevation	Door Number	Type	Remark	MMR

No.			(single-leaf or double leaf)		Number
Emergency Diesel Generator Building (ZD)					
1	D/G, EL.100’	338	Single-leaf	Emergency exit	M1-0735
2	D/G, EL.100’	347	Double-leaf	Anti-flying object door	
3	D/G, EL.100’	337A	Single-leaf	Emergency exit	
4	D/G, EL.100’	339A	Single-leaf	Emergency exit	
5	D/G, EL.100’	340	Single-leaf	Emergency exit	
6	D/G, EL.100’	348	Double-leaf	Anti-flying object door	
Control Building (ZA)					
7	C/B, EL.100’	98	Double-leaf	Anti-flying object door	M1-0737
8	C/B, EL.100’	115	Single-leaf	Emergency exit	
Auxiliary Building (ZA)					
9	A/B, EL. 100’	226	Single-leaf	Emergency exit	M1-0733
10	A/B, EL. 100’	238	Double-leaf	Anti-flying object door	
11	A/B, EL. 100’	255	Single-leaf	West Emergency exit	
12	A/B, EL. 100’	251	Double-leaf	Equipment entrance/exit	
NSCW Building (ZA)					
13	CCW, EL.100’	317	Double-leaf	Equipment entrance/exit	Planning in process
Fuel Building (ZF)					
14	F/B, EL.100’	321	Single-leaf	Inner door	M1-0733
15	F/B, EL.100’	322	Single-leaf	Inner door	
16	F/B, EL.100’	323	Single-leaf	Inner door	
CST Building (ZY)					
17	CST Building 98.5’	10	Single-leaf 3-C-ZY-810	General entrance/exit	Besides M1-0739 2-foot water-proof weir,

18	CST Building 98.5’	11	Single-leaf 3-C-ZY-810	General entrance/exit	additional one -foot waterproof facilities are planned to add.(The planned MMR is in process)
RWST					
19	Refueling Water Storage Tank	12	Single-leaf 3-C-ZY-810	General entrance/exit	Planning in process
Administration Access Control Building (ZG)					
20	Access Control Building EL.100’	1-1	Double-leaf	Frequent use entrance/exit	M1-0737
Radwaste Building (ZR)					
21	R/B, EL.100’	369	Single-leaf	General entrance/exit	M0-0732
22	R/B, EL.100’	371	Double-leaf	General entrance/exit	
23	R/B, EL.100’	372	Single-leaf	General entrance/exit	
24	R/B, EL.100’	379	Double-leaf	General entrance/exit rolling door	
25	R/B, EL.100’	421	Double-leaf	General entrance/exit	
26	R/B, EL.100’	SD1	Single-leaf	Inner rolling door	
New Radwaste Building					
27	New Fuel Building EL. 100’	Add waterproof gate at the waste repository tunnel entrance			M0-0889
The 5th Diesel Generator Building (ZD)					
NSCW					
28		NSCW external opening			M0-0853

Unit 2:

Sequence No.	Building/Elevation	Door Number	Type (single-leaf or double leaf)	Remark	MMR Number

Emergency Diesel Generator Building (ZD)					
1	D/G, E. 100’	338	Single-leaf	Emergency exit	M2-0736
2	D/G, E. 100’	347	Double-leaf	Anti-flying object door	
3	D/G, E. 100’	337A	Single-leaf	Emergency exit	
4	D/G, E. 100’	339A	Single-leaf	Emergency exit	
5	D/G, E. 100’	340	Single-leaf	Emergency exit	
6	D/G, E. 100’	348	Double-leaf	Anti-flying object door	
Control Building (ZA)					
7	C/B, EL. 100’	98	Double-leaf	Anti-flying object door	M2-0738
8	C/B, EL. 100’	115	Single-leaf	Emergency exit	
Auxiliary Building (ZA)					
9	A/B, EL. 100’	226	Single-leaf	Emergency exit	M2-0734
10	A/B, EL. 100’	238	Double-leaf	Anti-flying object door	
11	A/B, EL. 100’	255	Single-leaf	West emergency exit	
12	A/B, EL. 100’	251	Double-leaf	Equipment entrance/exit	
NSCW Building (ZA)					
13	CCW, EL. 100’	317	Double-leaf	Equipment entrance/exit	Planning in process
Fuel Building (ZF)					
14	F/B, EL. 100’	321	Single-leaf	Inner door	M2-0734
15	F/B, EL. 100’	322	Single-leaf	Inner door	
16	F/B, EL. 100’	323	Single-leaf	Inner door	
CST Building (ZY)					
17	CST Building 98.5’	10	Single-leaf 3-C-ZY-810	General entrance/exit	Besides M2-0740 2-foot water-proof weir, additional one -foot waterproof
18	CST Building 98.5’	11	Single-leaf 3-C-ZY-810	General entrance/exit	

					facilities are planned to add.(The planned MMR is in process)
RWST					
19	Refueling Water Storage Tank	12	Single-leaf 3-C-ZY-810	General entrance/exit	Planning in process
Administration Access Control Building (ZG)					
20	Access Control Building EL.100’	1-1	Double-leaf	Frequent use entrance/exit	M2-0738

3.2 Evaluation of margins

3.2.1 Envisaged additional protection measures based on the warning lead time

When the plant discovers signs of tsunamis after judgment or receives tsunamis warnings from Central Weather Bureau, it complies with procedure 582.2 -- “Tsunamis emergency response procedure” and considers the amount of warning lead time to be prepared in advance and respond. The description is as below:

1. If noticing signs of tsunamis after judgment:

   Then, the shift manager notifies pump room shift workers to inspect all doors designed to protect pumps against tsunamis, water-seal doors , manhole covers (manhole covers in the EL. 6’－6” wash pumps area do not need to be closed per detailed design, the manhole covers in this area are changed to water-proof steel plate attached with kickboard at the bottom. In case of tsunami flooding, the water-proof steel plate with kickboard will be floated by buoyant force to seal the opening.), and fine grid covers at the NSCW pump room. All these facilities need to stay closed and locked tight.

2. If receiving tsunamis warnings from Central Weather Bureau:

   (1) When Central Weather Bureau issues tsunamis warnings and forecasts that tsunamis may seize the plant, the plant uses procedure 1401 – “Event category judgment procedure” to judge whether the plant should —issue the notification of unusual event associated with HU1(Natural disasters and destructive phenomena affecting the protected area of the plant.). If Central Weather Bureau has already forecasted that tsunamis may seize the plant and the tsunamis are beyond design basis, the plant also needs to follow procedure 1451 – “Ultimate response guideline” together with procedure 1401 simultaneously. If tsunamis notifications forecast that tsunamis may seize the plant, the operation assistant superintendent gathers all

technology related divisions, supply divisions, and the civil service ethics division manager to establish the tsunami emergency response team.

(2) Then, the shift manager notifies pump room shift workers to inspect all doors designed to protect pumps against tsunamis, water-seal doors , manhole covers, and fine grid covers at the NSCW pump room. All these facilities need to stay closed and locked tight, and the manger notifies the maintenance division to send workers to support and help.

(3) The shift manager notifies divisions related to repairment, electricity, and instrument to relocate mobile equipment in pump room areas, and the mobile texting center of Maanshan Power Station to send text messages to South Bay Tsunamis Warning Notify Group to notify personnel living in the South Bay dormitory to be prepared to evacuate.

(4) If tsunamis may seize the plant, the tsunami emergency response team assigns security guards to make workers in all pump room areas to evacuate within one hour before tsunami arrive and put up fences to forbid people to enter, and to escort them to safe locations (such as the simulation center or the unit 2 turbine building, EL. 131 feet).

(5) The tsunami emergency response team judges the impact of tsunamis on both the NSCW system and the plant based on information from Central Weather Bureau and the oceanic condition in the Henchun area. If the team judges that tsunamis may damage the NSCW system, the plant makes the reactors leave hot standby mode and then shut down. Next, the plant immediately uses RCS to decrease the temperature of the reactors.

(6) If tsunamis have damaged the emergency area (containing the NSCW pump room and NSCW drainage trenches), comply with procedure 1401 -- "Event category judgment procedure" to judge whether the plant should enter the emergency event level - HA1 (Natural disasters and destructive phenomena affecting the plant vital area.) and procedure 1406 – "Emergency mobilization procedure" to mobilize plant staff and workers. After TSC is established, the tsunami emergency response team is incorporated into TSC.

(7) During tsunami warning lead time, the plant has to continuously and closely monitor NSCW pumps and operation parameters of CWP (electric current, pressure, volume flow rate, vibration, and etc.).

a. When CWP operation is abnormal:

i. If operation electric current of CWP increases, discharge pressure decreases, and vibration increases, the plant should start reduce power of the reactors and decide whether the reactors should leave hot standby mode based on CWP conditions.

ii. If the plant loses circulating water pumps, abide by procedure 514.1. If both the circulating water pumps N-P053/N-P054 or N-P055/N-P056 of the two water boxes belonging to the same condenser trip at the same time, the plant has to closely monitor operation parameters of the main turbine and adhere to procedure 210 in order to make the units reduce power, leave hot standby mode, and reduce their thermal power to 1% rated power.

iii.If circulating water pumps trip causes condensers unable to maintain required vacuum status, abide by procedure 508.6 to manually trip the reactors and the main turbine.

b. When NSCW operation is abnormal:

i. When abnormal operation situations, such as decrease of discharge pressure and volume flow rate of NSCW pumps, increase of electric current, vibration increasing to danger figure, obey procedure 545.

ii. When there is a concern of loss of NSCW, reactors should leave hot standby mode as soon as possible and shut down. Eventually, decrease the temperature of reactors to cold shutdown mode.

iii.If the plant loses all NSCW pumps, follow procedure 578. If NSCW pumps can not return to operate, utilize procedure 570.29 to adopt response measures.

3.2.2 Weak points and cliff edge effects

There are neither underground pipelines, such as cable tunnel, connected between plant area and seashore which will allow external water to invade into plant buildings, nor streams or reservoir around plant area. The weak point existed at the outer gates or openings of the plant buildings. Under the current condition, the analysis of MNPP tsunami evaluation by Event Tree analysis is shown as attached drawing Fig 3-1.

According to the analysis result of the event tree, the conclusion of the Maanshan Power Station tsunamis evaluation is that there is only one successful situation of reactor cold shutdown, which is: Tsunamis cause loss of ultimate heat sink. ➔Reactors scram. ➔Remove heat with turbine -driven auxiliary feedwater pumps controlled by DC. ➔ Due to loss of heat-removing capability, TDAFWP, MDAFWP, CCWN can not perform long term operation. ➔SG standby makeup (diesel engine fire-fighting pumps) succeeds. ➔Cooling succeeds.

Because there is only a success path, its cliff edge is the cliff edge of this tsunamis case. Its safety margin needs to adopt the smallest safety margin, namely 5.88m (15.0 m – 9.12 m); its cliff edge also needs to use the smallest figure, namely 15.0m. The description is as follows:

1. The plant installs screen at top of the seawater intake forebays, so large trash and debris do not enter intake forebay. Consequently, this effort is to ensure intake function of the pumps would not to be affected.
2. The lowest point of the seawater drainage pump motor is 1.5m above a 7.62m floor, whose

elevation is 9.12m. Therefore, if tsunamis water level reaches the elevation of 9.12m, the seawater drainage pump motors would trip, making the system not available for use.

3. If tsunamis water level reaches EL. 15m (Plant EL.100’-0”), flooding would start entering important buildings making the important power sources on the bottom floor of these buildings, including DC power source, not available for use. Hence, motor-driven auxiliary feedwater pumps (MDAFWP), turbine-driven auxiliary feedwater pumps (TDAFWP), primary coolant system, high-pressure circulating system, containment cooling water (CCW), and other equipment would stop operation due to loss of power source.
4. A, B emergency diesel generators use seawater system (NSCW) for cooling. When seawater drainage pumps can not operate, A, B emergency diesel generators are not available for use, either. Only the 5th emergency diesel generator can use air cooling, so it is still operational. Walkdown inspection confirmed that the critical component of the 5th emergency diesel generator is its excitation switch, whose elevation is 1 meter above the ground (EL.15m). Battery, panels whose elevation is 15.3 meter. As a result, the elevation of the A, B diesel generators is EL.15.3m.
5. The operation of the TDAFWP in the plant can be manually started. Consequently, even if DC power source loses, the plant can still operate it manually. However, this evaluation needs to conservatively assume that TDAFWP can not operate after losing DC power source, and therefore it adopts the height of the flooding in the control buildings that leads to the loss of DC bus, which is EL.15m, to be the height of TDAFWP failure.
6. The plant has diversified methods for SG standby makeup and its critical equipment is either diesel engine auxiliary feedwater pumps or diesel fire-fighting pumps. After walkdown verification, it is confirmed that the critical point of the pumps is the lowest point of the coupling, EL.15.3m, which hence is regarded to be the elevation of the pumps.

   To improve protection capability, MNPP will install water-tight doors at the outer gates of safety related buildings.

3.2.3 Envisaged measures to increase robustness of the plant

1. The ground elevation of the main building area is 15m above sea water level. The entrance and exit on the roof of the NSCW pump room near the sea is at an elevation of 12.6m. Both are higher than the potential maximum tsunamis run-up height near the plant. Therefore, when earthquake-induced tsunami happens, there is still no concern of seizure of seawater at the plant. However, in order to enhance protection capability, presently the plant finished installing grid covers at the service water intake forebay on June 30, 2011 to prevent large debris from entering the intake forebay through its top during tsunamis and influencing it. Moreover, the plant completed water-seal doors and flood barrier walls facilities in the motor area of the NSCW intake pump rooms on August 31, 2011 to protect, isolate, and maintain these NSCW pumps by dividing them based on units and series. Therefore, the plant would not lose all NSCW pumps at

the same time, when the plant is seized. This improvement made the original design basis tsunami elevation, the cause event, changed from the motor elevation of the NSCW pumps, 9.12m, to the bottom edge elevation of the ventilation openings on the roof of the NSCW pump room, which is 12.9m.

2. The plant completed an investigation on the oceanic and terrestrial geographic landscape near Maanshan Power Station and again reviewed the protection design of the plant against tsunamis and safety of the plant facilities in the Final Safety Analysis Report (FSAR) of the plant. On August 19, 2011, NSC Tsunamis Simulation Team published a report "Influence of Tsunami Induced by Potential Massive Scale of Earthquakes on the Nuclear Power Station in Taiwan" and stated that the potential tsunamis run-up height near the plant is lower than the elevation of the design basis tsunamis run-up of the plant.

3. Climate changes dramatically in recent years and precipitation intensity of all places seem to significantly increases, but the maximum precipitation intensity record the plant acquired from Henchun Weather Station is 156.5mm/hr (Sept. 3, 2005, Damrey Typhoon) and the maximum precipitation record from Dawu Weather Station is 103.5mm/hr (July, 2005). Both records are far smaller than the design basis of the plant for probable maximum precipitation intensity (PMP) 228mm/hr. Also, on August 30, 2011, the maximum precipitation intensity of Nanmadou Typhoon was 127mm/hr, still smaller than the design basis of the plant for PMP. To respond to dramatic change of weather, the plant acquired the maximum daily precipitation record of every year over the past 30 years from Henchun Weather Station and there were 32 precipitation intensity records. The plant estimated both the once every 100 year and once every 10,000 year maximum precipitation intensity indexes based on information and experienced formulas, and learned they are respectively 169.3mm/hr and 303mm/hr. The volume flow rate caused by both PMPs is still smaller than the total drainage capability of the east and west sides of drainage systems, which is 20cms and equal to 325mm/hr of precipitation intensity). Nevertheless, to enhance the capability to fight against flooding, even though the plant already has emergency drainage holes under the south side of fences in the building area, which give the plant additional 20cms of drainage capability, the plant will still install flood barrier walls that are higher than 1 meter at openings of important buildings. Inspection tour will be conducted periodically. The scupper (drainage capacity: 20cms) at south west corner will be cleared up, to ensure that it is not blocked by trash, and the drainage capability is maintained.

4. To prevent external flooding enters buildings, the plant has established a simple improvement program to evaluate the feasibility of installing flood barrier plates at exterior doors of safety related buildings, so the plant can install these plates in advance after Central Weather Bureau issues warnings for typhoons and extremely heavy rain or when the plant judges that external flooding may enter buildings. The plant has also submitted an improvement program to increase water-seal of critical fire-proof doors or explosion-proof doors at safety related buildings to stop external flooding from entering critical areas /rooms in order to prevent important equipment

/facilities from becoming out of order or failing. In the future after this improvement program is finished, the plant would not lose important power sources (including DC power source) on bottom floor of important buildings due to flooding and cliff edge can be increased from the e original 15.0m to the elevation of SG standby makeup, 15.3m. Meanwhile, after this improvement program is finished, the critical elevation of the 5th emergency diesel generator from the original 16m to the elevation of the ventilation openings of the building, 23.38m.

5. To improve drainage measures dealing with internal flooding, in addition to the original 20 drainage pumps the plant already has, the plant has also procured 30 diesel engine drainage pumps to enhance maneuverable drainage capability.
6. To deal with a situation of completely losing emergency DC power source, the plant has established procedure to guide workers to utilize measurement instruments in the control rooms to measure the electric current of other power sources and provide working voltage through transmitters. Under the situation of monitoring important parameters of the units, the TDAFWP of the plant has ability to run without DC power sources and manually start the units and maintain their operation. The plant has considered these operations to be important training contents for maintenance and operation workers.
7. The plant reviewed SG standby makeup and decided to use enhanced fire trucks maneuverable delivery and supply to be the alternative makeup measures if diesel engine auxiliary feedwater pumps and diesel fire-fighting pumps fail. Thus, the plant has not only procured a fire truck using fire-fighting foam, but will also procure a fire truck with a water tank to enhance the maneuverable delivery and supply capability. Because the existing fire trucks of the plant are located in the fire-fighting division (EL. 24m), this also helps with the capability of the plant to transport fire-fighting water to the SG feedwater system.

References:

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2. 中央氣象局恆春測站雨量紀錄
3. 台灣電力公司核三廠期終安全分析報告（FSAR），台灣電力公司
4. 核三廠水災評估 PRA 事件樹分析，台灣電力公司

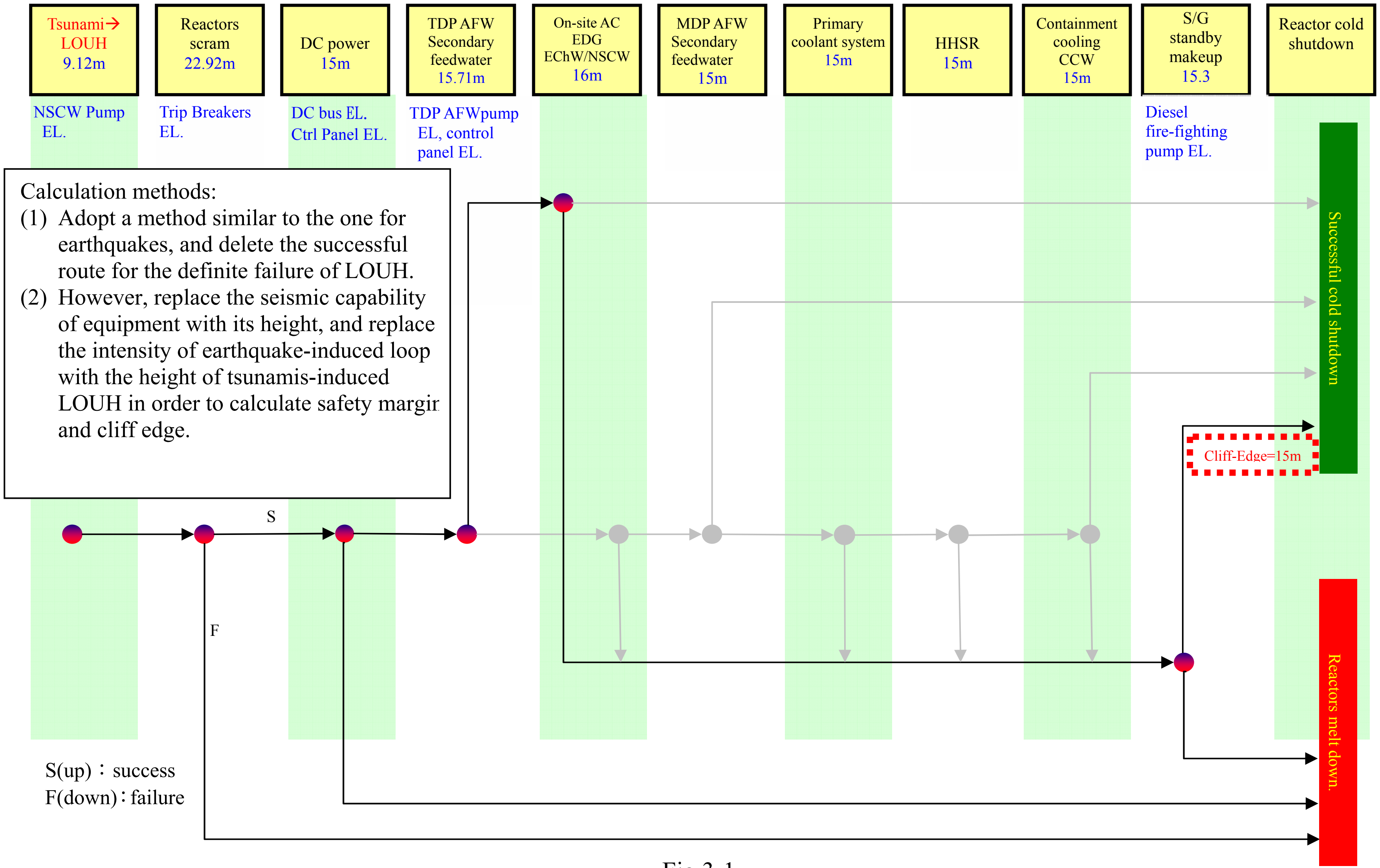
Tsunami→ LOUH 9.12m
Reactors scram 22.92m
DC power 15m
TDP AFW Secondary feedwater 15.71m
On-site AC EDG EChW/NSCW 16m
MDP AFW Secondary feedwater 15m
Primary coolant system 15m
HHSR 15m
Containment cooling CCW 15m
S/G standby makeup 15.3
Reactor cold shutdown
NSCW Pump EL.
Trip Breakers EL.
DC bus EL. Ctrl Panel EL.
TDP AFWpump EL, control panel EL.
Diesel fire-fighting pump EL.
Calculation methods:
(1) Adopt a method similar to the one for earthquakes, and delete the successful route for the definite failure of LOUH.
(2) However, replace the seismic capability of equipment with its height, and replace the intensity of earthquake-induced loop with the height of tsunamis-induced LOUH in order to calculate safety margir and cliff edge.
S
F
Successful cold shutdown
Cliff-Edge=15m
Reactors melt down.
S(up)：success
F(down)：failure

Fig 3-1

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
3.1 Outside Building				
	CST			Check openings and doors of building exterior walls below EL.109 feet
ACCESS DOOR #10	CST EL.98'-6"	PM ARC1-DR24 & ARC2-DR24	Y	N
ACCESS DOOR #11	CST EL.98'-6"	PM ARC1-DR24 & ARC2-DR24	Y	N
Wall Penetrator Y1 (LINK-SEAL)	CST EL.94'-7 3/4"	SOP 630-S-015	Y	N
Wall Penetrator Y18 (LINK-SEAL)	CST EL.94'-7 3/4"	SOP 630-S-015	Y	N
Wall Penetrator Y2 (LINK-SEAL)	CST EL.94'-7 3/4"	SOP 630-S-015	Y	N
Wall Penetrator Y3 (LINK-SEAL)	CST EL.95'-0 3/8"	SOP 630-S-015	Y	N
Wall Penetrator Y4 (LINK-SEAL)	CST EL.95'-0 3/8"	SOP 630-S-015	Y	N
Wall Penetrator Y5 (LINK-SEAL)	CST EL.95'-0 3/8"	SOP 630-S-015	Y	N
Wall Penetrator Y27 (LINK-SEAL)	CST EL.95'- 3"	SOP 630-S-015	Y	N
Wall Penetrator OY1 (LINK-SEAL)	CST EL.94'-7 3/16"	SOP 630-S-015	Y	N

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
Wall Penetrator Y28 (LINK-SEAL)	CST EL.95'- 3"	SOP 630-S-015	Y	N
Wall Penetrator OY2 (LINK-SEAL)	CST EL.94'-7"	SOP 630-S-015	Y	N
Wall Penetrator Y6 (LINK-SEAL)	CST EL.95'-0 3/8"	SOP 630-S-015	Y	N
Wall Penetrator Y7 (LINK-SEAL)	CST EL.95'-0 3/8"	SOP 630-S-015	Y	N
Wall Penetrator Y8 (LINK-SEAL)	CST EL.94'-10 5/16"	SOP 630-S-015	Y	N
Wall Penetrator Y9 (LINK-SEAL)	CST EL.94'-7 3/4"	SOP 630-S-015	Y	N
Wall Penetrator Y10 (LINK-SEAL)	CST EL.95'-0 3/8"	SOP 630-S-015	Y	N
Wall Penetrator Y11 (LINK-SEAL)	CST EL.95'-0 3/8"	SOP 630-S-015	Y	N
Wall Penetrator Y17 (LINK-SEAL)	CST EL.94'-7 3/4"	SOP 630-S-015	Y	N
Wall Penetrator Y12 (LINK-SEAL)	CST EL.94'-7 3/4"	SOP 630-S-015	Y	N
Wall Penetrator Y13 (LINK-SEAL)	CST EL.94'-7 3/4"	SOP 630-S-015	Y	N
Wall Penetrator AY41 (VENTING)	CST EL.103'-6"	Visual Inspection	Y	N
Wall Penetrator AY42 (VENTING)	CST EL.103'-6"	Visual Inspection	Y	N
	FIRE PUMP HOUSE			

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
ACCESS DOOR #46 (VENTING)	ELEC. EQUIP. ROOM EL.99'-0"	Close & Open Test	Y	N
ACCESS DOOR #47 (VENTING)	ELEC. EQUIP. ROOM EL.99'-0"	Close & Open Test	Y	N
ACCESS DOOR #48 (VENTING)	DIES. FIRE PUMP RM EL.99'-0"	Close & Open Test	Y	N
ACCESS DOOR #49 (VENTING)	DIES. FIRE PUMP RM EL.99'-0"	Close & Open Test	Y	N
ACCESS DOOR #50 (VENTING)	DIES. FIRE PUMP RM EL.99'-0"	Close & Open Test	Y	N
ACCESS DOOR #51 (VENTING)	DIES. FIRE PUMP RM EL.99'-0"	Close & Open Test	Y	N
ACCESS DOOR #52 (VENTING)	ELEC. FIRE PUMP RM EL.99'-0"	Close & Open Test	Y	N
ACCESS DOOR #53 (VENTING)	ELEC. FIRE PUMP RM EL.99'-0"	Close & Open Test	Y	N
	D/G			
MISSILE PROOF DOOR #347	D/G COL.13 EL.100'-0"	WALKDOWN	Y	N
MISSILE PROOF DOOR #348	D/G COL.21 EL.100'-0"	WALKDOWN	Y	N
ACCESS DOOR #338	D/G COL. 13 EL.100'-0"	PM ARC1-DR21 & ARC2-DR21	Y	N
ACCESS DOOR #340	D/G COL. 21 EL.100'-0"	PM ARC1-DR21 & ARC2-DR21	Y	N

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
ACCESS DOOR #337A	D/G COL. Q.2 EL.100'-0"	PM ARC1-DR21 & ARC2-DR21	Y	N
ACCESS DOOR #339A	D/G COL. Q.2 EL.100'-0"	PM ARC1-DR21 & ARC2-DR21	Y	N
Wall Penetrator AD14 ,fire proof sealing (ELA 003 00)	D/G COL. 13 EL.107'-9"	SOP 630-S-015	Y	N
Wall Penetrator AD15 ,fire proof sealing (ELA 003 00)	D/G COL. 21 EL.107'-9"	SOP 630-S-015	Y	N
Wall Penetrator D1 ,LINK-SEAL	D/G COL. Q EL.92'-6"	SOP 630-S-015	Y	N
Wall Penetrator D3 ,LINK-SEAL	D/G COL. Q EL.94'-7 1/2"	SOP 630-S-015	Y	N
Wall Penetrator D4 ,LINK-SEAL	D/G COL. Q EL.94'-7 1/2"	SOP 630-S-015	Y	N
Wall Penetrator D5, LINK-SEAL	D/G COL. Q EL.94'-7 1/2"	SOP 630-S-015	Y	N
Wall Penetrator D6, LINK-SEAL	D/G COL. Q EL.94'-7 1/2"	SOP 630-S-015	Y	N
Wall Penetrator D17, LINK-SEAL	D/G COL. 13 EL.92'-3 3/8"	SOP 630-S-015	Y	N
Wall Penetrator D7, LINK-SEAL	D/G COL. Q EL.94'-8 1/4"	SOP 630-S-015	Y	N
Wall Penetrator D18 LINK-SEAL	D/G COL. Q EL.90'-6 3/8"	SOP 630-S-015	Y	N

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
	#5 D/G			
ACCESS DOOR #526	#5 D/G COL.10 EL.100'-0"	PM ARC0-DR06	Y	N
MISSILE PROOF DOOR #550	#5 D/G COL.10 EL.100'-0"	WALKDOWN	Y	N
ACCESS DOOR #525	#5 D/G COL. DGA EL.100'-0"	PM ARC0-DR06	Y	N
Wall Penetrator D122 NON-SHRINK GROUT	#5 D/G COL. DGA EL.95'-9"	SOP 630-S-015	Y	N
Wall Penetrator D162 NON-SHRINK GROUT	#5 D/G COL. DGA EL.95'-9"	SOP 630-S-015	Y	N
Wall Penetrator D163 NON-SHRINK GROUT	#5 D/G COL. DGA EL.95'-9"	SOP 630-S-015	Y	N
Wall Penetrator D182 NON-SHRINK GROUT	#5 D/G COL. DGA EL.90'-6"	SOP 630-S-015	Y	N
Wall Penetrator D231, fire proof sealing (PLA 003 00)	#5 D/G COL. DGA EL.100'-6"	SOP 630-S-015	Y	N
Wall Penetrator D232 ,fire proof sealing (PLA 003 00)	#5 D/G COL. DGA EL.101'-1"	SOP 630-S-015	Y	N
	CTMT			

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
ACCESS DOOR #356	TENDOM GARRY EL.100'-6"	Close & Open Test	Y	N
EMERG. EXIT LOCK	CTMT. EL.108'-8"	SOP 600-M-009A&B	Y	N
EQUIP. HATCH	CTMT. EL.148'-0"	SOP 600-M-006	Y	N
PERSONAL ACCESS DOOR	CTMT. EL.148'-0"	SOP 600-M-009A&B	Y	N
	F/B			
ROLL UP DOOR #329	F/B COL. A1 EL.100'-0"	PM ARC1-DR02 & ARC2-DR02	Y	N
EMERG. EXIT DOOR #328	F/B COL. A1 EL.100'-11"	PM ARC1-DR22 & ARC2-DR22	Y	N
EMERG. EXIT DOOR #326	F/B COL. 26 EL.100'-0"	PM ARC1-DR22 & ARC2-DR22	Y	N
Wall Penetrator OF4 ,防氣填封(PLB V03 00)	F/B COL. 26 EL.102'-0"	SOP 630-S-015	Y	N
Wall Penetrator OF5, 防氣填封(PLB V03 00)	F/B COL. 26 EL.102'-0"	SOP 630-S-015	Y	N
Wall Penetrator OF6 ,防氣填封(PLB V03 00)	F/B COL. 26 EL.102'-0"	SOP 630-S-015	Y	N

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
Wall Penetrator F53 ,LINK SEAL	F/B COL. A1 EL.101'-0"	SOP 630-S-015	Y	N
Wall Penetrator F83, LINK SEAL	F/B COL. A1 EL.101'-0"	SOP 630-S-015	Y	N
	AB/B (Aux Boiler Building)			
Glass window for lighting	AB/B COL. X1 EL.101'-0"	Visual Inspection	Y	N
Louver for ventilation	AB/B COL. X1 EL.101'-0"	Visual Inspection	Y	N
Glass window for lighting	AB/B COL. X1 EL.101'-0"	Visual Inspection	Y	N
Louver for ventilation	AB/B COL. X1 EL.101'-0"	Visual Inspection	Y	N
Roller shutter louver	AB/B COL. X1 EL.101'-0"	Close & Open Test	Y	N
Glass window for lighting	AB/B COL. X2 EL.101'-0"	Visual Inspection	Y	N
Louver for ventilation	AB/B COL. X2 EL.101'-0"	Visual Inspection	Y	N
Glass window for lighting	AB/B COL. X2 EL.101'-0"	Visual Inspection	Y	N
Louver for ventilation	AB/B COL. X2 EL.101'-0"	Visual Inspection	Y	N
Roller shutter doors 1	AB/B COL. X2 EL.100'-0"	Close & Open Test	Y	N

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
Louver for ventilation	AB/B COL. XA EL.101'-0"	Visual Inspection	Y	N
Big roller shutter doors	AB/B COL. XA EL.100'-0"	PM ARC1-DR03 & ARC2-DR03	Y	N
Louver for ventilation	AB/B COL. XA EL.101'-0"	Visual Inspection	Y	N
Glass window for lighting	AB/B COL. XB EL.101'-0"	Visual Inspection	Y	N
Roller shutter window	AB/B COL. XB EL.101'-0"	Close & Open Test	Y	N
Roller shutter doors 2	AB/B COL. XB EL.100'-0"	Close & Open Test	Y	N
	CONTROL BLDG			
Wall Penetrator A117 LINK SEAL EQUAL	A/B COL. 21 EL.97'-8"	SOP 630-S-015	Y	N
Wall Penetrator A787 LINK SEAL EQUAL	A/B COL. 21 EL.94'-5 3/4"	SOP 630-S-015	Y	N
Wall Penetrator OA540 LINK SEAL EQUAL	A/B COL. 21 EL.96'-3"	SOP 630-S-015	Y	N
Wall Penetrator AA65 LINK SEAL EQUAL	A/B COL. 21 EL.93'-3 7/16"	SOP 630-S-015	Y	N
Wall Penetrator AA393 LINK SEAL	A/B COL. 21 EL.95'-7"	SOP 630-S-015	Y	N

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
EQUAL				
Wall Penetrator A106 NON-SHRINK GROUT	A/B COL. 21 EL.92'-6"	SOP 630-S-015	Y	N
Wall Penetrator OA713 ELA 0W0 00	A/B COL. 21 EL.95'-6"	SOP 630-S-015	Y	N
Wall Penetrator AA242 ELA 0W3 00	A/B COL. 21 EL.109'-10"	SOP 630-S-015	Y	N
Wall Penetrator OA403 PLB V00 00	A/B COL. 21 EL.109'-0"	SOP 630-S-015	Y	N
Wall Penetrator AA9 PLC 0W3 00	A/B COL. 21 EL.100'-9"	SOP 630-S-015	Y	N
Wall Penetrator AA10 PLC 0W3 00	A/B COL. 21 EL.101'-9"	SOP 630-S-015	Y	N
EMERG. EXIT DOOR #115	A/B COL. 21 EL.100'-0"	PM ARC1-DR18 & ARC2-DR18	Y	N
MISSILE PROOF DOOR #98	A/B COL. 21 EL.100'-0"	Close & Open Test	Y	N
	AUX./BLDG			
Wall Penetrator OA952 ELA 0W0 00	A/B COL. 21 EL.89'-2"	SOP 630-S-015	Y	N
Wall Penetrator OA953 ELA 0W0 00	A/B COL. 21 EL.88'-6"	SOP 630-S-015	Y	N

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
Wall Penetrator OA954 ELA 0W0 00	A/B COL. 21 EL.87'-10"	SOP 630-S-015	Y	N
Wall Penetrator OA955 ELA 0W0 00	A/B COL. 21 EL.86'-6"	SOP 630-S-015	Y	N
Wall Penetrator OA956 ELA 0W0 00	A/B COL. 21 EL.81'-4"	SOP 630-S-015	Y	N
Wall Penetrator OA957 ELA 0W0 00	A/B COL. 21 EL.89'-2"	SOP 630-S-015	Y	N
Wall Penetrator OA958 ELA 0W0 00	A/B COL. 21 EL.88'-6"	SOP 630-S-015	Y	N
Wall Penetrator OA959 ELA 0W0 00	A/B COL. 21 EL.87'-10"	SOP 630-S-015	Y	N
Wall Penetrator OA960 ELA 0W0 00	A/B COL. 21 EL.81'-4"	SOP 630-S-015	Y	N
Wall Penetrator OA961 ELA 0W0 00	A/B COL. 21 EL.89'-2"	SOP 630-S-015	Y	N
Wall Penetrator OA962 ELA 0W0 00	A/B COL. 21 EL.88'-6"	SOP 630-S-015	Y	N
Wall Penetrator OA963 ELA 0W0 00	A/B COL. 21 EL.87'-10"	SOP 630-S-015	Y	N
Wall Penetrator OA964 ELA 0W0 00	A/B COL. 21 EL.86'-6"	SOP 630-S-015	Y	N
Wall Penetrator OA965 ELA 0W0 00	A/B COL. 21 EL.81'-4"	SOP 630-S-015	Y	N
Wall Penetrator OA966 ELA 0W0 00	A/B COL. 21 EL.89'-2"	SOP 630-S-015	Y	N
Wall Penetrator OA967 ELA 0W0 00	A/B COL. 21 EL.87'-10"	SOP 630-S-015	Y	N

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
Wall Penetrator OA968 ELA 0W0 00	A/B COL. 21 EL.86'-6"	SOP 630-S-015	Y	N
Wall Penetrator OA969 ELA 0W0 00	A/B COL. 21 EL.83'-10"	SOP 630-S-015	Y	N
Wall Penetrator OA970 ELA 0W0 00	A/B COL. 21 EL.81'-4"	SOP 630-S-015	Y	N
Wall Penetrator OA541 LINK SEAL EQUAL	A/B COL. 21 EL.96'-6"	SOP 630-S-015	Y	N
Wall Penetrator AA115 LINK SEAL EQUAL	A/B COL. 21 EL.93'-3 1/4"	SOP 630-S-015	Y	N
Wall Penetrator A107 LINK SEAL EQUAL	A/B COL. 21 EL.95'-0"	SOP 630-S-015	Y	N
Wall Penetrator A127 LINK SEAL EQUAL	A/B COL. 21 EL.92'-2 1/4"	SOP 630-S-015	Y	N
Wall Penetrator OA037 LINK SEAL EQUAL	A/B COL. 21 EL.93'-0"	SOP 630-S-015	Y	N
Wall Penetrator OA038 LINK SEAL EQUAL	A/B COL. 21 EL.93 '04"	SOP 630-S-015	Y	N
Wall Penetrator A126 LINK SEAL EQUAL	A/B COL. 21 EL.94'-1 1/8"	SOP 630-S-015	Y	N
Wall Penetrator AA380 LINK SEAL EQUAL	A/B COL. 21 EL.96'-1 3/4"	SOP 630-S-015	Y	N
Wall Penetrator A113 LINK SEAL EQUAL	A/B COL. 21 EL.94'-3 1/4"	SOP 630-S-015	Y	N
Wall Penetrator A105 LINK SEAL EQUAL	A/B COL. 21 EL.93'-1 3/8"	SOP 630-S-015	Y	N

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
Wall Penetrator OA1682 PLB V00 R0	A/B COL. 21 EL.106'-9"	SOP 630-S-015	Y	N
Wall Penetrator AA545 DRY PACK	A/B COL. 21 EL.102'-0"	SOP 630-S-015	Y	N
Wall Penetrator A1744 DRY PACK	A/B COL. 21 EL.103'-6"	SOP 630-S-015	Y	N
EMERG. EXIT DOOR #226	A/B COL. 21 EL.100'-0"	PM ARC1-DR14 & ARC2-DR14	Y	N
MISSILE PROOF DOOR #238	A/B COL. 21 EL.100'-0"	WALKDOWN	Y	N
	CCW			
MISSILE PROOF EQUIP. HATCH #1	CCW COL. 26.3 EL.100'-0"	N	Y	N
MISSILE PROOF EQUIP. HATCH #2	CCW COL. 26.3 EL.100'-0"	N	Y	N
ACCESS DOOR #317	GARBAGE RM. EL.100'	PM ARC1-DR14 ARC2-DR14	Y	N
	T/B			
STEEL DOOR #31	T/B COL. A EL.100'-0"	PM ARC1-DR01 & ARC2-DR01	Y	N

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
ACCESS DOOR #30	T/B COL. A EL.100'-0"	PM ARC1-DR23 & ARC2-DR23	Y	N
ACCESS DOOR #27	T/B COL. 12 EL.100'-0"	PM ARC1-DR23 & ARC2-DR23	Y	N
ACCESS DOOR #22	T/B COL. 12 EL.100'-6"	PM ARC1-DR23 & ARC2-DR23	Y	N
ACCESS DOOR #16	T/B COL. 12 EL.100'-0"	PM ARC1-DR23 & ARC2-DR23	Y	N
ACCESS DOOR #33	SWG. COL. 7 EL.100'-0"	PM ARC1-DR23 & ARC2-DR23	Y	N
	NSCW VALVE RM.			
ACCESS DOOR #54	VALV. RM. EL.99'-10"	PM ARC1-DR24 & ARC2-DR24	Y	N
MISSILE PROOF DOOR #55	VALV. RM. EL.100'-0"	Close & Open Test	Y	N
Wall Penetrator AY060 VENTING	EL.104'-10"	Visual Inspection	Y	N
Wall Penetrator AY061 VENTING	EL.106'-3"	Visual Inspection	Y	N
	DIESEL FUEL OIL TANK			

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
ACCESS DOOR #13	PUMP RM. EL.100'-0"	PM ARC1-DR24 & ARC2-DR24	Y	N
ACCESS DOOR #14	PUMP RM. EL.100'-0"	PM ARC1-DR24 & ARC2-DR24	Y	N
	NSCW PUMP ROOM			
ACCESS DOOR	ROOF EL.41'-4 1/2"	Close & Open Test	Y	N
VENTING WINDOW(TYP. 4)	ROOF EL.42'-4 1/2"	WALKDOWN	Y	N
TRAVEL SCREEN HATCH(TYP.4)	ROOF EL.44'-10 1/2"	WALKDOWN	Y	N
FINE SCREEN HATCH(TYP.4)	ROOF EL.44'-2"	WALKDOWN	Y	N
NSCW PUMP HATCH(TYP.4)	ROOF EL.44'-2"	WALKDOWN	Y	N
WASHWATER PUMP HATCH(TYP.2)	ROOF EL.44'-2"	WALKDOWN	Y	N
Floor Penetrator NS01	OPERATION FL. EL.25'-0"	PM ARC0-5601	Y	N
Floor Penetrator NS02	OPERATION FL. EL.25'-0"	PM ARC0-5601	Y	N
Floor Penetrator NS03	OPERATION FL. EL.25'-0"	PM ARC0-5601	Y	N

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
Floor Penetrator NS04	OPERATION FL. EL.25'-0"	PM ARC0-5601	Y	N
Floor Penetrator NS05	OPERATION FL. EL.25'-0"	PM ARC0-5601	Y	N
Floor Penetrator NS06	OPERATION FL. EL.25'-0"	PM ARC0-5601	Y	N
Floor Penetrator NS07	OPERATION FL. EL.25'-0"	PM ARC0-5601	Y	N
Floor Penetrator NS08	OPERATION FL. EL.25'-0"	PM ARC0-5601	Y	N
Floor Penetrator NS09	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS10	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS11	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS12	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS13	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS14	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS15	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS16	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS17	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
Floor Penetrator NS18	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS19	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS20	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS21	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS22	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS23	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS24	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS25	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS26	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS27	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS28	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS29	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS30	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS31	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
Floor Penetrator NS32	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS33	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS34	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS35	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS36	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS37	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS38	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS39	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS40	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS41	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS42	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS43	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS44	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS45	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
Floor Penetrator NS46	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS47	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Wall Penetrator NS48	SEPERATING WALL EL.21'-6"	PM AR0-SL01	Y	N
Wall Penetrator NS49	SEPERATING WALL EL.21'-6"	PM AR0-SL01	Y	N
Wall Penetrator NS50	SEPERATING WALL EL.9'-9"	PM AR0-SL01	Y	N
Wall Penetrator NS51	SEPERATING WALL EL.9'-9"	PM AR0-SL01	Y	N
Wall Penetrator NS52	SEPERATING WALL EL.9'-9"	PM AR0-SL01	Y	N
Wall Penetrator NS53	SEPERATING WALL EL.9'-9"	PM AR0-SL01	Y	N
Wall Penetrator NS54	SEPERATING WALL EL.9'-9"	PM AR0-SL01	Y	N
Wall Penetrator NS55	SEPERATING WALL EL.9'-9"	PM AR0-SL01	Y	N
Wall Penetrator NS56	SEPERATING WALL EL.9'-9"	PM AR0-SL01	Y	N
Wall Penetrator NS57	SEPERATING WALL EL.9'-9"	PM AR0-SL01	Y	N
Wall Penetrator NS58	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS59	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
Floor Penetrator NS60	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS61	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
Floor Penetrator NS62	OPERATION FL. EL.25'-0"	PM AR0-SL01	Y	N
WORKING HOLE(TYP.4)	OPERATION FL. EL.25'-0"	PM item	Y	N
DRAIN DITCH 1(TYP.2) FOR TRAVEL SCREEN	OPERATION FL. EL.25'-0"	WALKDOWN	Y	N
DRAIN DITCH 2(TYP.4) FOR FINE SCREEN	OPERATION FL. EL.25'-0"	WALKDOWN	Y	N
VENTING DUCT (TYP.4)	OPERATION FL. EL.35'-10"	WALKDOWN	Y	N
	Drainage trenches in east side of building area	Walkdown inspection of the unclogged status of trenches	Y	N
	Drainage trenches in west side of building area	Walkdown inspection of the unclogged status of trenches	Y	N
	Drainage holes at safety fences in south side of the building area	Walkdown inspection of the unclogged status of trenches	Y	N

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
	Drainage holes at safety fences in north side of the building area	Walkdown inspection of the unclogged status of trenches	Y	N
	Drainage trenches in west side of the building area	Walkdown inspection of the unclogged status of trenches	Y	N
	Drainage trenches in east side of the building area	Walkdown inspection of the unclogged status of trenches	Y	N

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
3.2 Protection measures for inside flooding of buildings (FSAR TABLE 3.4-1)				
DR NO.196 water-seal doors	RM.NO.198 RHR P'P B Train EL.64'	PM ARC12-DR06	Y	N
Bricked up opening(Only consider flooding problems w/o water-seal metal membrane, opening bottom elevation EL.75')	RM.NO.198 RHR P'P EL.75'		Y	N
DR NO.205 water-seal doors	RM.NO.199 SPR. P'P B Train EL.64'	PM ARC12-DR10	Y	N
Bricked up opening(Only consider flooding problems w/o water-seal metal membrane, opening bottom elevation EL.75')	RM.NO.199 SPR P'P EL.75'		Y	N
DR NO.197 water-seal doors	RM.NO.200 RHR. P'P A Train EL.64'	PM ARC12-DR06	Y	N
Bricked up openings (Only consider flooding problems w/o water-seal metal membrane, opening bottom elevation EL.75')	RM.NO.200 RHR P'P EL.75'		Y	N
DR NO. 204 water-seal doors	RM.NO.201 SPR. P'P A Train EL.64'	PM ARC12-DR09	Y	N
Bricked up opening(Only consider flooding problems w/o water-seal metal membrane, opening bottom elevation	RM.NO.201SPR. P'P EL.75'		Y	N

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
EL.75’)				
DR NO.208 water-seal doors	RM.NO.196 CHARG. P'P B Train EL.64'	PM ARC12-DR08	Y	N
Bricked up opening with water-seal metal membrane	RM.NO.196CHARG. P'P EL.75'		Y	N
PENE. NO. A145 (WATER SEAL)(Only consider penetrators under flooding water level)	RM.NO.196CHARG. P'P RM EL.79'	S.O.P. 630-S-015	Y	N
PENE. NO. AA268 (WATER SEAL)(Only consider penetrators under flooding water level)	RM.NO.196CHARG. P'P RM EL.77'	S.O.P. 630-S-015	Y	N
DR NO.198 water-seal doors	RM.NO.197CHARG. P'P S 台 RM EL.75'	PM ARC12-DR11	Y	N
Bricked up openings with water-seal metal membrane	RM.NO.197CHARG. P'P EL.75'		Y	N
PENE. NO.OA162 (WATER SEAL)(Only consider penetrators under flooding water level)	RM.NO.197CHARG. P'P EL.79'	S.O.P. 630-S-015	Y	N
PENE. NO. OA163 (WATER SEAL)(Only consider penetrators under flooding water level)	RM.NO.197CHARG. P'P EL.79'	S.O.P. 630-S-015	Y	N
PENE. NO. OA539 (WATER SEAL)	RM.NO.197CHARG. P'P EL.79'	S.O.P. 630-S-015	Y	N

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
(Only consider penetrators under flooding water level)				
PENE. NO. OA1006 (WATER SEAL)(Only consider penetrators under flooding water level)	RM.NO.197CHARG. P'P EL.77'	S.O.P. 630-S-015	Y	N
PENE. NO. AA266 (WATER SEAL)(Only consider penetrators under flooding water level)	RM.NO.197CHARG. P'P EL.78'	S.O.P. 630-S-015	Y	N
DR NO.202 water-seal doors	RM.NO.202 CHARG. P'P A Train EL.75"	PM ARC12-DR07	Y	N
Bricked up opening with water-seal metal membrane	RM.NO.202 CHARG. P'P EL.75"		Y	N
PENE. NO. OA1004 (WATER SEAL)(Only consider penetrators under flooding water level)	RM.NO.196CHARG. P'P EL.78'	S.O.P. 630-S-015	Y	N
PENE. NO. OA211 (WATER SEAL)(Only consider penetrators under flooding water level)	RM.NO.196CHARG. P'P EL.79'	S.O.P. 630-S-015	Y	N
PENE. NO.OA1723 (WATER SEAL)(Only consider penetrators under flooding water level)	RM.NO.196CHARG. P'P EL.77'	S.O.P. 630-S-015	Y	N
PENE. NO.OA1724 (WATER SEAL)(Only consider penetrators under flooding water level)	RM.NO.196CHARG. P'P EL.77'	S.O.P. 630-S-015	Y	N
PENE. NO.OA887 (WATER SEAL)(Only consider penetrators under flooding water level)	RM.NO.196CHARG. P'P EL.77'	S.O.P. 630-S-015	Y	N

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
PENE. NO.OA1723,1724,887(WATER SEAL)(Only consider penetrators under flooding water level)	RM.NO.196CHARG. P'P EL.77'	S.O.P. 630-S-015	Y	N
FLOOR DRAIN	A/B EL.74'-0"(3-P-ZA-801)	S.O.P 700-M-263,MEA1/2-0364	Y	N
FLOOR DRAIN	A/B EL.88'-0"(3-P-ZA-802)	S.O.P 700-M-263,MEA1/2-0364	Y	N
FLOOR DRAIN	A/B EL.100'-0"(3-P-ZA-803)	S.O.P 700-M-263,MEA1/2-0364	Y	N
FLOOR DRAIN	A/B EL.126'-0"(3-P-ZA-804)	S.O.P 700-M-263,MEA1/2-0364	Y	N
FLOOR DRAIN	A/B EL.148'-0"(3-P-ZA-805)	S.O.P 700-M-263,MEA1/2-0364	Y	N
SUMP PUMP (N-LE-P117/P118/P119/P120)	RM.NO.81 EL.80'-0"(3-OP-ZJ-111,211)	MEA1/2-0364	Y	N
FLOOR DRAINS	RM.NO.60~63,65,66,70,71,74,75 EL.80'-0"(3-P-ZJ-801)	S.O.P 700-M-263	Y	N
WALL SCUPPERS	RM.NO.89,90,93 EL.100'-0"(3-P-ZJ-802)	Visual Inspection	Y	N
FLOOR DRAINS	RM.NO.117,126 EL.126'-0"(3-P-ZJ-803)	S.O.P 700-M-263,MEA1/2-0364	Y	N
FLOOR DRAINS	RM.NO.160~163 EL. 148'-0"(3-P-ZJ-804)	S.O.P 700-M-263,MEA1/2-0364	Y	N
LARGE PIT & SUMP PUMP(N-LE-P125/P126)	RM.NO.467,470 EL.100'-0" (3-P-ZD-101,151)	MEA1/2-0364	Y	N

Equipment/ material	Location	Methods to verify functions	Function (Y/N)	Deviation and Enhancement measures
FLOOR DRAINS	RM. NO.361,362 EL.100’-0”(3-P-ZA-806)	S.O.P 700-M-263,MEA1/2-0364	Y	N
FLOOR DRAINS	RM.NO. 367 EL.126’-0”(3-P-ZA-806)	S.O.P 700-M-263,MEA1/2-0364	Y	N
4’X 8’LOUVERED OPENINGS	RM.NO. 367 EL.126’-0”	Open & Close Test	Y	N
FLOOR DRAINS	RM.NO.378,379 EL.100’-0”(3-P-ZF-801)	S.O.P 700-M-263,MEA1/2-0364	Y	N

4. Extreme natural events

4.1 Very bad weather conditions (storm, heavy rainfalls)

Due to global warming effect, climate changes have become more severe and unpredictable. May and June are the rain season in Taiwan and typhoons may attack Taiwan between July and October. Statistics data from Central Weather Bureau indicates that typhoon is an important factor to extreme rainfall in Taiwan. The longer typhoon stays, the more damages it causes. Maanshan FSAR included storms in design basis events and proved that the preventive measures of the plant meet design basis requirements. After the Fukushima Daiichi Nuclear Plant accident on March 11, 2011, flooding protection design of important equipment in Auxiliary, Control, Turbine, Administration, Radwaste, Aux. Boiler and NSCW pump buildings, including penetration seals, floor drains, doorsills, and sump pumps, .had been reviewed and listed. Field walk down had been completed. And maintenance and test programs had been established to assure equipment reliability. Meanwhile, to prevent the impact of extreme nature events, Taipower Company examined preventive measures of every site in Taiwan in September, 2011 by performing stress tests as shown in Appendix 4-1 which response to multiple extreme natural events such as typhoons and heavy rain/mudslides, and beyond design basis events. Through the stress tests, Taipower Company tried to identify weaknesses and cliff edge effects of the site and enhance each site's preventive measures. This chapter contains the results of beyond design basis stress tests in response to multiple extreme natural events such as typhoons and heavy rain/mudslides. According to Central Weather Bureau, Maanshan area has no lightening or hail damage record. If lightening or hail disaster did occur, safety related equipment would not be affected. However, transmission lines of off-site power might be damaged, and the consequence is covered by this chapter.

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

The site locates in South Bay, Hengchun Township, Pingtung County of Taiwan, and covers an area of 329 hectares, approximately 5 km from Hengchun Township, 15 km north of Cape Eluanbi and 110 km south of Kaohsiung. Extreme weather conditions that may potentially threaten the plant include typhoons, heavy rain, mudslides, etc. The most severe multiple disaster events is the combination of typhoons, heavy rain, and mudslides. To protect the site from this kind of multiple disaster events, the plant is designed with the following design bases:

1. Protection against onsite flooding design base
   (1) Drainage pipe design: Onsite flood draining utilizes gravity. The design for ground level flood drainage system includes:
      a. The drainage capability of the east side pipes and trenches is 11CMS (The ending part of the outlet trench is 180cm in width and 200cm in depth, with screening on fences.).

b. The drainage capability of the west side pipes and trenches is 9CMS (The ending part of the outlet trench is 180cm in width and 200cm in depth, with screening on fences.).

The total drainage capability of both east and west side of pipes and trenches is 20CMS. This drainage system covers an area of 216,627m^2 (onsite building areas, parking lot in the north site, and warehouse areas). Based on the design maximum rainfall of 120mm/hr stated in FSAR section 2.3.2.3, the estimated drainage requirement is 7.22CMS, which is far smaller than the designed draining capability. Besides, there is a natural drainage gate at south side of the site, providing additional 20CMS drainage capability of direct surface drain to the sea where circulating water intake area is located.

(2) There are highlands in north, east, and west sides of the site. This landscape surrounding the site allows it to have an isolated drainage system. Roads separate the drainage system in the north of the site; roads and safety fences divide the system in the east of the site; stone rip raps separate the system in the west of the site. Therefore, rainfalls outside of the site do not enter the site.

(3) Considerations on designs for site surrounding area

a. In order to prevent accumulated rainfall (stated in section 3.4.1.1.2) from flowing into the site, all the doors on the outer walls of all buildings and openings on the ground are at least 6 inches above ground. The elevation of site buildings is 14.85 meters above sea level.

b. Synthetic rubber water-proof tape is installed at contraction seams and structure seams of foundation and underground walls. The foundation and the outer walls under the ground of all onsite buildings are water-proof. Water-proof tapes and water-proof coatings are inaccessible, so examination is not possible. However, since they are buried underground, chances of degradation and the resulting leakages would be small.

c. The design of site surrounding area includes a ground drainage system which is capable of draining the probable maximum precipitation (PMP) with enough slope ratio to release the rain from pipes on roofs even when maximum rainfall intensity is reached.

Note: All approachable water-proof doors, barriers (including anti-missile doors, CCW RC shielding wall, etc) and the completeness of penetration sealing have been verified and examined. Except the penetration sealing in the pump house (which has been fixed), all of these meet design basis requirements.

(4) According to FSAR 2.3.2.3, the design basis of the site can sustain sudden heavy rainfall of 7.22CMS at a peak intensity of 120mm/hr (in a statistically calculated 100-year storm) and sudden heavy rainfall of 13.72CMS at a peak intensity of 228mm/hr (in a statistically calculated 10,000-year storm). Both sudden heavy rainfall data do not exceed draining capability of the protection against external design flood event, which is 20CMS (maximum rainfall intensity of 325mm/hr).

Note: Based on Central Weather Bureau's regional historic record of maximum rainfall intensity, the most serious one is 156.5 mm/hr (9.56CMS), which occurred when typhoon Damrey lingered on Sept. 23, 2005. This data does not exceed the design basis of 325 mm/hr and typhoon Damrey did not cause any flooding in the site.

Based on daily maximum rainfall data from 1980 to 2011 collected by Central Weather Bureau's Hengchun weather station, and calculation result using Log-Pearson Type III model, the estimated regional maximum rainfall per hour is 169.36 mm/hr once every 100-year and 303.32 mm/hr once every 10,000-year. Although FSAR's design basis for the frequency of once every 10,000 years is 228mm/hr, the runoff generated from maximum rainfall 303.32mm/hr is still smaller than the drainage capability of the onsite drainage system, which is 20 CMS (equal to 325mm/hr rainfall).

2. Mudslides disaster

(1) Official information from Soil and Water Conservation Bureau, Council of Agriculture, Executive Yuan shows there is no debris-flow-prone stream in Hengchun region.

(2) The site conducted a slope investigation after a freeway slope collapsed a year ago at northern Taiwan. The investigation results confirmed that there is no dip-slope near the site.

(3) The landscape in south of the site is next to the ocean and lower than the site, while the landscape in the other three directions of the site is higher and there are stone rip raps on the slopes in these directions. The plant structure is located directly on the plate of fresh mudstone soil with no liquefaction conditions. The peripheral slope heights are low, and the slopes are small. There is no water source. The potential surface changes will be minimal in the earthquake. No special measure is required.

a. The peak elevation of the whole retaining wall structure on the east side is approximately 30 meters. The whole structure is built in four layers from top to bottom, which are plateau, slope, plateau, and slope. The incline of the slope is smaller than 34° and there is no concern for collapse.

b. On top of the slope in north of the site is Switchyard which is well-planned and well-constructed. In between the site and the Switchyard are two slopes and one plateau. The elevation of the Switchyard is 25 meters and the incline of slope is smaller than 34˚. There is no concern for collapse.

c. The top of the slope in west of the site is at an elevation of approximately 24 meters, where there are roads next to protection fences of a reserve and protection vegetation and forest. The elevation is about 25 meters. The slope is stable and there is no concern for collapse.

3. Design protection against flooding inside buildings

If the height of a tsunami is higher than the elevation of the site (15 meters), the tsunami and the debris it brings may cause damage to many buildings, doors, roads, tanks and other infrastructures in the site. According to “the Comprehensive Safety Assessments of Taipower Company’s nuclear power plant”, the elevation of main building of the site is higher than highest tsunami run-up (12.53meters), so the site is not affected by tsunami.

Design basis of protection against flooding of equipment inside buildings (See FSAR 3.4 for more detail.):

(1) Safety related components are redundant. The arrangements of safety equipment are appropriately separated. In addition, the equipment rooms are also designed with drainage system.

(2) Water seal rooms are designed to protect safety related equipment. There are switches and circuits on the water seal doors, which allow alarms to go off to notify the control room when the doors are inappropriately opened.

(3) Waterproof design exists in rooms that have safety related equipment inside, pass ways for workers to use, piping, and other penetrated holes on walls.

(4) In regards to sealing function of walls, doors, (control, electrical, air, and etc) panels, or other compartments, they are all designed according to FSAR 3.4.1.2 Flood protection for Flooding from component Failures.

(5) There is a flood alarm system for system components and piping in the rooms of buildings, which is connected to the control room.

(6) Water systems connected to ocean, no matter where they are located or what their protection functions are, will not fail in a flooding events.

(7) The openings of movable bricked-up located in probable flooding area are designed to have metallic diaphragm water seal. The design for the hatches for equipment maintenance includes water seal.

(8) There are louver openings at the bottom of non water seal doors.

(9) There are 6 inches curbs for the doors of the rooms where flooding level is lower, but the curbs are higher than 6 inches in some special areas.

(10) Elasto-metric expansion joints are used as water seal at separated joints among construction structures. For the penetrators that are lower than maximum flood level and are between pipes and penetrator pipes, they are designed to be equipped with elasto-metric expansion joints as water seal.

(11) All building rooms are designed to be able to withstand hydrostatic pressure from predictable flooding events.

(12) Areas where fast flooding accumulation or high flow break may happen are designed to have outfalls.

(13) Electrical pull boxes and other fragile equipment are installed with mats. Fire-proof nozzles have protection design.

(14) Flow orifices are installed in different fire-fighting pipes.

Based on the design basis of protection for the equipment in buildings just stated above, preventive measures against flooding in buildings are designed with consideration of the analysis result and suggestion for flooding, resulting from pipe rupture events in each room (For detail, see FSAR 3.4).

Design for protection of important safety equipment in buildings (outside of containment building) against flooding is as below:

(1) There are water-proof doors.

(2) Bricked up openings contain water seal metallic diaphragm.

(3) Water seal penetration and floor drains exist in the design.

(4) There are overflow dikes in buildings and curbs higher than 6 inches in rooms with important electric equipment inside to prevent flooding.

4. Sustainability of outdoor equipment against strong winds:

(1) 345kV circuit can sustain wind velocity of up to 61.9m/s (Beaufort scale 17: 56.1~61.2 m/s).

(2) 161kV circuit can sustain wind velocity of up to 45m/s (Beaufort scale 14: 41.5~46.1 m/s)

(3) Towers can sustain wind velocity of up to70.7m/s (stronger than Beaufort scale 17).

(4) The wind resistant strength of seismic category 1 structure is 70 m/s (stronger than Beaufort scale 17). The class I structures containing ESF equipment are designed to withstand the powerful wind speed of typhoon and ensure sufficient capability to implement the reactor safe shutdown. FSAR 3.5.1.4 Missiles Generated by the Natural Phenomena has incorporated the threat of typhoon rolled flying objects into the assessment. Table 3.5-7 analyzed a 4000 lb. car with a horizontal speed of 75 ft / sec and vertical speed of 50 ft/sec impacted the building. The building can sustain and absorb impact energy and protect system components. Rolled ups by strong winds flying objects (projectile) impact, will not cause damage to the safety-related equipment, but may affect the outside plant power transmission lines. Its impact is covered in this chapter.

4.1.2 Weak points and cliff edge effects

1. Design for protection against flooding in buildings is based on analysis result and suggestion from flooding caused by pipe rupture events in each room. Except for the 7 ECCS pump rooms at the bottom of auxiliary building, there is no need to install water seal doors for any other rooms. Drainage system for rain and influence of tsunami were considered at the beginning of the design, but then it was determined that no buildings would be inundated by flooding from outside. However, if flooding resulting from natural disasters is beyond design basis and causes water to accumulate in buildings, the vulnerability would be in the control building 80 feet area.
2. Flood vulnerability and cliff-edge effect can lead to flooding at the bottom 80 feet of control building, where there is safety related electrical equipment, including A/B essential buses,

A/B/C/D safety train battery rooms, chargers etc. If equipment were flooded, it could not perform its interned function. This also means loss of all AC/DC powers, reactor decay heat can only be removed by secondary side heat sink. Turbine-driven auxiliary feed water pump makes up water to S/G, and locally operate AL-HV213, HV-214, HV-215 and S/G power operated relief valves, maintaining S/G feed and bleed. If secondary side heat sink is also lost, serious consequences such as reactor core meltdown might happen. This cliff edge effect is same as section 5.1.3 "Loss of off-site power, ordinary back-up power, and other diverse back-up power". The duration before fuel damage is also discussed in section 5.1.3.

3. Flood vulnerability appears when safety related pumps (located in rooms with water seal doors) are in 74 feet of flooding in auxiliary buildings. Hence, immediate responses are needed when there is high water level alarm in sumps of buildings.
4. Additionally, if the inlets of nuclear service cooling water pumps (NSCW) are blocked by debris, the screens will be clogged and pump would loss its intake water function and result in lost of ultimate heat sink.

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

1. Response measures to severe extreme weather (refer to Fig. 4-1 "Typhoon Response Procedure" and Fig. 4-2 "Onsite Building Flooding Response Procedure")
   (1) When Central Weather Bureau issues typhoon alert that typhoons may influence the plant, procedure 154 (typhoon-period response procedure) will be followed.
   (2) When Central Weather Bureau forecasts that the radius of typhoons may cover Taiwan, Jin Men, and Ma Zu within 18 hours and issues "alerts for typhoons alarm at sea and land area". If the plant is inside the forecast typhoon coverage area, the plant follows procedure 584 (typhoon-period operating procedure).
   (3) If tsunami alert for the site is issued, the plant follows procedure 582.2 (tsunami handling procedure).
   (4) Once building of the site is flooded, the plant follows procedure 583 (emergent flooding event procedure).
   (5) Follow procedure 1401 (emergency event classification procedure) based on the influence of strong winds and extremely heavy rain to the plant, and categorize the influence. Therefore, the plant can move forward to make correct judgment about the event based on the procedure as soon as possible, decide response measures, and immediately report following guidance.
   (6) When situations/conditions beyond design basis happen and plant units lose AC/DC powers or make-up water to reactors/steam generators, the plant must be prepared to take decisive actions to abandon reactors and follow procedure 1451 (ultimate response guideline procedure).

2. Enhancement measures

(1) To enhance the capability to prevent the impact from tsunami, a trash rack grating cover has been installed on top of intake pool of nuclear service cooling water pump house. The purpose of the installation is to prevent large garbage and debris from dropping into the intake pool. Besides, the seawater pump motor rooms have been enhanced with water seal enhancement to prevent the lost of seawater pump due to the strike of tsunami.
(2) Perform structure inspection according to procedure 700-A-001. The scope of inspection includes pipe structure, integrity and un-impediment of drainage trench and vicinity of retaining structures, such that it can be timely repaired.
(3) According to procedure 582, 582.1, 582.2 for equipment inspection and handling after the event of earthquake/tsunami.
(4) Emergency equipment are maintained and tested according to procedure 192 to keep available at all times. Emergency equipment includes 12 gas-powered water pumps, 8 electrical sink pumps and emergency power (1 diesel-powered generator, 3 multifunctional work stations, 18 gasoline generators) for sink pumps.
(5) In case important buildings, such as control building or auxiliary building, were flooded and sump pumps can not drain out the water in time, additional temporary sink pumps will be added to increase the discharge capability. Buildings connecting to control building and auxiliary building such as access control building and radwaste building will be reviewed for flooding protection.
(6) There are 10-inch curbs installed at the entrance of the room of A/B essential bus and A/B/C/D charger in control building to prevent these rooms from flooding. DCR-M1-4249/M2-4250 enhances water tight capability of important buildings outside doors are in progress. If the fire/explosion-proof doors can sustain hydrostatic pressure, then the cliff edge effect will be external flooding to the top of building opening (≧ 19m above sea level).
(7) The plant has procured 30 diesel-powered water pumps to increase temporary drainage capability.
(8) The plant has procured 10 480VAC mobile diesel generators, which can provide emergency backup power to feedwater pumps, air-conditioning equipment, monitoring instruments and emergency lighting/communication equipment.
(9) The plant will procure two 4.16kV mobile diesel-powered generators as backup power to long-term cooling equipment. (To be completed by Jun 30, 2012)

Appendix 4-1 “Typhoon and Extremely Heavy Rain/Mudslide” Onsite Stress Test

Severe Typhoons with Extremely Heavy Rain Stress Test Process for the Third Nuclear Power Plant

Scenario:

1. Two units are in full-power operation.
2. Central Weather Bureau issues an extreme heavy rain warning and the plant is in an area under the typhoon warning (Accumulated rainfall can reach up to 350 mm in 24 hours).
3. Typhoon emergency response team is established. 6 fire fighters and the typhoon team members are put on stand by.
4. One shift stands by in the dormitory while one shift is on duty.
5. A severe typhoon has pounded the plant, causing the loss of emergency power and standby power.
6. The typhoon carries extremely heavy rain, causing flooding at the bottom of buildings and the loss of water feeding function of the safety system.

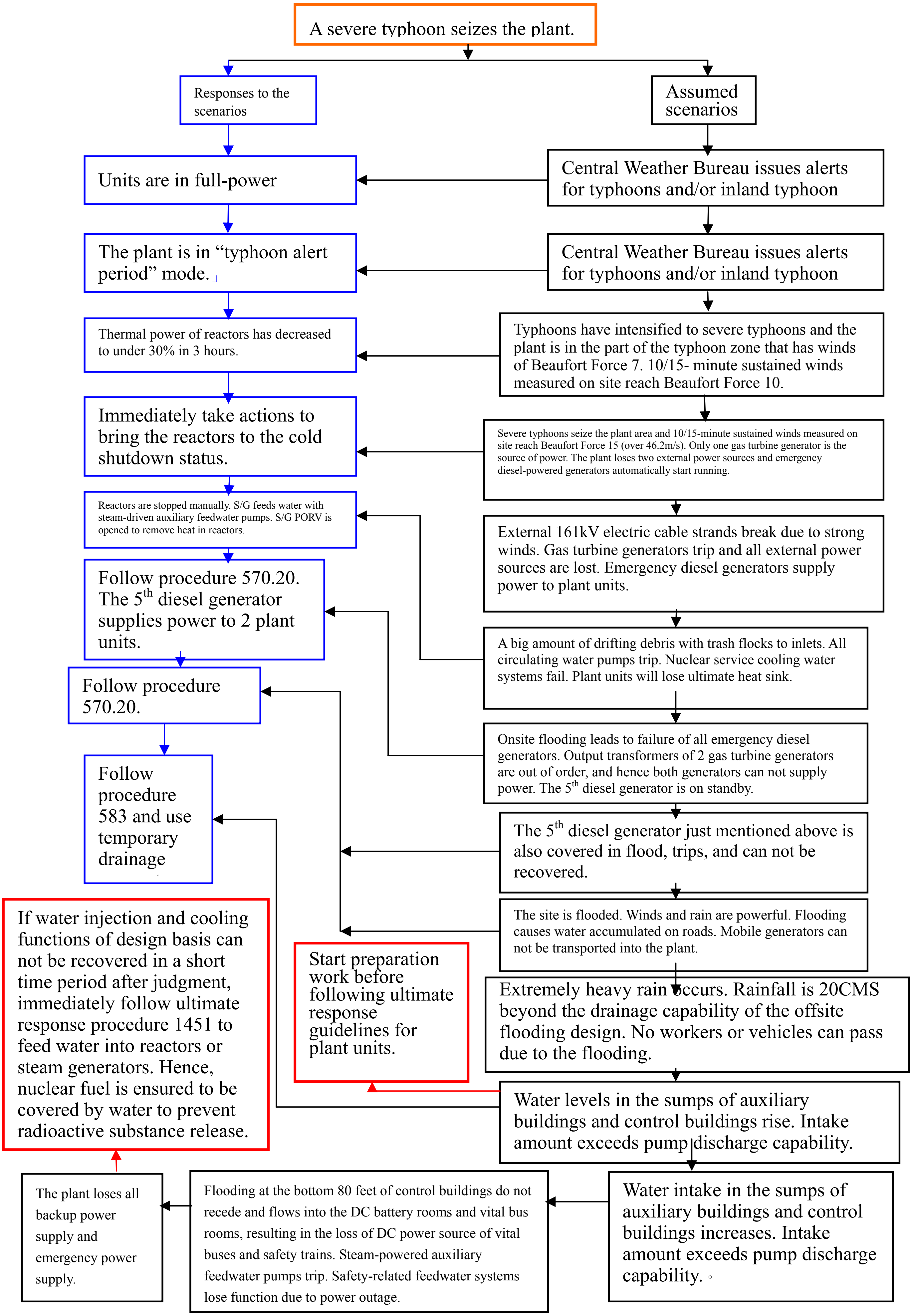

Fig 4. Block diagram of stress test sequence

Scenarios：

1. Two units are in full power operation.
2. Central Weather Bureau issues an extreme heavy rain warning and the plant is in an area under the typhoon warning. (Accumulated rainfall can reach up to 350mm in 24 hours.).
3. Typhoon emergency response team is established. 6 firemen and the typhoon team members are put on stand by.
4. One shift stands by in the duty room while one shift is on duty.
5. A severe typhoon has pounded the plant, causing the loss of emergency power and standby power.

Failure scenarios	DB and scenario baseline	Unit treatment: Preventive intensity	Unit treatment: Procedure	Manpower/ Duration
Central Weather Bureau issues sea alerts for typhoons and/or inland typhoon warnings, and the typhoons may influence the plant. The plant is in "typhoon watching period" mode.	1.345kV circuit can sustain wind velocity of 61.9ms (Beaufort Force 17: 56.1~61.2 m/s). 2.161kV circuit can sustain wind velocity of 45m/s (Beaufort Force 14: 41.5~46.1 m/s). 3.Towers can sustain wind velocity of 70.7m/s. 4.The wind resistant strength of seismic-resistant class 1structure is 70 m/s.	**Power sources** 1.345kV 4 loops. 2.161kV 2 loops. (including gas turbine generators). 3.Emergency diesel generators. 4.The 5^{th} diesel generator (capable of providing power to two plant units simultaneously). 5.The 3^{rd} power source: 11.4kV/4.16kV, providing emergency power 4.16kV and 480VAC to #1 or #2 plant unit via 5^{th} D/G. 6.480V mobile diesel generator. 7.DC power. 8.Will add two 4.16kV mobile generators. (To be finished by 101.06.30) 9.Will add ten 480VAC mobile diesel generators. **S/G feed water** Electrical auxiliary feedwater pumps. Steam-driven auxiliary feedwater pumps. Diesel feedwater pumps. Diesel fire-fighting pumps. 5.Fire trucks. **Feeding water into the reactors** 1. Reactor feedwater system (including feeding done by fire trucks). 2. ECCS feed water.. 3. Feed water by RWST through gravity. 4.BH-P020。 5.Feed water into containments. 6.Install quick connectors on RWST to allow fire trucks to feed water. **Heat sink** 1.Nuclear service cooling water systems 2.CST。 3.DST。 4.Raw water pool. 5.Install quick connectors on CST to allow fire trucks to feed water.	1. After Central Weather Bureau issues typhoon warnings/ alerts, the site superintendent or his authorized person should assess/ evaluate actual site situations and decide whether a typhoon emergency response team should be established. 2. Three hours after the typhoon emergency response team is established, each division demonstrates each inspection item in procedure 154 and takes preventive measures. Then, submit the inspection list to the typhoon deputy director for compilation. 3. When typhoons hit and the local government announces days off due to typhoons, commuter buses for plant workers are not in service. But after consideration of the safety of plant units and the site, if the typhoon deputy director has safety concerns, he should have plant managers contact relevant workers to be on duty. Besides, he should have managers from the supply department to dispatch cars. 4. The typhoon deputy director compiles personnel rolls for the typhoon emergency response team from each department into SOP 154 list 1.A copy is sent to the supply division (for the use of both car and food preparations). 5. Operation division evaluates intensity of wind and rain, and, when needed, informs workers on duty to stay onsite to be on call. Next shift will take its turn on duty. Meanwhile, consider situations and arrange the operation response group and the training group to increase shift staff onsite. Additionally, ask shift staff to come to the plant in advance if roads may collapse or landslides may happen due to strong winds and rain.	Each division sends workers to finish inspecting procedure 154 in 3 hours.

Failure scenarios	DB and scenario baseline	Preventive intensity	Procedure	Manpower / Duration
		Unit treatment		
Central Weather Bureau issues sea alerts for typhoons and/or inland typhoon warnings, and the plant is in an area under the typhoon warning. The plant is in "typhoon alert period" mode.	1.345kV circuit can sustain wind velocity of up to 61.9m/s (Beaufort Scale 17: 56.1~61.2 m/s). 2. 161kV circuit can sustain wind velocity of up to 45m/s (Beaufort Scale 14: 41.5~46.1 m/s) 3.Towers can sustain wind velocity of up to70.7m/s (stronger than Beaufort Scale 17). 4.The wind resistant strength of seismic-resistant class 1structure is 70 m/s (stronger than Beaufort Scale 17).	**Power sources** 1.345kV 4 loops. 2.161kV 2 loops (including gas turbine generators). 3.Emergency diesel generators. 4.The 5th diesel generator (capable of providing power to two plant units simultaneously). 5.The 3rd power source: 11.4kV/4.16kV, providing emergency power 4.16kV and 480VAC to #1 or #2 plant unit via 5th D/G. 6.480V mobile diesel generator. 7.DC power source. 8.Will add two 4.16kV mobile generators. (To be finished by 101.06.30) 9.Will add ten 480VAC mobile diesel generators. **S/G feed water** 1.Eletrical auxiliary feedwater pumps. 2.Steam-driven auxiliary feedwater pumps. 3.Diesel auxiliary feedwater pumps.。 4.Diesel fire-fighting pumps. 5.Fire trucks. **Feeding water into the reactors** 1. Reactor feedwater systems. 2.ECCS feed water. 3.Feed water by RWST through gravity. 4.BH-P020。 5.Feed water into containments. 6.Install quick connectors on RWST to allow fire trucks to feed water. **Heat sink** 1.Nuclear service cooling water systems 2.CST。 3.DST。 4.Raw water pool. 5.Install quick connectors on CST to allow fire trucks to feed water.	1.During typhoons, plant employees should follow "Judgment principles and response measures for catastrophes, accidents, and unexpected events" available on the homepage of the human resource division. 2.Follow procedure 584 step V "operation strategies of the plant for typhoons." 3. Considering average wind speeds and gust speeds announced by Central Weather Bureau, the plant predicts the duration and intensity of influence of typhoons on the site. Besides, the plant makes operation strategies and judgment in accordance with "Typhoon information, and judgment on damage level to the plant" and "Estimate on duration and intensity of influence of typhoons on the plant" in AOP 584.	23 workers on duty from each group/ 1 hour
			4. During typhoons, managers or their authorized person of each division should send workers to inspect protection facilities and equipment again typhoons at irregular time intervals in order to ensure they are able to function normally and workers can record inspection results for later use. The equipment includes gas turbine generators, emergency diesel generators, equipment used to remove trash in pump rooms, water-proof drainage pumps, fire trucks and etc.	3 workers from each division on duty/ hour.

Failure scenarios	DB and scenario baseline	Preventive intensity	Procedure	Manpower / Duration
		Unit treatment		
Central Weather Bureau issues sea alerts for typhoons and/or inland typhoon warnings, and the typhoons have intensified to severe typhoons. The plant is in the part of the typhoon zone that has winds of Beaufort Force 7. 10/15-minute sustained winds measured on site reach Beaufort Force 10.	.345kV circuit can sustain wind velocity of 61.9ms (Beaufort Force 17: 56.1~61.2 m/s). 2.161kV circuit can sustain wind velocity of 45m/s (Beaufort Force 14: 41.5~46.1 m/s). 3.Towers can sustain wind velocity of 70.7m/s. 4.The wind resistant strength of seismic-resistant class 1structure is 70 m/s.	**Power sources** 1.345kV 4 loops. 2.161kV 2 loops (including gas turbine generators). 3.Emergency diesel generators. 4.The 5th diesel generator (capable of providing power to two plant units simultaneously). 5.The 3rd power source: 11.4kV/4.16kV, providing emergency power 4.16kV and 480VAC to #1 or #2 plant unit via 5th D/G. 6.480V mobile diesel generator. 7.DC power source. 8.Will add two 4.16kV mobile generators. (To be finished by 101.06.30) 9.Will add ten 480VAC mobile diesel generators. **S/G FEED WATER** 1.Eletrical auxiliary feedwater pumps. 2.Steam-driven auxiliary feedwater pumps. 3.Diesel auxiliary feedwater pumps。 4.Diesel fire-fighting pumps. 5.Fire trucks. **Feeding water into the reactors** 1.Reactor feedwater system (including feeding done by fire trucks). 2.ECCS feed water. 3.Feed water by RWST through gravity. 4.BH-P020。 5.Feed water into containments. 6.Install quick connectors on RWST to allow fire trucks to feed water. **Heat sink** 1.Nuclear service cooling water systems 2.CST。 3.DST。 4.Raw water pool. 5.Install quick connectors on CST to allow fire trucks to feed water.	1.Follow procedure 584 "Typhoon-period operation strategies."Thermal power of reactors has decreased to under 30% in 3 hours.。	23 workers on duty from each grou
			2.Typhoon emergency response team workers receive dispatch of the typhoon director or the deputy director to rescue damaged equipment.	Typhoon emergency response team workers are on call.

Cliff-edge Effect: Flooding results in the loss of DC power source, failure of monitoring equipment and safety equipment systems, and unclear status of plant units

Failure scenarios	DB and scenario baseline	Preventive intensity / Unit treatment	Procedure	Manpower / Duration
Severe typhoons seize the plant area and 10/15-minute sustained winds measured on site reach Beaufort Force 15 (over 46.2m/s). Only one turbine generator is the source of power. The plant loses two external power sources and emergency diesel-powered generators automatically start running.	1.345kV circuit can sustain wind velocity of 61.9ms (Beaufort Force 17: 56.1~61.2m/s). 2.161kV circuit can sustain wind velocity of 45m/s (Beaufort Force 14: 41.5~46.1m/s). 3.Towers can sustain wind velocity of 70.7m/s. 4.The wind resistant strength of seismic-resistant class 1structure is 70 m/s.	**Power sources** 2. Gas turbine generators supply power to 161kV. 3.Emergency diesel generators. 4.The 5th diesel generator (capable of providing power to two plant units simultaneously). 5.The 3rd power source: 11.4kV/4.16kV, providing emergency power 4.16kV and 480VAC to #1 or #2 plant unit via 5th D/G. 6.480V mobile diesel generator. 7.DC power source. 8.Will add two 4.16kV mobile generators. (To be finished by 101.06.30) 9.Will add ten 480VAC mobile diesel generators. **S/G feed water** 1.Eletrical auxiliary feedwater pumps. 2.Steam-driven auxiliary feedwater pumps. 3.Diesel auxiliary feedwater pumps.。 4.Diesel fire-fighting pumps. 5.Fire trucks. **Feeding water into the reactors** 1.Reactor feedwater system (including feeding done by fire trucks). 2.ECCS feed water. 3.Feed water by RWST through gravity. 4.BH-P020。 5.Feed water into containments. 6.Install quick connectors on RWST to allow fire trucks to feed water. **Heat sink** 1.Nuclear service cooling water systems 2.CST。 3.DST。 4.Raw water pool. 5.Install quick connectors on CST to allow fire trucks to feed water.	Follow procedure 584 "Typhoon-period operation strategies" and immediately take actions to bring the reactors to the cold shutdown status. Follow 501.3 if all external power sources trip, gas turbine generators and differential relay will also trip. Then the plant should make sure emergency diesel generators are still operating.	23 workers on duty from each group/ 6 hours. 4 workers for each generator/ minute.
External 161kV electric cable strands break due to strong winds. Turbine generators trip.	Same as above.	Same as above.		

Failure scenarios → DB and scenario baseline → Preventive intensity | Procedure | Manpower / Duration

Unit treatment

The output transformers of 2 gas turbine generators are out of order, so the generators can not supply power.

Same as

Power sources
3.Emergency diesel generators.
4.The 5th diesel generator (capable of providing power to two plant units simultaneously).
5.The 3rd power source: 11.4kV/4.16kV, providing emergency power 4.16kV and 480VAC to #1 or #2 plant unit via 5th D/G.
6.480V mobile diesel generator.
7.DC power source.
8.Will add two 4.16kV mobile generators. (To be finished by 101.06.30)
9.Will add ten 480VAC mobile diesel generators.

S/G feed water
1.Eletrical auxiliary feedwater pumps.
2.Steam-driven auxiliary feedwater pumps.
3.Diesel auxiliary feedwater pumps。
4.Diesel fire-fighting pumps.
5.Fire trucks.

Feeding water into the reactors
1.Reactor feedwater system (including feeding done by fire trucks).
2.ECCS feed water.
3. Feed water by RWST through gravity.
5.Feed water into containments.
6.Install quick connectors on RWST to allow fire trucks to feed water.

Heat sink
1.Nuclear service cooling water systems
2.CST。
3.DST。
4.Raw water pool.
5. Install quick connectors on CST to allow fire trucks to feed water.

Gas turbine generators can not supply power. Make sure diesel generators supply power to the plant units.

4 workers for each generator/minute.

Failure scenarios	DB and scenario baseline	Preventive intensity	Procedure	Manpower / Duration
		Unit treatment		
A big amount of drifting debris with trash flocks to inlets. This leads to flow plunge of circulating water pumps, high differential pressure at screens of seawater inlet, and current overload of fine mash screens and traveling screen wash pumps. Then the pumps trip. All circulating water pumps also trip one after another.	(1)According to the description of FSAR, the capacity of the unit ultimate final heat sink intake forebay is 350382 ft^3 (total capacity of the intake forebay and the drainage building，from EL.-8.2'to EL.-27'，the bottom of the intake forebay EL.-28'，the bottom of the drainage building EL.-36.5'）.This capacity is enough for the amount of water needed for two units to operate for 30 minutes. Based on the calculation of FSAR, local tsunami cycle is 49 minutes and the falling tidal period is about 25 minutes. Therefore, seawater will be fed before reserved water is used up. (2) Backup system-power source, traveling screen, spare goods condition (including backup system): a Traveling screen racks spin vertically, driven by chains, or by hands when necessary. The screen racks receive power through safety trains A-1E-PH-E06 and-1E-PH-E06 b.. Both safety trains are maintained periodically. Spare components include wheels, chains, and screens for traveling screen racks. The quantity is enough to be used in three times of big maintenance.	**Power sources** 4.The 5th diesel generator (capable of providing power to two plant units simultaneously). 5.The 3rd power source: 11.4kV/4.16kV, providing emergency power 4.16kV and 480VAC to #1 or #2 plant unit via 5th D/G. 6.480V mobile diesel generator. 7.DC power source. 8.Will add two 4.16kV mobile generators. (To be finished by 101.06.30) 9.Will add ten 480VAC mobile diesel generators. **S/G feed water** 1.Eletrical auxiliary feedwater pumps. 2.Steam-driven auxiliary feedwater pumps. 3.Diesel auxiliary feedwater pumps.。 4.Diesel fire-fighting pumps. 5.Fire trucks. **Feeding water into the reactors** 1.Reactor feedwater system (including feeding done by fire trucks). 2.ECCS feed water. 3.Feed water by RWST through gravity. 5. Feed water into containments. 6. Install quick connectors on RWST to allow fire trucks to feed water. **Heat sink** 1.Nuclear service cooling water systems 2.CST。 3.DST。 4.Raw water pool. 5. Install quick connectors on CST to allow fire trucks to feed water.	Follow procedure 154: A big amount of drifting debris with trash flocks to inlets. Notify typhoon directors to send workers on call to clean up. (1) Situation 1: Inlets of nuclear service cooling water systems function normally (not stuck by tsunami debris), and drainage pumps have 5 extra pieces of power supply equipment available to use. Nuclear service cooling water systems and drainage pumps are submerged type, so they will not be damaged by tsunami. (Spare components are stored in warehouse #4, whose elevation is 26.1meters.) (2) Situation 2: Nuclear service cooling water systems(NSCW) Nuclear service cooling water pump inlets can not function, so feed water from stream generators. Through steam dump, residual heat in reactors is removed.	4 workers /4 hours

Failure scenarios	DB and scenario baseline	Preventive intensity / Unit treatment	Procedure	Manpower / Duration
Water discharge and pressure at outlets of Nuclear service cooling water systems fluctuate. Inlet areas of Nuclear service cooling water systems are full of driftwood and debris.	Same as above.	Same as above.	If all nuclear service cooling water systems can not operate, follow AOP578. When needed, stop the systems manually and follow EOP510.00. If the actions above cause NSCW to stop operating, follow EOP 570.29-- emergency procedure for loss of all component cooling water systems.	23 shift workers /hour.
There are flooding, strong winds, and heavy rain in the site. Flooding results in water accumulation on roads on site. Vehicles can not pass. Driftwood and debris at emergency inlets can not be cleaned up.	Same as above.	Same as above.	If all nuclear service cooling water systems can not operate, follow AOP578. When needed, stop the systems manually and follow EOP510.00. If the actions above cause the component cooling water systems to stop operating, follow EOP 570.29-- emergency procedure for loss of all component cooling water systems.	23 workers on

Failure scenarios	DB and scenario baseline	Preventive intensity (Unit treatment)	Procedure	Manpower / Duration
All nuclear service cooling water systems trip and can not recover for a short time period, so ultimate heat sink loses. Current overload of fine mash screens and traveling screen wash pumps occur and then both trip. Manually stop the operation of the reactors.	Same as above.	**Power sources** 4. The 5th diesel generator (capable of providing power to two plant units simultaneously). 5.The 3rd power source: 11.4kV/4.16kV, providing emergency power 4.16kV and 480VAC to #1 or #2 plant unit via 5th D/G. 6.480V mobile diesel generator. 7. DC power source. 8. Will add two 4.16kV mobile generators. (To be finished by 101.06.30) 9. Will add ten 480VAC mobile diesel generators. **S/G feed water** 1. Electrical auxiliary feedwater pumps. 2. Steam-driven auxiliary feedwater pumps. 3. Diesel auxiliary feedwater pumps.。 4. Diesel fire-fighting pumps. 5. Fire trucks. **Feeding water into the reactors** 1. Reactor feedwater system (including feeding done by fire trucks). 3. Feed water by RWST through gravity. 5. Feed water into containments. 6. Install quick connectors on RWST to allow fire trucks to feed water. **Heat sink** 2.CST。 3.DST。 4. Raw water pool. 5.Install quick connectors on CST to allow fire trucks to feed water.	If emergency diesel generators trip, follow EOP570.20, align 5THD with the (essential?) bus, and then restore the power. Operate the 5th diesel generator following ultimate response procedure 1451. Supply power to the essential buses of the two units.	23 shift workers /hour.

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Failure scenarios	DB and scenario baseline	Preventive intensity / Unit treatment	Procedure	Manpower / Duration
The plant is flooded. All emergency diesel generators and differential relay trip, and they can not be reset. The 5th diesel generator is on standby.	1. The total draining capability of both the east and the west side of pipes and trenches is 20CMS. According to FSAR2.3.2.3, the design basis of the site can sustain sudden heavy rainfall of 7.22CMS at a maximum rainfall intensity of 120mm/hr (in a statistically calculated 100-year storm) and sudden heavy rainfall of 13.72CMS at a maximum rainfall intensity of 228mm/hr (in a statistically calculated 10,000-year storm). Both sudden heavy rainfall data do not exceed the drainage capability of the protection against external design flood, which is 20CMS. Besides, there is a natural drainage gate at the south side of the site, providing direct current to the sea where the circulating water intake area is located. In extreme weather conditions (storms, extremely heavy rain), onsite flooding occurs if rainfall exceeds offsite flooding design basis, which is 20CMS. 2. Based on Central Weather Bureau's regional historic record of maximum rainfall intensity, the most serious one is 156.5 mm/hr (9.56CMS), which happened when typhoon Damrey struck on Sept. 23, 2005. This data does not exceed the design basis data of 325 mm/hr and typhoon Damrey did not cause any flooding in the site.	**Power sources** 4. The 5th diesel generator (capable of providing power to two plant units simultaneously). 5.The 3rd power source: 11.4kV/4.16kV, providing emergency power 4.16kV 及 480VAC to #1 or #2 plant unit via 5th D/G. 6.480V mobile diesel generator. 7. DC power source. 8. Will add two 4.16kV mobile generators. (To be finished by 101.06.30) 9. Will add ten 480VAC mobile diesel generators. **S/G feed water** 1. Electrical auxiliary feedwater pumps. 2. Steam-driven auxiliary feedwater pumps. 3.Diesel auxiliary feedwater pumps.。 4. Diesel fire-fighting pumps. 5. Fire trucks. **Feeding water into the reactors** 1. Reactor feedwater system (including feeding done by fire trucks). 3. Feed water by RWST through gravity. 5.Feed water into containments. 6.Install quick connectors on RWST to allow fire trucks to feed water. **Heat sink** 2.CST。 3.DST。 4.Raw water pool. 5.Install quick connectors on CST to allow fire trucks to feed water.	If emergency diesel generators trip, follow EOP570.20, align 5THD with the (essential?) bus, and then restore the power.	23 shift workers / 1 hour.
			Operate the 5th diesel generator following ultimate response procedure 1451. Supply power to the essential buses of the two units.	2 workers / 1 hour.

Failure scenarios	DB and scenario baseline	Preventive intensity / Unit treatment	Procedure	Manpower / Duration
After the 5^{th} diesel generator supplies power to two units, it is inundated by flooding and can not be recovered.	Same as above.	**Power sources** 6.480V mobile diesel generator. 7. DC power source. 8. Will add two 4.16kV mobile generators. (To be finished by 101.06.30) 9. Will add ten 480VAC mobile diesel generators. **S/G feed water** 1. Auxiliary feedwater pumps. 2.Steam-driven auxiliary feedwater pumps. 3.Diesel auxiliary feedwater pumps。 4.Diesel fire-fighting pumps. 5.Fire trucks. **Feeding water into the reactors** 1. Reactor feedwater system (including feeding done by fire trucks). 3. Feed water by RWST through gravity. 5.Feed water into containments. 6.Install quick connectors on RWST to allow fire trucks to feed water. **Heat sink** 2.CST。 3.DST。 4.Raw water pool. 5.Install quick connectors on CST to allow fire trucks to feed water.	(1) The 5^{th} diesel generator trips. Follow procedure 570.20 –Loss of all AC power sources.	23 shift workers / 1 hour.
			(2) Connect 480 mobile diesel generators to the 3^{rd} power source.	3 workers from each division / 1 hour.
Strong winds and heavy rain occur at the gas turbine generator building area. There is a blackout in the plant, so start diesel generators first to black start gas turbine generators. Besides, winds are too strong for workers to perform work.	Same as above.	Same as above.	1. The plant plans to add and connect two 1500KW power source vehicles with 4.16 vital buses. The plant does not plan to black start gas turbine generators via starting diesel generators first.	9 workers / 4 hours.
			2. Follow procedure 570.20 –Loss of all AC power sources.	23 workers on duty from each group/ 1 hour.

Failure scenarios	DB and scenario baseline	Preventive intensity	Procedure / Unit treatment	Manpower / Duration
There are flooding, strong winds, and heavy rain onsite. Flooding is seen on roads leading to the site. 1500KW power source vehicles	Same as abo	Same as above.	1500KW power source vehicles are needed for the power source of long-term cooling. If they can not be connected at this time, try again after flooding recedes and follow procedure 570.20 –Loss of all AC power sources..	23 workers on duty from each group/ 1 hour.
The plant is flooded and winds are strong. 480V mobile power source vehicles can not be brought to the correct location to be connected due to extremely strong winds.	Same as above.	Same as above.	Follow procedure 192: place 480 mobile power source at warehouses of higher elevation to avoid flooding. If connecting work can not be done at correct locations due to extremely strong winds, the typhoon emergency response team should send workers to help and follow procedure 570.20 –Loss of all AC power sources.	23 workers on duty from each group/ 1 hour

Cliff-edge Effect: The plant is flooded and it faces challenges of reliability and maneuverability of the backup power sources.

Failure scenarios	DB and scenario baseline	Preventive intensity / Unit treatment	Procedure	Manpower / Duration
Extremely heavy rain occurs. Rainfall is 20CMS beyond the drainage capability of the offsite flooding design. No workers or vehicles can pass due to the flooding.	1. The total drainage capability of both the east and the west side of pipes and trenches is 20CMS. The total drainage capability of both the east and the west side of pipes and trenches is 20CMS. According to FSAR2.3.2.3, the design basis of the site can sustain sudden heavy rainfall of 7.22CMS at a maximum rainfall intensity of 120mm/hr (in a statistically calculated 100-year storm) and sudden heavy rainfall of 13.72CMS at a maximum rainfall intensity of 228mm/hr (in a statistically calculated 10,000-year storm). Both sudden heavy rainfall data do not exceed the drainage capability of the protection against external design flood, which is 20CMS. Besides, there is a natural drainage gate at the south side of the site, providing direct current to the sea where the circulating water intake area is located. In extreme weather conditions (storms, extremely heavy rain), onsite flooding occurs if rainfall exceeds offsite flooding design basis, which is 20CMS. 2.Based on Central Weather Bureau's regional historic record of maximum rainfall intensity, the most serious one is 156.5 mm/hr (9.56CMS), which happened when typhoon Damrey struck on Sept. 23, 2005. This data does not exceed the design basis data of 325 mm/hr and typhoon Damrey did not cause any flooding in the site.	**Power sources** 7.DC power source. 8.Will add two 4.16kV mobile generators. (To be finished by 101.06.30) 9.Will add ten 480VAC mobile diesel generators. **S/G feed water** 2.Steam-driven auxiliary feedwater pumps. 3.Diesel auxiliary feedwater pumps.。 4.Diesel fire-fighting pumps. 5.Fire trucks. **Feeding water into the reactors** 1.Reactor feedwater system (including feeding done by fire trucks). 3.Feed water by RWST through gravity. 5.Feed water into containments. 6.Install quick connectors on RWST to allow fire trucks to feed water. **Heat sink** 2.CST。 3.DST。 4.Raw water pool. 5.Install quick connectors on CST to allow fire trucks to feed water.	Owning to the flooding design basis, onsite flooding would not happen. If drainage trenches fail, this will cause onsite flooding. Once this does happen, move mobile diesel generators to supply power to emergency safety equipment. Otherwise, proceed actions after the flooding recedes.	3 workers from each division / 1 hour

Failure scenarios	DB and scenario baseline	Preventive intensity / Unit treatment	Procedure	Manpower / Duration
Water intake in the sumps of auxiliary buildings and control buildings surges. Intake amount exceeds pump discharge capability.	1. Flooding design basis exists inside buildings and the preventive design does not require electricity equipment. Outlets of each floor can function to drain water into sumps even during power outage. If the amount of water flowing into each building exceeds the amount drained out, flooding will appear on each floor and worse situations will occur on lower floor levels. Waterseal doors and the sump pipes of ESF pump rooms do not directly lead to sumps in auxiliary buildings. This design prevents accumulated water from entering ESF pump rooms. 2.Onsite flooding design basis uses drainage trenches around the plant to attain the goal of drainage. 3. Inspect and seal building penetrators (630-S-015)(Conduct inspection during every big maintenance).Moreover, necessary building openings, such as doors/windows (650-S-006) (Conduct inspection every 6 months), need to be maintained to make sure their functions are normal. After breaking seals when necessary, follow procedure 1265-drilling, cutting, and sealing on pipes. 4. To enhance measures aimed at preventing external flooding entering buildings, seal penetrators on outer walls of buildings (630-S-015) (Conduct inspection during every big maintenance). Moreover, necessary building openings, such as doors/windows (650-S-006) (Conduct inspection every 6 months), need to be maintained to make sure their functions are normal. 5.To enhance measures aimed at preventing internal flooding in buildings, use outlets (700-M-263)of each floor level, ESF pump room water-tight doors (inspected by shift workers periodically), and sealing penetrators on walls (630-S-015) to attain the goal. 6.Flood vulnerability can lead to flooding at the bottom 80 feet of buildings, where there is safety related electrical equipment, including A/B essential buses, A/B/C/D safety train battery chamber, chargers, and etc. If all the equipment sits in flooding, none of it would function. This also means loss of all AC/DC power, which will result in serious consequence. Next flood vulnerability appears when safety-related pumps (all located in rooms with waterseal doors) are in 74 feet of flooding in nuclear auxiliary buildings. Hence, immediate responses are needed when there are alarms of high water level in sumps of buildings. If drainage pumps can not drain as fast as wanted, bring in temporary drainage pumps to increase drainage capability. The plant has issued MMR-M1-0737, M2-0738 to install water-shielding facilities or to improve the water-tightness of critical fire-proof doors/explosion-proof doors at outer openings of control buildings/auxiliary buildings. Furthermore, buy 30 emergency drainage pumps to increase drainage capability.	**Power sources** 7.DC power source. 8.Will add two 4.16kV mobile generators. (To be finished by 101.06.30) 9.Will add ten 480VAC mobile diesel generators. **S/G feed water** 2.Steam-driven auxiliary feedwater pumps. 3.Diesel auxiliary feedwater pumps。 4.Diesel fire-fighting pumps. 5.Fire trucks. **Feeding water into the reactors** 1.Reactor feedwater system (including feeding done by fire trucks). 3.Feed water by RWST through gravity. 5.Feed water into containments. 6.Install quick connectors on RWST to allow fire trucks to feed water. **Heat sink** 2.CST。 3.DST。 4.Raw water pool. 5.Install quick connectors on CST to allow fire trucks to feed water.	1. Follow AOP583 to make sure whether the drainage pumps of sumps function normally and trace the origin of water leaking. Inspect low spots in all buildings to look for signs of flooding.	23 shift workers from each group/ 1 hour.
			2. Besides, move mobile diesel generators to supply power to emergency safety equipment.	3 workers from each division / hour.
			3. Start preparation work before following immediate	2 workers from each division / 2 hours.

Failure scenarios	DB and scenario baseline	Preventive intensity	Unit treatment	Procedure	Manpower / Duration
There is flooding at the bottom of control buildings and auxiliary buildings. Receiving tanks in radiate buildings begin spillover.	Same as above.	Same as above.		Follow procedure 583 and add temporary drainage pumps to increase discharge capability. Find out the origin of the flooding and isolate it. If the flooding affects the safety of plant operation, bring the reactors to a cold shutdown till the flooding is under control or removed.	The total of the shift workers and members of the typhoon emergency response team is 20 people / 1 hour.
In addition to steam-driven auxiliary feedwater pumps, diesel-powered auxiliary feedwater pumps and diesel-powered fire-fighting pumps can not start due to flooding.	Use steam-driven auxiliary feedwater pumps to help steam generators keep injecting water and performing steam dump. Therefore, the temperature and pressure in RCS can be lowered. The rated flow of the steam-driven auxiliary feedwater pump is 380gpm. The origin of the water can be CST, DST, and raw water. 1.The rated flow of the backup diesel-powered auxiliary feedwater pumps is 360gpm. The origin of the water can be CST, DST, and raw water. Pressure of the steam generators can be lowered to below 60kg/ cm^2. 2.Connect to fire-fighting water system. Water can be injected through diesel fire-fighting pumps, whose rated flow is 1500gpm. Pressure of the steam generators must come down to below 9kg/ cm^2. 3.Connect fire trucks to upstream fire-fighting connectors of AL-V660 with fire hoses , so water can be injected into steam generators, whose flow rate is 200gpm at 6-10 kg/ cm^2. Pressure of steam generators must be lowered to below 6kg/cm^2	**Power sources** 7.DC power source. 8.Will add two 4.16kV mobile generators. (To be finished by 101.06.30) 9.Will add ten 480VAC mobile diesel generators. **S/G feed water** 2.Steam-driven auxiliary feedwater pumps. 5.Fire trucks. **Feeding water into the reactors** 1.Reactor feedwater system (including feeding done by fire trucks). 2.ECCS feed water. 3.Feed water by RWST through gravity. 4.BH-P020 5.Feed water into containments. 6.Install quick connectors on RWST to allow fire trucks to feed water. **Heat sink** 2.CST。 3.DST。 4.Raw water pool. 5.Install quick connectors on CST to allow fire trucks to feed water.		Follow 570.20: make steam-driven auxiliary feedwater pumps continue operating, and open steam dump valves. Feed water and use steam dump to lower the temperature and pressure of RCS.	23 shift workers /1 hour

Failure scenarios	DB and scenario baseline	Preventive intensity / Unit treatment	Procedure	Manpower / Duration
Flooding at the bottom 80 feet of control buildings flows into the DC battery chamber sand vital bus chambers, resulting in the loss of DC power source of vital buses and safety trains. Steam-powered auxiliary feedwater pumps trip. Safety-related feedwater systems lose function due to power outage.	1. Safety related DC power equipment is the power source of safety-related equipment. It's comprised of four 125VDC subsystems-A/B/C/D-PK-F001. Among them, A and C subsystems belong to train-A load group; B and D subsystems belong to train-B load group. This design ensures that protection for reactors and operation of ESF safety function can last for at least 8 hours when any of these subsystems is out of order. 2. As long as battery sets are usable, important AC power and DC power sources (through inverters) for operation will remain available. Similarly, as long as the chargers can function normally, the battery sets will also be usable. 3. 4.16kV safety train of the plant has been depressed from 11.4kV and is a backup of the third power source. (This is finished.) 4. If 11.4kV can not function during accidents, install mobile diesel generators among A/B/C/D safety train as interfaces.	**Power sources** 8.Will add two 4.16kV mobile generators. (To be finished by June 30,100) 9.Will add ten 480VAC mobile diesel generators.(To be finished by Dec. 31,100.) **S/G feed water** 1.Fire trucks. **Feeding water into the reactors** 1.Reactor feedwater system (including feeding done by fire trucks). 3.Feed water by RWST through gravity. 5.Feed water into containments. 6.Install quick connectors on RWST to allow fire trucks to feed water. **Heat sink** 2.CST。 3.DST。 4.Raw water pool. 5.Install quick connectors on CST to allow fire trucks to feed water.	1. Follow 570.20. Steam-driven auxiliary feedwater pumps trip. Manually adjust T&T (trip turning valve) and then start the steam-driven auxiliary feedwater pumps. Otherwise, follow procedure 1451; utilize fire trucks to feed water via S/G and manually start S/G PORV to release steam in order to lower the temperature and pressure.	23 shift workers /1 hour
			2. After sending workers to battery chambers to remove accumulated water, connect mobile diesel generators to PK system (125V DC CLASS), so generators can supply power to the system.	3 workers from each division /3 hours.

Cliff-edge Effect: Flooding results in the loss of DC power source, failure of monitoring equipment and safety equipment systems, and unclear status of plant units.

Failure scenarios	DB and scenario baseline	Unit treatment: Preventive intensity	Unit treatment: Procedure	Manpower / Duration
The plant loses all backup power supply and emergency power supply.	Core of reactors must be covered with water. Maintain the intact status of the containments.	Core of reactors must be covered with water. Maintain the intact status of the containments.	If water injection and coolant functions of design basis can not be recovered in a short time period after judgment, immediately follow ultimate response procedure 1451 to feed water into reactors or steam generators. Hence, nuclear fuel is ensured to be covered by water to prevent radioactive substance release.	(1) 3 workers from each division/ 1 hour. (2) Continue operation.

Cliff-edge Effect: The plant is flooded and it faces challenges of reliability and maneuverability of the backup power sources.

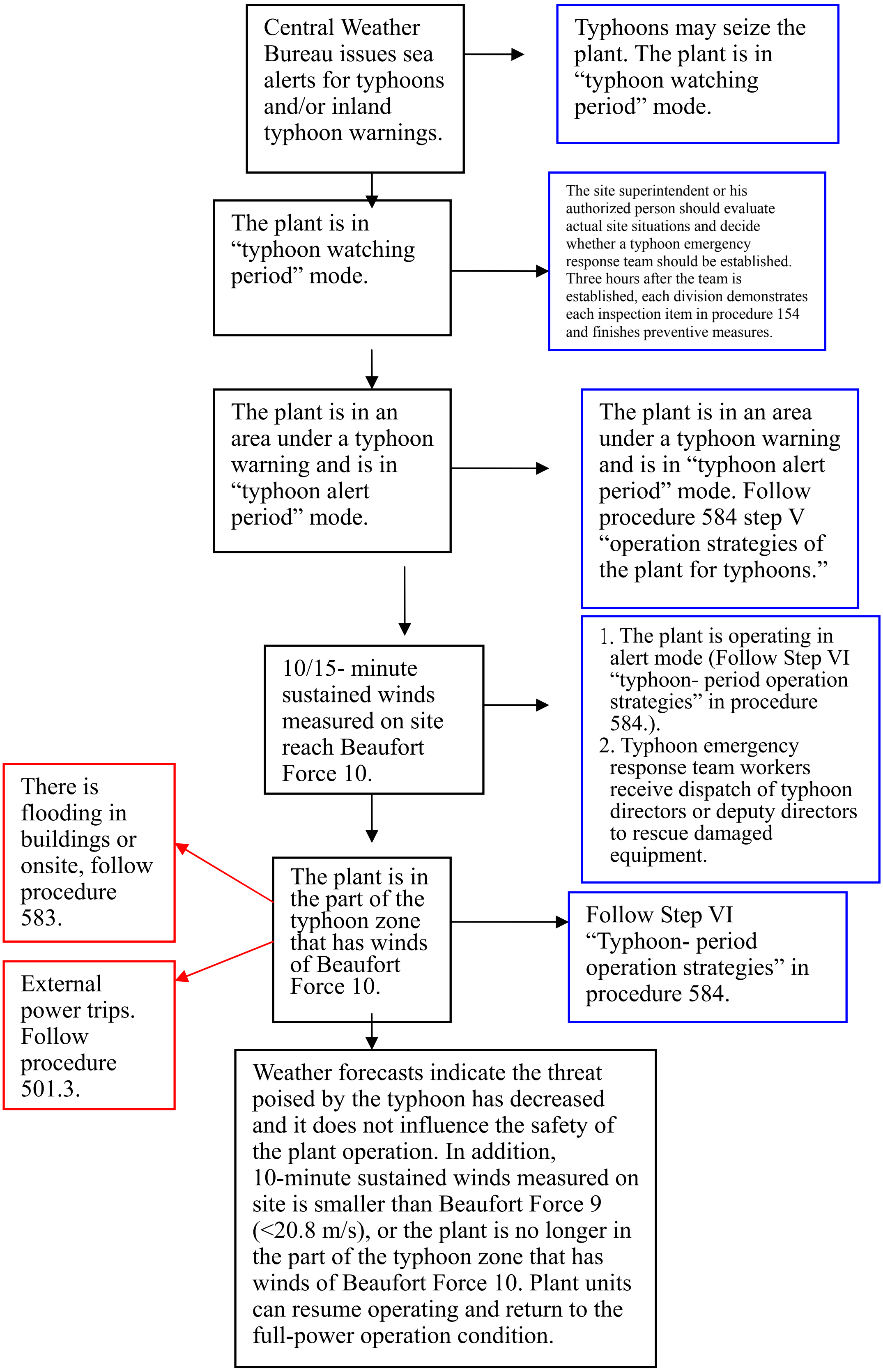


Fig.4-1：Typhoon response procedure

5. Loss of electrical power and loss of ultimate heat sink

5.1 Nuclear power reactors

5.1.1 Loss of off-site power (LOOP)

Maanshan station has two offsite power systems, one of which is 345kV system and the other is 161kV system. The 345kV system has two buses (Bus-1 and Bus-2) and is connected to the electric grid by four transmission lines. Three lines (Dapeng-1,-2,-3) are connected to Dapeng extra high voltage (EHV) substation; and one line is connected to Meelee EHV substation. The 161kV system has only one single bus (161kV Bus) and has two loops. One is connected to Fengkang substation; the other is connected to Kenting substation, then on to Fengkang substation. Maanshan station has one 345kV start-up transformer and two 161kV start-up transformers (One for Unit 1 and the other for Unit 2; they can support each other in emergency) to provide the power required for start-up and shutdown for both units. When a unit is in normal operation, its service power can be provided from its auxiliary transformer.

Upon loss of off-site power, power for safety related buses A/B-PB- S01 is provided by the emergency diesel generators.

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

Each safety related bus (A/B-PB-S01) of each unit is equipped with one 4.16kV, 60Hz, 3-phase emergency diesel generator (EDG A/B). The generator is a rotating magnetic field, synchronous and air-cooled machine, and is of Seismic Category I design. It can provide continuous 7,000 kW or short-term (2 hours) 7,700kW load. The generator is driven by a fast-starting diesel engine. Each EDG is connected to the safety-related 4.16 kV load groups through circuit breakers. Upon loss of voltage (LOV) on A/B-PB-S01, the connected EDG will automatically start and based on loading sequence, supply power to ESF equipment to safely shutdown the reactor. The cooling water of EDGs is provided by Nuclear Service Cooling Water system (NSCW).

EDGs A and B are of Seismic Category I design, and can withstand a strong earthquake with 0.4g acceleration, and still perform their design functions. The EDGs are located at an elevation of 15 meters above sea level, which is higher than the design basis for flooding prention(the maximum tsunami uprising height) of elevation 12.53 meters (FSAR 2.4.5.3). The building gate is for general access and is explosion-proof, but it is not of waterproof design.

Surveillance tests are performed monthly on EDGs A and B, and their components are regularly checked, to confirm their availability.

5.1.1.2 Autonomy of the on-site power sources_Toc311118493

1. EDG fuel storage and transfer system

   The design of the fuel storage and transfer system of EDGs A and B is Seismic Category I. Each EDG is equipped with one fuel storage tank, one fuel day tank and two fuel transfer pumps. Under the condition of design basis accident and loss of voltage (LOV), the capacity of the fuel storage tank can support EDG continuous running at rated load for 7 days plus 15% extra fuel for surveillance test use. The capacity of the EDG fuel storage tank is 94,000 gallons. Technical specifications require that at least, the fuel in the fuel storage tank must be greater than 81,420 gallons (75%/5M/308.2 kiloliter). The capacity of the day tank is 1,950 gallons. It can provide for the EDG continuous running at full load for 4 hours. Technical specifications require that at least, the fuel in the fuel day tank must be greater than 533 gallons (29.55%/48.8 kiloliter).

2. The EDG startup air system:

   Except for air compressors, the design of the EDG startup air system is Seismic Category I. Each EDG is equipped with two independent startup air systems. The startup air system consists of one compressor, one air storage tank, after cooler, air dryer, two air intake valves and other auxiliary equipment. Pressure of the air storage tank is maintained between 225~250 psig. Under the condition that the air compressor is not operating, each air storage tank still has a capacity to support EDG startup for 5 times. The minimum air pressure required to start EDG is 150 psig. Technical specifications require that at least one of the air storage tanks should have its pressure greater than 225 psig (15.85 kg/cm^2).

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

1. In addition to the capacity of the EDG fuel storage tank, which can support EDG continuous running at rated load for 7 days, the auxiliary boiler fuel storage tank, with capacity of 1155 kiloliter, can serve as back up fuel source, and its fuel can be transferred to the EDG storage tank to extend the period for EDG. continuous running for approximately 14 days.
2. Subsequent fuel makeup for the EDG fuel storage tank can be taken from the 35,000 kiloliter gas turbine fuel storage tank with fuel tanker. The gas turbine fuel storage tank is currently filled with 11,000 kiloliters of fuel., which can provide for one EDG further continuous running for 140 days at full load.

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

1. The following enhanced inspections for EDG reliability have been completed:

(1) Review the existing plant procedures to see if they need to be enhanced regarding the protection against earthquake, flooding and fire.

(2) Inspect to see if the ancillary accessories of EDG are in normal standby configuration.

(3) Inspect to see if there is any loose part in all components of EDGs that could cause damages in earthquake and could affect the EDG reliability.

(4) Inspect to see if there is any loose part in EDGs and ancillary systems (including fuel storage tank) that could be damaged in earthquake and could affect the EDG system reliability. When EDGs (including gas turbine black start diesel generators) are in standby mode, inspect if the space heaters are functional to maintain electrical equipment in proper condition.

(5) Inspect and make sure EDG emergency procedures and equipment, e.g., cables, switches, and tools for manual operation are available.

(6) Examine and ensure measures for protection of electrical conduits and instrument tubing from water intrusion are functionally.

(7) Examine the adequacy of spare parts and whether periodic maintenance is regularly performed to keep them readily available.

2. The EDG building is of Seismic Category I design, and it is at an elevation of 15 meters, which is higher than the maximum uprising height of tsunami (12.53 m), and thus, no further tsunami protection is needed. For prevention of flooding into plant buildings, the station has proposed design change request to evaluate the feasibility of installing flood barrier plate at the ingress/egress gates of the buildings with safety-related systems, such that when the Meteorological Bureau issues warning of typhoon plus heavy rain, or it is judged that there is possibility for site to be flooded, flood barrier plates can be installed in advance to prevent water intrusion. The station has also proposed a design change request to improve the water-tight characters for the key fire-proof doors or explosion-proof doors of the buildings with safety-related systems, so as to prevent flood intrusion into key areas or rooms, and prevent faults/failures of the important equipment/facilities. The proposed modification will be completed before December 31, 2012.

3. A parking area has been designated for storing the crane in the EDG building, with a locking device installed for fixing the crane in-place, when the crane is not in use. This arrangement is made with safety consideration that the important safety-related equipment under the crane will not be damaged due to earthquake that may cause the crane to fall down; and that the crane will not have a horizontal movement during earthquake.

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

5.1.2.1 Design provisions

When both offsite power and EDG A&B are unavailable, the station has two gas turbine-generators and the 5th emergency diesel generator for SBO, which can provide required power for safe shutdown of the reactor. (Note: These three generators are air-cooled, and do not require NSCW to provide cooling water). The station has also a third power source, which can provide to the safety-related buses from the 11.4kV distribution lines. These three diverse back-up resources are described in detail as follows:

1. The Gas turbine generators

   The gas turbine generators (Model: MS 7001B) and related equipment were procured from GEH company. The rated capacity of the gas turbines (assuming at sea level, one atmospheric pressure, and air temperature 90°F) is 51.48MW as base output and 57MW as peak output. The generators are manufactured by Hitachi, and are of two-pole, three-phase, 3600rpm, 60Hz, Y type wiring, neutral point grounded through transformer, exterior cylindrical rotor, and open air cooling, AC synchrous generators. The rated capacity of the generator is 69,600 kVA; rated output is 59,160kW; the terminal voltage is13,800V, armature current is 2,912amp; magnetic field voltage is 430V; magnetic field current is 476A; and power factor is 0.85.

   Two surveillance tests are performed regularly for each of the gas turbine-generator sets to ensure its availability: One is the monthly SBO startup test according to plant procedure 650-O-032,in which, the generator is loaded to 40MW and run for 1 hour.; the other is the monthly normal startup test according to plant procedure 650-O-031, in which the generator is loaded to 5MW and run for 30 minutes.

   The minimum amount of fuel stored in the gas turbine fuel storage tank (capacity 35,000 kiloliter) is 9,000 kiloliters (including 1,500 kiloliters stagnant fuel). If fuel level indicator decreases to approach the level of 10,000 kiloliters, operation division is notified for procurement and makeup.

   The gas turbine-generator set is of general, not Seismic Category design. It is located at an elevation of 35 meters above sea level, which is higher than the maximum uprising height of tsunami at elevation of 12.53 meters. There is no concerns for flooding due to heavy rains.

2. The 5th EDG

   The 5th EDG is a synchronous generator with rotating magnetic field, and is air cooled. The generator can provide a rated load of 7159 kW or a load at 7,875kW for a short period (2 hours). The excitation power is independent of the onsite auxiliary AC power. The rated voltage of the generator is established by the magnetic field flashing device of the exciter. The power of this device is provided from the permanent magnet generator. The 5th swing EDG is connected, in turn every month, to vital bus A1E-PB-S01, B1E-PB-S01, A2E-PB-S01 or B2E-PB-S01 to perform a 6,300 kW load test.

The top of the fuel storage tank (S-T133) for the 5^{th} EDG has access to the atmosphere through a fire protection device. The volume of the tank is designed for the 5th EDG to run continuously for 7 days plus extra 15% required for surveillance tests. The total capacity of this storage tank is 118,730 gallons. However, the usable capacity is 114,000 gallons. Technical specifications request that the minimum fuel stored in the tank must be greater than 85,000 gallons (70%).

The main function of the startup air system is to inject startup air at 40 $kg/cm^{2\ pressure}$ into the cylinders to start the diesel engine. It is composed of two independent compressed air subsystems. Each subsystem consists of a compressor, intercooler, after cooler, air dryer and air storage tank. Any one of the compressed air subsystems can startup the 5^{th} EDG. The pressure of the air storage tank is maintained at 38~42 kg/cm^2 to ensure that a single tank, without air compressor running, can provide enough compressed air to startup the EDG for at least five times.

The 5^{th} EDG is of Seismic Category I design. It can withstand an strong earthquake with 0.4g acceleration and can still perform the designed functions. The 5^{th} EDG is located at an elevation above sea level 15 meters, which is higher than the maximum tsunami uprising height at elevation of 12.53 meters. The gate of the 5th EDG building has a door for access, with explosion-proof, but not water-proof design.

3. The third power supply

The third power supply is from the 11.4kV system stepped down to 4.16 kV, and can serve as the back up power for the safety-related 4.16kV buses. The safety-related bus S0E-PB-S01and the non-safety-related third power 11.4kV is isolated by bus S0E-PB-S01-07. (Note: the third power supply is provided from the 161kV switchyard through a 161Kv/4.16Kv step-down transformer. In case of loss of the 161 kV offsite power, its power is provided from the gas turbines.)

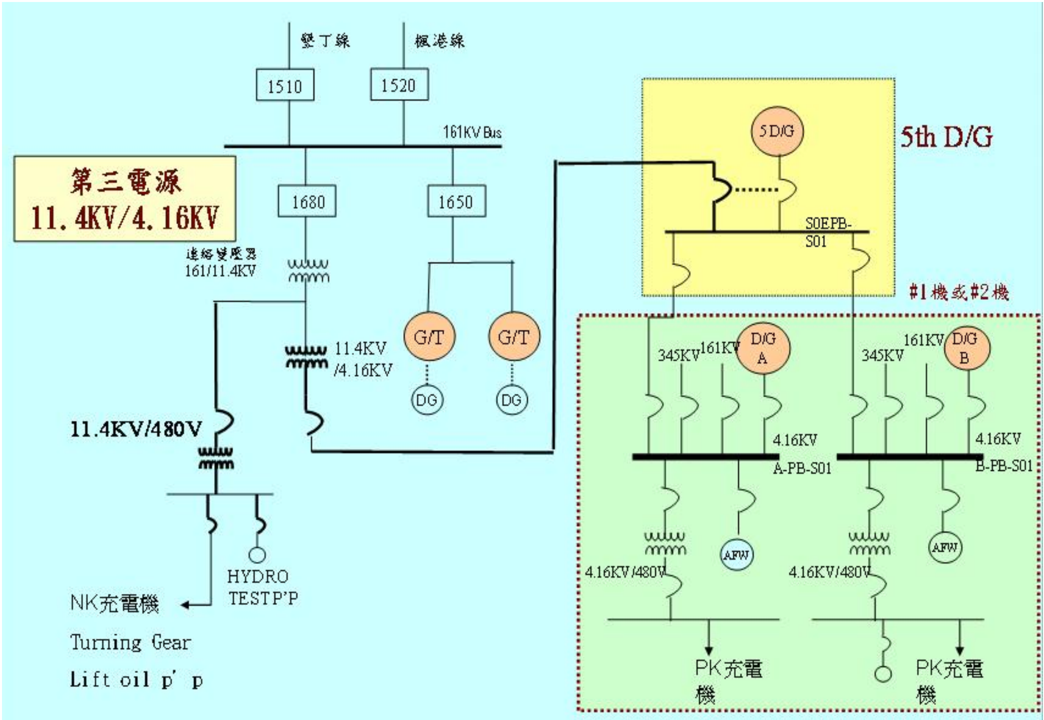


Figure 5.1-1 The third power supply

5.1.2.2 Battery capacity and duration

1. The lead acid battery set for the gas turbine black start diesel generator (GTBSDG) consists of 6 Yuasa 190H52 batteries with capacity 12V/200AH, and provides the 24VDC required by the gas turbine black start diesel generator (GTBSDG). This battery set is maintained monthly according to plant procedure 700-E-1000.3 form ELT003 " ”The gas turbine black start diesel generator (GTBSDG) lead acid battery maintenance check list". This maintenance action ensures DC battery in normal standby condition. Once the gas turbine is started, it can provide AC power to charge the battery which is used to startup the gas turbines.
2. The battery capacity of the 5th EDG is 125VDC/220AH. It can provide emergency power for 2 hours. Once the 5th EDG is started, it can provide AC power to charge the battery which is used to startup the 5th EDG.

5.1.2.3 Autonomy of the site before fuel degradation

1. The gas turbine-generator

   Each of the gas turbines is equipped with a black start diesel generator (the GTBSDG) with capacity 1,100kW. If the offsite power is available, the offsite power provides the power for the control and accessories of the gas turbines. If the offsite power is unavailable, the GTBSDG provides the power for control and accessories for startup of the gas turbine-generator .

The gas turbine-generator has one fuel storage tank with capacity of 35,000 kiloliters and 2 day tanks with capacity of 600 kiloliters. The fuel storage tank is currently filled with 11,000 kiloliters fuel. It can provide fuel for the 2 gas turbine-generator sets continuously running at full load for 14 days. If the load is limited to plant essential loads, the capacity can support the 2 gas turbine-generators to run for 30 days.

2. The 5th EDG

The capacity of the 5th EDG fuel storage tank can support EDG continuous running at rated load for 7 days.

5.1.2.4 Foreseen actions to prevent fuel degradation

1. The station has auxiliary boiler fuel storage tank with capacity of 1,155 kiloliters. Fuel in this tank can be transferred to the fuel storage tank of the 5th EDG to extend its operation for 14 days. Operations of fuel transfer from auxiliary boiler fuel storage tank to the fuel storage tanks of the EDGs are according to SOP 395.3 “diesel generator fuel storage and transfer” and SOP 395.3.1 “ The 5th diesel generator fuel storage and transfer”.
2. Fuel can be made-up from the 35,000 kiloliters gas turbine fuel storage tank to the 5th EDG fuel storage tank by fuel tanker. The gas turbine-generator fuel storage tank is currently filled with 11,000 kiloliters of fuel. It can provide one EDG continuous running for 140 days at full load.
3. If the fuel in the 35,000 kiloliters gas turbine fuel tank is used up, make-up from offsite is needed. Table 5.1-1 is a list of the tanks that can provide fuel for the EDGs and the gas turbines.

Table 5.1-1 Capacity of Fuel Storage Tanks (Inventory date July 29, 2011)

Tank	Normal storage(kiloliter)	Remarks
Gas turbine fuel storage tank (capacity 35,000 kiloliters)	11,720	
Gas turbine day tank A	443	The bottom of Tank A and B has connecting pipe and valves
Gas turbine day tank B	443	
Unit 1 EDG-A fuel storage tank	308.2	Minimum storage required by Tech. Spec.
Unit 1 EDG-B fuel storage tank	308.2	
Unit 2 EDG-A fuel storage tank	308.2	
Unit 2 EDG-B fuel storage tank	308.2	
5th EDG fuel storage tank	321.8	
Auxiliary boiler fuel storage tank	1155	Can make up to DG A/B and the 5TH DG fuel storage tanks
Total	14,429.6	

5.1.2.5 Measures which can be envisaged to increase robustness of the plant back-up power

1. Taipower's "Nuclear Power Plant Seismic Evaluation Task Force ", has completed the seismic evaluation of the gas turbine-generator and the raw water reservoir. The station will follow corporate plans to implement enhancements. (It will be completed before December 31, 2013)
2. The 5th EDG can provide emergency power to both units simultaneously. In addition, the EDGs of each unit can support each other via bus S-0E-PB-S01. The related tests have been completed, and operating steps have been incorporated into plant procedure 1451.
3. The station has proposed design change request to evaluate the feasibility of installing flood barrier plate at the ingress/egress gates of the buildings with safety-related systems, such that when the Meteorological Bureau issues warning of typhoon plus heavy rain, or it is judged that there is possibility for site to be flooded, flood barrier plates can be installed in advance to prevent water intrusion. The station has also proposed a design change request to improve the water-tight characters for the key fire-proof doors or explosion-proof doors of the buildings with safety-related systems, so as to prevent flood intrusion into key areas or rooms, and prevent faults/failures of the important equipment/facilities. The proposed modification will be completed before December 31, 2012.
4. A parking area has been designated for storing the crane in the EDG building, with a locking device installed for fixing the crane in-place, when the crane is not in use. This arrangement is made with safety consideration that the important safety-related equipment under the crane will

not be damaged due to earthquake that may cause the crane to fall down; and that the crane will not have a horizontal movement during earthquake.

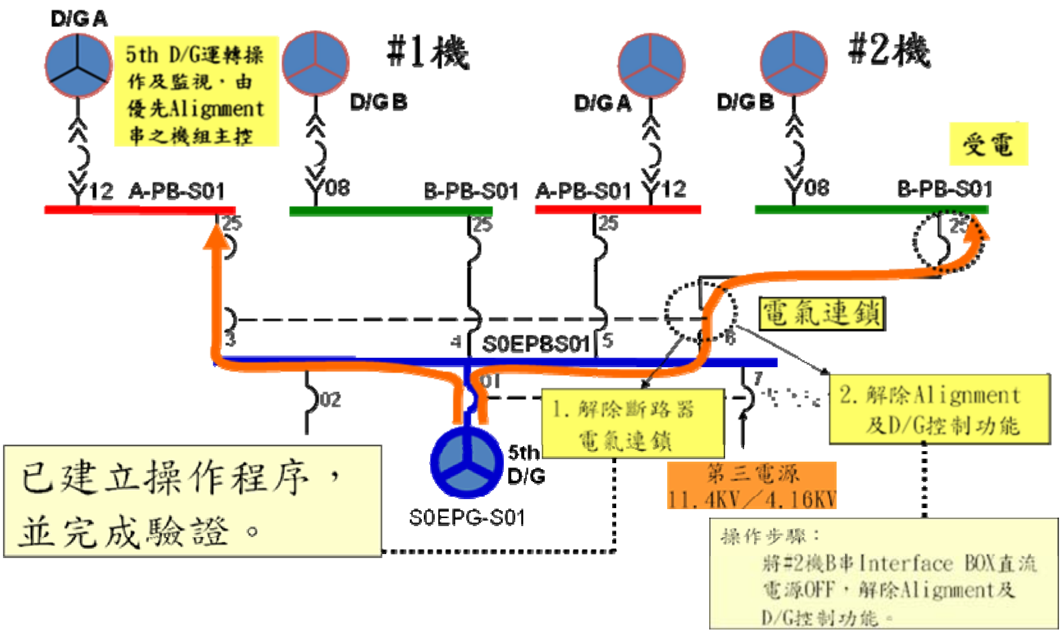


Figure 5.1-2 The 5th EDG Provides Emergency power to Both Units

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

5.1.3.1 Design provisions

1. SBO event evolution

   SBO event is caused by loss of the offsite power due to failures of switchyard, grid interference, or climatic factor. Loss of the offsite power will affect both units. If one of the units is also loses its onsite emergency AC power (not including AAC), then, this will constitute a SBO event. At the early stage of the event, loss of the offsite power will cause reactor and turbine trip, meanwhile the main steam isolation valve (MSIV) will be closed. The closure of MSIV will cause the steam generator (SG) pressure to increase, then, the PORVs of the SG will be actuated to release the steam generated in the SGs. PORV actuation will decrease the SG water level. The steam driven auxiliary feedwater pump will automatically startup when the SG is at water level low. This pump will make up water into the SG to maintain its water level and to consume some steam. Based on NUMARC-87-00, during the first 8 hours of SBO, it is assumed that each RCP seal has a 25gpm leakage. Therefore, reactor water level is decreasing.

   FSAR Section 15.9 assumes that AAC (gas turbine) is unavailable during the first 8 hours of SBO.

Under this assumption, the long term evolution of SBO event is determined by the operation measures defined in plant procedure "570.20 Loss of All Essential AC Power Procedure".

2. Evaluation of Nuclear Steam Supply System (NSSS)

   Based on results of the analysis in FSAR Section 15.9, the reactor core will not be uncovered under SBO event, even if a leak rate of 25gpm is considered for each RCP seal. This is because the auxiliary feedwater system and the PORVs of the SG can perform their design functions during the 8 hours after SBO.

3. The required amount of condensate water to remove decay heat

   Assume steam generator water level is stable by controlling the operation of the auxiliary feedwater system. During the 8 hours of SBO, the total amount of required water in Condensate Storage Tank (CST) is 134,646 gallons, which is less than the minimum available CST water required by Tech Spec (275,000 gallons). The water in CST can provide for auxiliary feedwater continuous operation for more than 8 hours.

4. Capability of the compressed air system

   FSAR 15.9 analysis shows that the total capacity of the available compressed air for each unit, including liquid nitrogen and instrument air provided from safety-related compressed air storage tanks, is 33,768 SCF. It is 11 times of the amount required during the 8 hours of SBO.

5. Auxiliary feed water (AFW) system

   FSAR Section 15.9 shows that turbine driven auxiliary feedwater pump (AFP) and accessory piping, valves, water source, DC power, I&C, AFP room temperature, etc. are capable to support the AFW system continuous running for 8 hours during SBO. Based on the evaluation of Item 9 (loss of ventilation), if keeping the door of the AFP room open, the room temperature can be maintained below equipment operating limits. If SBO occurs, following plant procedure "570.20 Loss of All Essential AC Power" can ensure AFW system continuous running for 8 hours.

6. Instrument and control system

   FSAR Table 15.9.2-1 lists all the required systems, equipment, components, related I&C and electrical power for SBO, and also evaluates their capability to perform the design function within the first 8 hours of SBO. It is concluded that, the s Instrument and control system design is capable to cope with 8 hours.

7. Battery loads

   FSAR Section 15.9 evaluates the adequacy of battery capacity based on IEEE Standard 485. If some of the unnecessary DC loads are isolated by following related plant procedure, the design capacity of battery systems A (A-1E-PK-B001), B (B-1E-PK-B001), C (C-1E-PK-B001) and D (D-1E-PK-B001) are capable to provide all the electrical loads needed for system operation during the 8 hours of SBO.

8. Containment Integrity

(1) Evaluation of containment isolation

FSAR Section 15.9 evaluates, based on the guidance described in NUMARC 87-00 Section 7.2.5, whether all containment isolation valves are in safe configuration and whether control room has indication for the valves needed to remain open during SBO. The evaluation consists of 3 steps:

a. All the containment isolation valves are listed in FSAR Figure 6.2-55, from the list remove some of the valves, based on NUMARC 87-00 guidance including normal locked closed valves, fail-closed valves (fail on loss of AC power or loss of operating air), check valves, valves located in non-radiated closed system and without clearance during SBO, and all the valves with nominal diameter less than 3 inches.
b. For the valves remaining from step a, identify the valves that must be opened during SBO and evaluate their operability without Class 1E AC power, meanwhile check their position indication in control room.
c. Finally, for other remaining valves, evaluate and confirm their isolation function during the 8 hours of SBO.

FSAR Section 15.9 shows that valves listed in the following table must be actuated during the 8 hours of SBO.

Valve No.	Normal Status	Description
AB-HV311	Open	MSL-A to auxiliary feedwater pump turbine isolation valve
AB-HV109	Open	MSL-A to PORV PV501 isolation valve
AB-HV116	Open	MSL-A to PORV PV504 isolation valve
AB-HV211	Open	MSL-B to auxiliary feedwater pump turbine isolation valve
AB-HV209	Open	MSL-B to PORV PV502 isolation valve
AB-HV216	Open	MSL-B to PORV PV504 isolation valve
AB-HV309	Open	MSL-C to PORV PV503 isolation valve
AB-HV316	Open	MSL-C to PORV PV506 isolation valve
AL-HV213	Open	AFWP(TD) to S/G A flow control valve
AL-HV214	Open	AFWP(TD) to S/G B flow control valve
AL-HV215	Open	AFWP(TD) to S/G C flow control valve

For the valves listed in the above table, isolation valves (AB-HV109, AB-HV116, AB-HV209, AB-HV216, AB-HV309, and AB-HV316) of SG power operated relief valves (PORV) are normal-open MOVs. They remain in original position and no indication is needed.

Between main steam line and AFP turbine, the isolation valves, AB-HV311and AB-HV211, are air operated valves (AOVs). They are normal open and remain in open position on loss of AC power. Subsequent operation is by means of compressed air. Valve position indication is powered by 125DC.

Between turbine-driven AFP and SG, the throttling valves, AL-HV213, AL-HV214 and AL-HV215, are AOVs. They are normal-open and remain in open position on loss of AC power. Subsequent operation is by means of compressed air. Valve position indication is powered by 125DC. For the other remaining valves, including the throttling valves between motor driven AFP and SG (AL-HV113, AL-HV114 and AL-HV115), containment low volume gas supply/exhaust isolation valves (GT-HV106/GT-HV107), train-A hydrogen re-combiner back-flow containment inbound isolation valve (GT-HV317), containment sump pipe inbound isolation valve (HG-HV101), RHR pump-A inlet isolation valves (BC-HV206 and BH-HV008), and RHR pump-B inlet isolation valves (BC-HV106 and BH-HV005) and reactor coolant drain tank outlet valve (HG-HV103), evaluation in FSAR shows that these valves are normal-open and will remain in open position if failed. However, isolation can be achieved by operating the outbound isolation valves (fail-close) or check valves (means the throttling valves located between motor driven AFP and SG, e.g., AL-HV113, AL-HV114, and AL-HV115).

(2) Containment structure integrity

During the 8 hours after SBO, the key factors that determine containment pressure and temperature are: (a) Sensible heat resulting from heat transfer between RCS and containment environment, (b) The heat sourced from the 25gpm leakage from each RCP seal to containment under SBO condition. The comparison between FSAR Section 15.9 analysis results and containment design values are shown as follows:

Design pressure: 75psia vs. SBO 8 hours max. pressure: 38psia.

Design temperature: 300°F vs. SBO 8 hours max. temperature: 232°F.

9. Loss of ventilation

In the condition of SBO induced loss of ventilation system, the dominant areas of concern for temperature rise includes: ESF equipment room A/B, ESF equipment room C/D, AFP pump room and main control room. During normal operation, ESF equipment rooms are kept below outside temperature by central chilled water system and air handling units. Upon loss of voltage (LOV), essential chilled water system and their AHUs will be started. If subsequently, SBO occurs, although equipment will stop operating, ESF equipment including essential chilled water system and AHUs will stop too; hence the residual equipment temperature will heat up the environment which has a relatively high temperature already, resulting in room temperature rise during SBO.

Main control room annunciator window JP07C-11 “SBO & AL-P019 RM Door NT Open” will prompt operator to open turbine driven AFWP room door. FSAR Section15.9 has the results as shown in the following table:

Area	Normal Temp. (°F)	SBO Temp. (°F)	Equipment operating Tempe. limit (°F)
ESF equipment room A/B	86	122	131
ESF equipment room C/D	86	122	131
Auxiliary feedwater pump room	104	155	160
Main control room	75	120	120

10. The other systems, e.g., communication and lighting systems

    FSAR Section 15.9 shows communication and lighting systems are adequate for the first 8 hours after SBO.

5.1.3.2 Battery capacity and duration

1. Based on minimum loads on SBO, the designed battery capacity can continuously provide DC power for at least 8 hours. However, to extend it to 24 hours, the capacity of all battery sets A, B, C, and D is inadequate .
2. Battery capacity and operation duration
   (1) Battery train A, B rated capacity: 1,650 AH (number of poles: 11)
   (2) Battery train C, D rated capacity: 900 AH (number of poles: 6)
   (3) Battery train A, B, C, and D rated capacity can provide DC power for 8 hours on SBO event, if some of the unnecessary loads are isolated.

5.1.3.3 Autonomy of the site before fuel degradation

1. When SBO occurs, emergency operating procedure EOP 570.20 must be followed immediately, to ensure that CLASS-1E battery sets are capable to provide the total DC demand in SBO, with unneeded loads in safety trains isolated within 30 minutes.
2. If all DC power is lost, turbine-driven AFP and PORV of SG still can be manually operated to make up water into SG and to release steam from SG. These actions can control RCS temperature and pressure to keep core cooling.

3. If turbine-driven AFP is unavailable, the other diesel engine-driven AFP can be used to make up water into SG.
4. It will take about 16 hours to cool the unit from hot standby to hot shutdown condition require approximate 1,041tons of water (FSAR Table 9.2-12). The available volume of CST is 2,680 tons which is adequate for 40 hours. The available volume of DST is 378.5 tons which is adequate for 6 hours. If AFP intakes water from raw water reservoir (100,000 tons), it is adequate for 32days for two units.
5. Emergency operating procedure EOP 570.20 has steps to open the doors of the rooms housing equipment, including turbine-driven AFWP room, switchgear rooms, battery set rooms, and the doors of instrument panels, for improvement for heat dissipation. The procedure, also has provisions to use mobile fans to enhance heat dissipation. .

5.1.3.4 Foreseen actions to prevent fuel degradation

1. Taipower is a comprehensive electrical power company. It integrates electrical power generation, transmission and distribution, and sale of electricity. If the station has an emergency and lost offsite power, the company can take immediate actions to recover the 345kV or 161kV power system and provide power to the onsite safety-related systems.
2. If onsite water source is inadequate, water can be makeup from fire engine to CST, RWST, SFP, and RCS. The station has one 7-ton fire water tank vehicle. The 4^{th} battalion of Pingtung County Fire Bureau has four squads (Hengchun, Cherchen, Manchu, and Fangshan). They have two 10-tons and two 12-ton water reservoir vehicles; one 3-ton and four 3.5ton water tank vehicles; and also have four 1-ton small water tankers. Offsite water sources can be taken from No.2 and No. 3 deep wells, Longluan lake, and sea water. The supporting manpower from contractors include the supporting manpower from the contractors who signed contracts with the responsible divisions of the station.
3. Confirming timing of cliff-edge effects

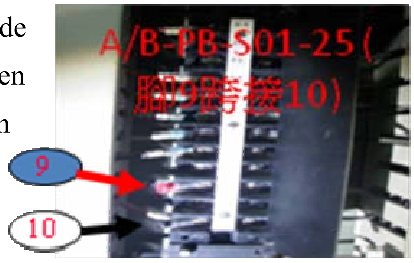
The available volume of CST is 2,680 tons which is adequate for 40 hours. The available volume of DST is 378.5 tons which is adequate for 6 hours. The total is 46hours. If AFP intakes water from raw water reservoir (100,000 tons), it is adequate for 32days for two units.

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

1. It has been confirmed that the capacity of battery sets is adequate to provide DC power continuously for 8 hours. The related operating steps to isolate some non-essential loads have been included into plant procedure 570.20. The station will purchase 480V mobile diesel generators. With quick connecting interface, the 480V mobile diesel generators can charge battery

sets and maintain the battery set long-term supply capability. (This design modification was completed by January 31 2012).

2. The feasibility for the 5th air-cooled diesel generator to provide emergency AC power to both units simultaneously has been validated. The terminal points for quick connection have been set up. The related operating instructions have been included in plant procedure 1451.



3 Taipower headquarters will procure six 4.16kV /1500kW mobile diesel generators, of which two will be placed in Maanshan station (already delivered). DCR-M0-4325 has been set up to connect the new mobile diesel generators with the existing equipment (The design is completed).

4 Ten 370kVA/3ψ/480V mobile diesel generators have been procured to provide AC power to: battery chargers to maintain 125VDC bus power; to vital water pumps for supplying water to critical equipment/facilities; to telephone exchange/TSC/control room in order to maintain the necessary communication, commandingand habitability systems, and to other important 480V loads. A DCR has been set up to install 480V mobile diesel generators power supply interfaces to facilitate rapid connection with mobile emergency 480 V power sources (The design plan is attached as Appendix 5.1-1. The modification is completed).

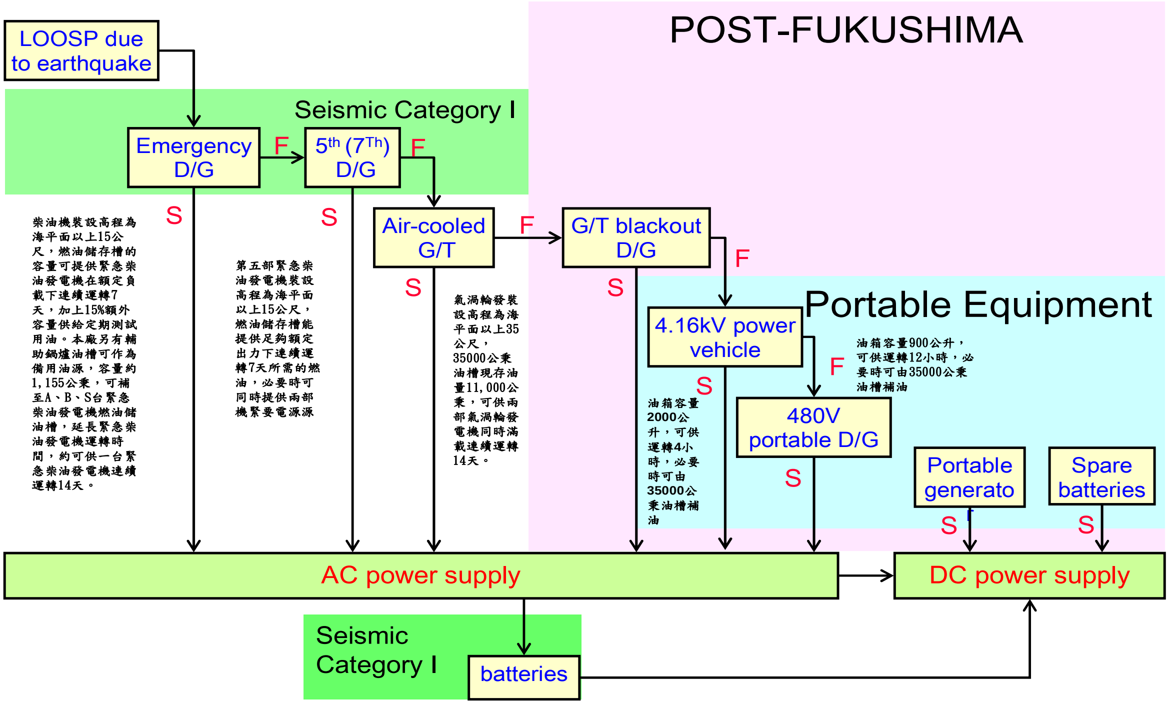
5. The station has already prepared 24 small mobile generators. They can provide temporary power to submerge pumps, exhaust fans, and radiation monitors to ensure the proper function of those rescuing equipment or instruments.

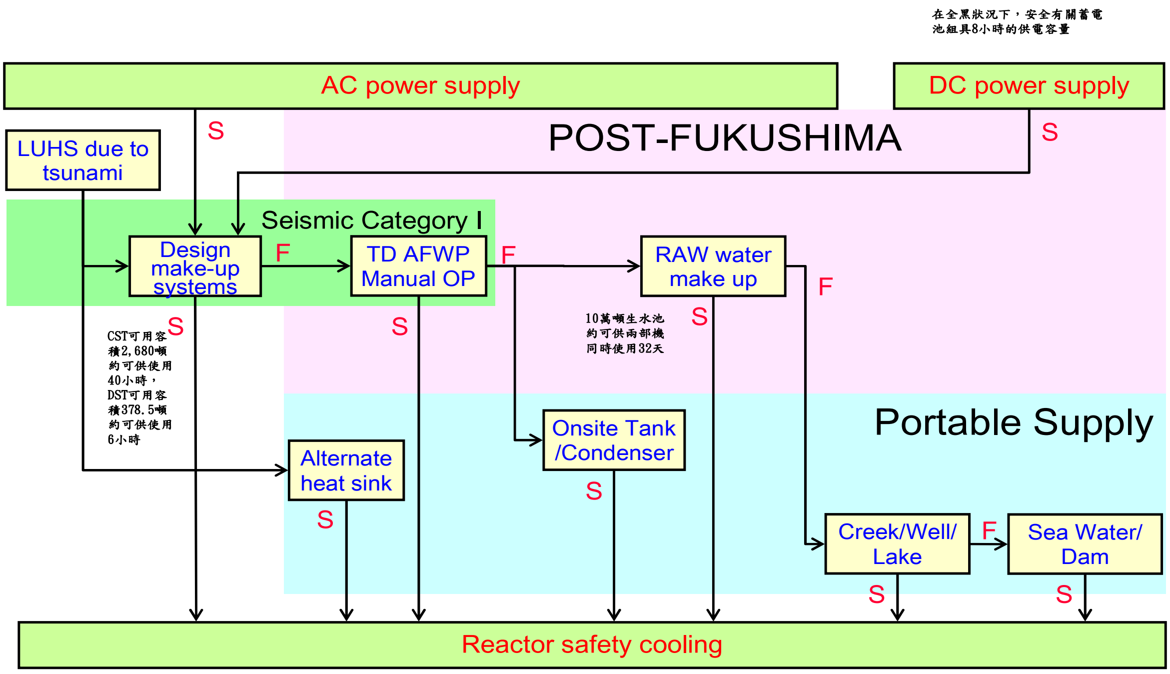
6. A review of the key parameters that have to be monitored during SBO has been completed. Those key parameters include water level and pressure of steam generator, reactor, pressurizer, and containment; reactor temperature; containment radiation level; spent fuel pool water level and temperature; ex-core nuclear instrument indications; AFW flow rate of steam generator and water level indication of RWST/BAT/CST. By enhancing measures for supply of emergency back up AC power on SBO, it can be ensured that battery sets are available and instrument power supply is strengthened.

7. If onsite water is not enough, water can be made up to CST, RWST, SFP, and RCS by fire engines. The station has procured one chemical foam fire engine with capacity of 7 tons (already delivered); one water tanker fire engine with capacity of 12 tons (scheduled to arrive before June 30, 2012). Offsite water sources can be taken from No.2 and No. 3 deep wells, Longluan lakeand sea water.

8. The station has procured 3 mobile air compressors to provide working air to individual air-operated valves.

9. Rescue equipment are stored in warehouses at elevation 25 meters above sea level. These warehouses are light-structured. If structure is damaged during earthquake, the rescue equipment will not be damaged.


POST-FUKUSHIMA
LOOSP due to earthquake
Seismic Category I
Emergency D/G
F
5th (7Th) D/G
F
Air-cooled G/T
F
G/T blackout D/G
F
Portable Equipment
4.16kV power vehicle
F
480V portable D/G
Portable generato
Spare batteries
S
S
S
S
S
S
S
S
柴油機裝設高程為海平面以上15公尺，燃油儲存槽的容量可提供緊急柴油發電機在額定負載下連續運轉7天，加上15%額外容量供給定期測試用油。本廠另有輔助鍋爐油槽可作為備用油源，容量約1,155公秉，可補至A、B、S台緊急柴油發電機燃油儲油槽，延長緊急柴油發電機運轉時間，約可供一台緊急柴油發電機連續運轉14天。
第五部緊急柴油發電機裝設高程為海平面以上15公尺，燃油儲存槽能提供足夠額定出力下連續運轉7天所需的燃油，必要時可同時提供兩部機緊要電源源
氣渦輪發裝設高程為海平面以上35公尺，35000公秉油槽現存油量11,000公秉，可供兩部氣渦輪發電機同時滿載連續運轉14天。
油箱容量2000公升，可供運轉4小時，必要時可由35000公秉油槽補油
油箱容量900公升，可供運轉12小時，必要時可由35000公秉油槽補油
AC power supply
DC power supply
Seismic Category I
batteries


在全黑狀況下，安全有關蓄電池組具8小時的供電容量
AC power supply
DC power supply
S
S
POST-FUKUSHIMA
LUHS due to tsunami
Seismic Category I
Design make-up systems
F
TD AFWP Manual OP
F
RAW water make up
F
CST可用容積2,680噸約可供使用40小時，DST可用容積378.5噸約可供使用6小時
10萬噸生水池約可供兩部機同時使用32天
S
S
S
Portable Supply
Alternate heat sink
Onsite Tank /Condenser
Creek/Well/ Lake
F
Sea Water/ Dam
S
S
S
S
Reactor safety cooling

Appendix 5.1-1 Maanshan Station 480V Mobile Emergency Diesel Generator Program (Based on DCR M1-4245/ M2-4246)

A. Abstract of requirement (each unit)

1. MOV --- power provided from new 480V mobile diesel generator (DG) (4) (7)
   (1) GT-HV401A (Auxiliary building 126ft)
   (2) BH-HV101/HV102 (Auxiliary building 126ft)
   (3) BH-HV201/HV202 (Auxiliary building 126ft)
2. Hydro test pump BH-P020 (Auxiliary building 74ft) --- existing 3rd power source and new 480V mobile DG provide power (1)(5)
3. A/B/C/D safety train battery charger --- A/B train power is provided by new 480V mobile DG (3)(6), while C/D train power is extended from the same source as Item 1 (4)(7)
4. NJ/NK battery charger --- same as the existing 3rd power source described in Item 2 (1) (5)
5. Control room lighting --- same as the safety train A/B battery charger described in Item 3 (3)(6)
6. PA back up power --- same as described in Item 1 (4)(7)
7. EC-P102/112 power--- same as described in Item 1 (4)(7)
8. Telephone exchanger battery charger ------ new 480V mobile diesel generator power providing interface (2)
9. TSC power --- same as that described in Item 8 (2)
10. Hydrogen Analyzer --- same as that described in Item 1 (4)(7)
11. Control room emergency ventilation --- same as the power source of safety train A/B described in Item 3 (3)(6)
12. Seismic fire pump--- same as that described in Item 1 (4)(7)
13. AP-M100, AP-M101--- same as the power source of safety train A/B described in Item 3 (3)(6)

    Note: The number inside ( ) indicates the number of mobile diesel generators as shown in "All 480V Moveable Diesel Generators Layout".

Note: number in () indicate the ID no. of the mobile diesel generators

Item 1: MOV actuation required--- power from new 480V mobile diesel generator (DG):

(1) GT-HV401A (Auxiliary building 126ft)

(2) BH-HV101/HV102 (Auxiliary building 126ft)

(3) BH-HV201/HV202 (Auxiliary building 126ft)

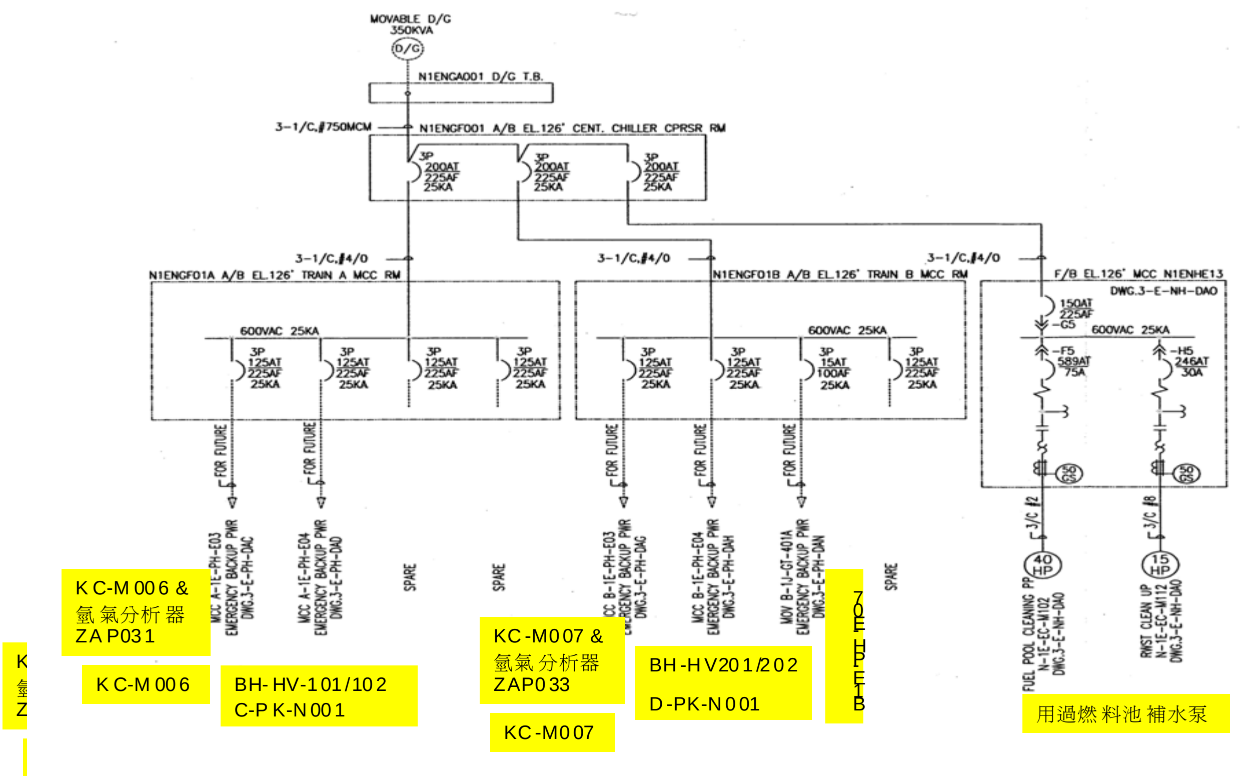
Item 3: C-PK-N001, D-PK-N001 safety train battery charger

Item 6: PA back up power (UPS locates at A/B 126ft, 480V moveable DG can be served as new backup power. Power can be provided from the extension interface of 480V moveable DG)

Item 7: EC-P102/112 power

Item 10: Hydrogen Analyzer

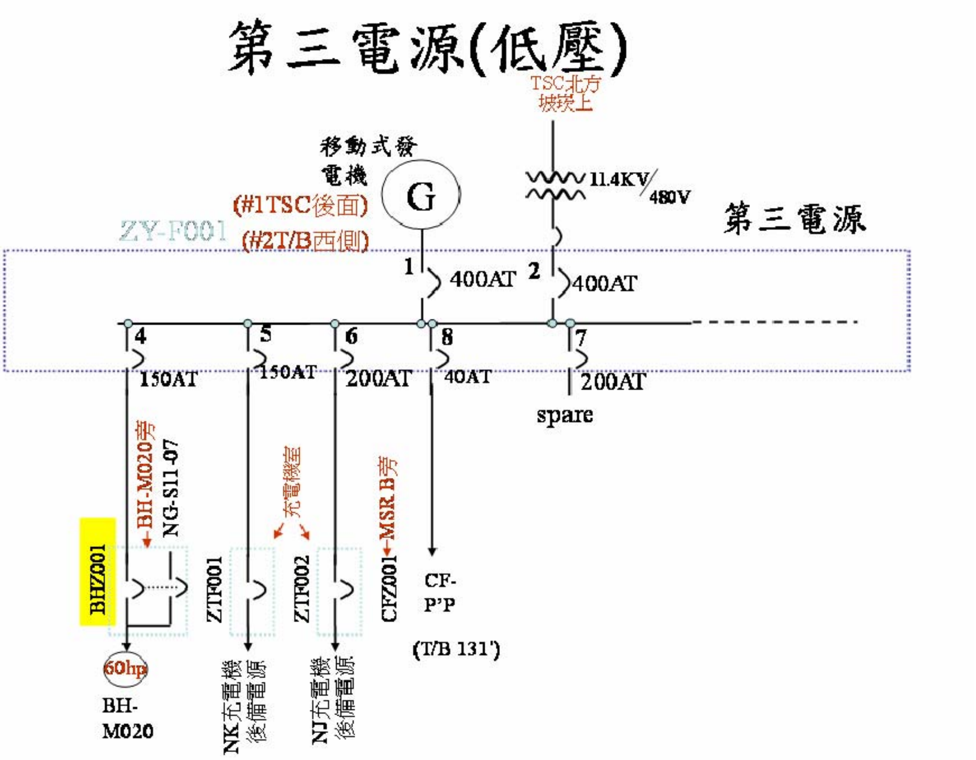
Item 12: Seismic fire pump (KC-M006, KC-M007)



Item 2: Hydro test pump BH-P020

Item 4: NJ/NK battery charger

Existing 3rd power source and new 480V mobile DG emergency power supply

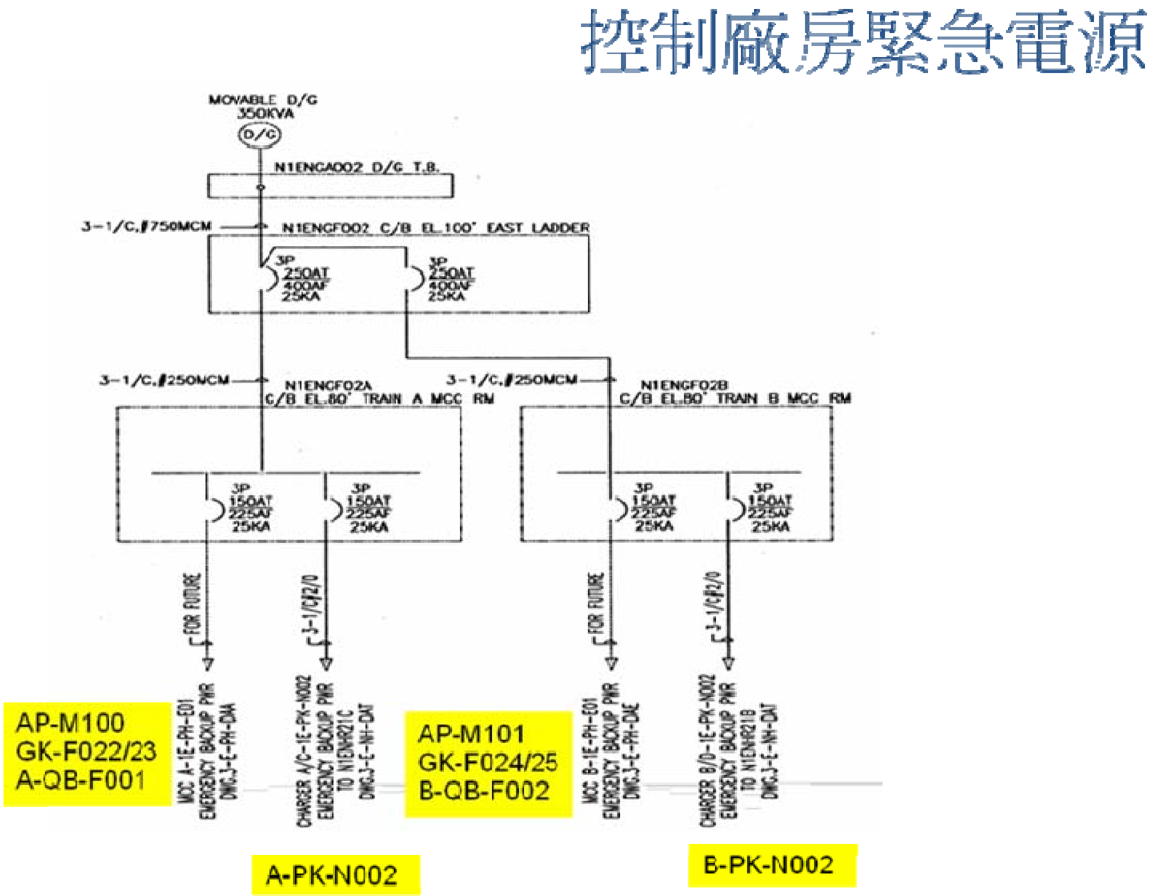


Item 3: A-PK-N001, B-PK-N001 safety train battery charger

Item 5: Control room lighting

Item 11: Control room emergency ventilation

Item 13: AP-M100, ÁP-M101

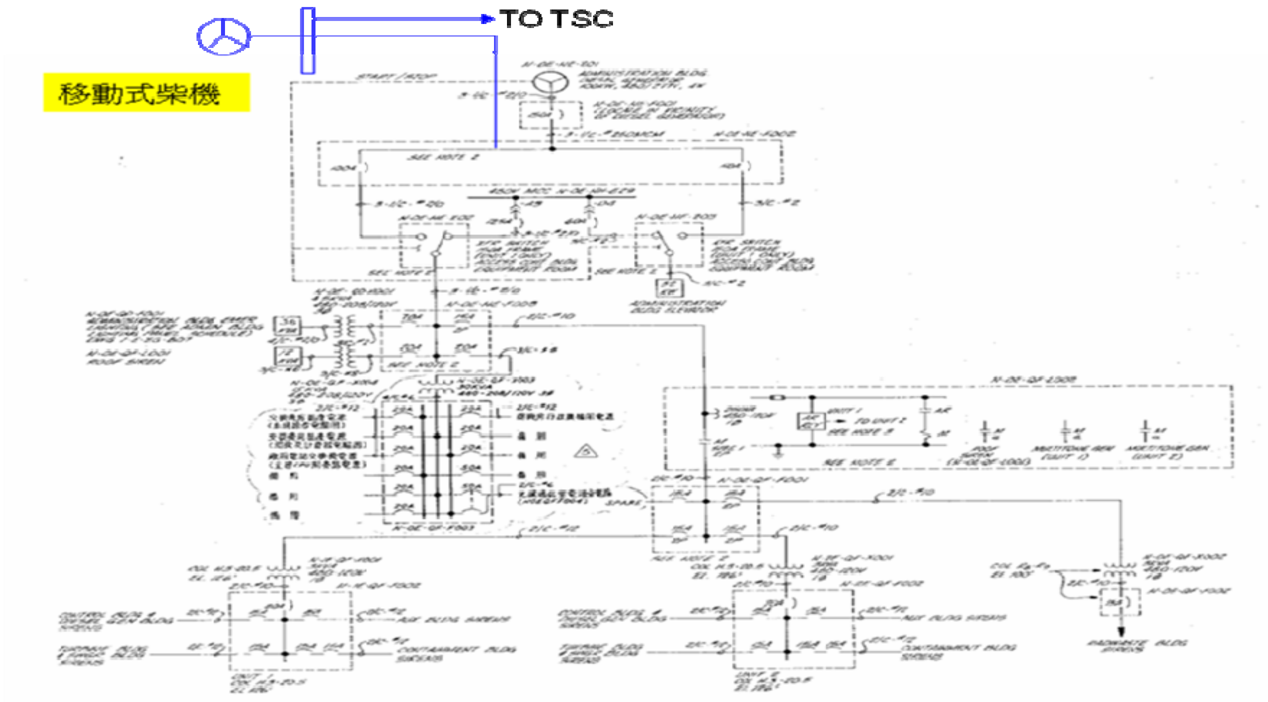


Item 8: Telephone exchanger battery charger

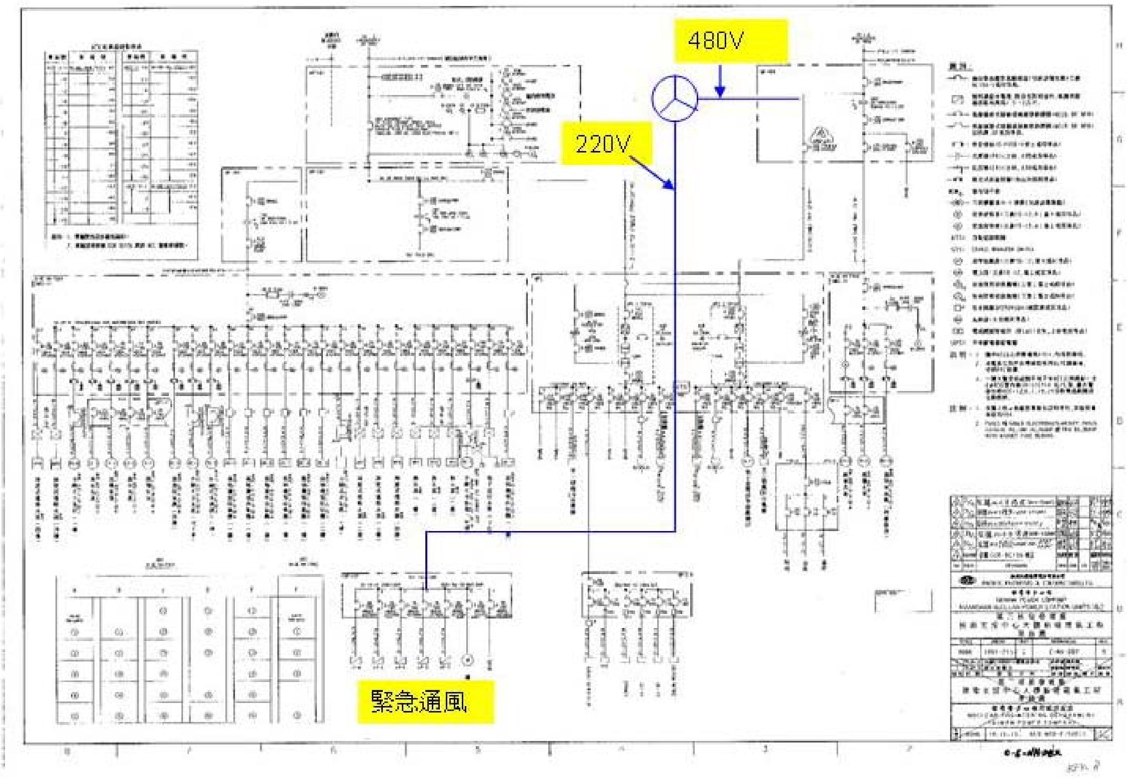
Item 9: TSC power

(1) The diesel generator in administration building can provide power to the battery of telephone exchanger. It also can provide power to site telephone system, PHS, and microwave telephone.

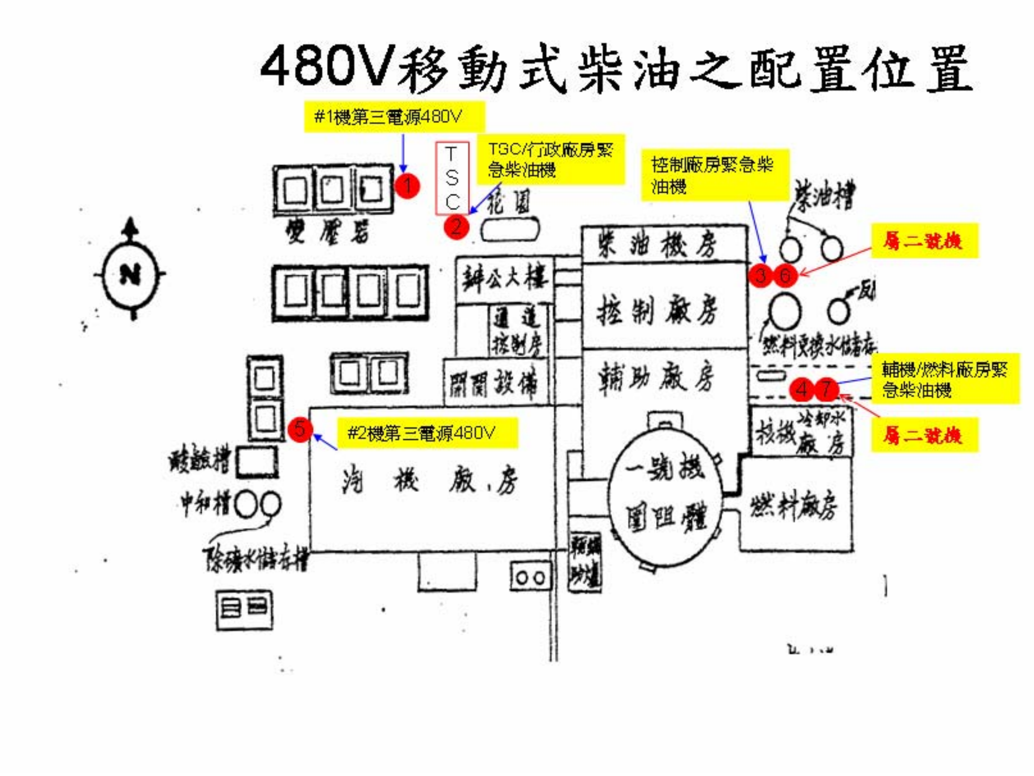
(2) If the diesel generator in administration building is not available, 480V movable diesel can be used as substitution.



TSC緊急電源



B. All 480V Mobile Diesel Generators Layout



C. Implementation Schedule

1. The electrical wiring design has been completed. Details are shown in DCR.
2. The station has purchased 10 mobile 480 VAC diesel generators. Each has capacity 370kVA.
3. The station has purchased 3 moveable air compressors.
4. This DCR has been completed before January 31, 2012.

D.1 DCR M1-4245/M2-4246 load distribution N-NGF001

<table>
<tr><th>Load</th><th>Power Name</th><th>Power Location</th><th>Modification</th><th>Power Source</th></tr>
<tr><td>BH-HV101/102,
KC-M006,
A1JZAP031</td><td>A-PHE04F1&F2,
A-PHE03D3,
A-PHE03J3B&F2-08</td><td>Auxiliary building EL.126’ train-A, MCC room</td><td>Distribution panel N-NGF01A will be installed in A-train MCC room to provide emergency power to MCC train A.
Power is supplied to N-NGF01A from N-NGF001</td><td rowspan="6">The generator distribution panel N-NGF001 provides power to the listed loads</td></tr>
<tr><td>BH-HV201/202,
GT-HV401A,
B1JZAP033,
KC-M007</td><td>B-PHE04F4&D1
B-PHE07D2&B2A
B-PHE03H1B&
F2-10
B-PHE03D3</td><td>Aux Bldg. EL.126’ train-B, MCC room</td><td>Distribution panel N-NGF01B will be installed in B-train MCC room to provide emergency power to MCC train B.
Power is supplied to N-NGF01B from N-NGF001</td></tr>
<tr><td>PA-PAA (auxiliary, fuel, control, D/G)
PA-PAH (containment)</td><td>N-NHE05
N-NHE26</td><td>Aux Bldg. EL.126’ train-A, MCC room</td><td>Power supplied from MCC train A</td></tr>
<tr><td>PA-PAB (auxiliary, fuel, control, D/G)
PA-PAK (containment)</td><td>N-NHE12
N-NHE25</td><td>Aux Bldg. EL.126’ train-B, MCC room</td><td>Power supplied from MCC train B</td></tr>
<tr><td>N-ECM102/112</td><td>N-NHE13F5&H5</td><td>Fuel building EL.126’ MCC room</td><td>Power is supplied to MCC N-NHE13 from N-NGF001</td></tr>
<tr><td>C-PK-N001</td><td>A-PHE04G2</td><td>Aux Bldg. EL.126’ train-A, MCC room</td><td>A-PHE04 is planned to get power from N-NGF01A</td></tr>
<tr><td>D-PK-N001</td><td>B-PHE04G2</td><td>Aux Bldg. EL.126’ train-B, MCC room</td><td>B-PHE04 is planned to get power from N-NGF01B</td></tr>
</table>

D.2 NG-F001 Moveable Diesel Generator load

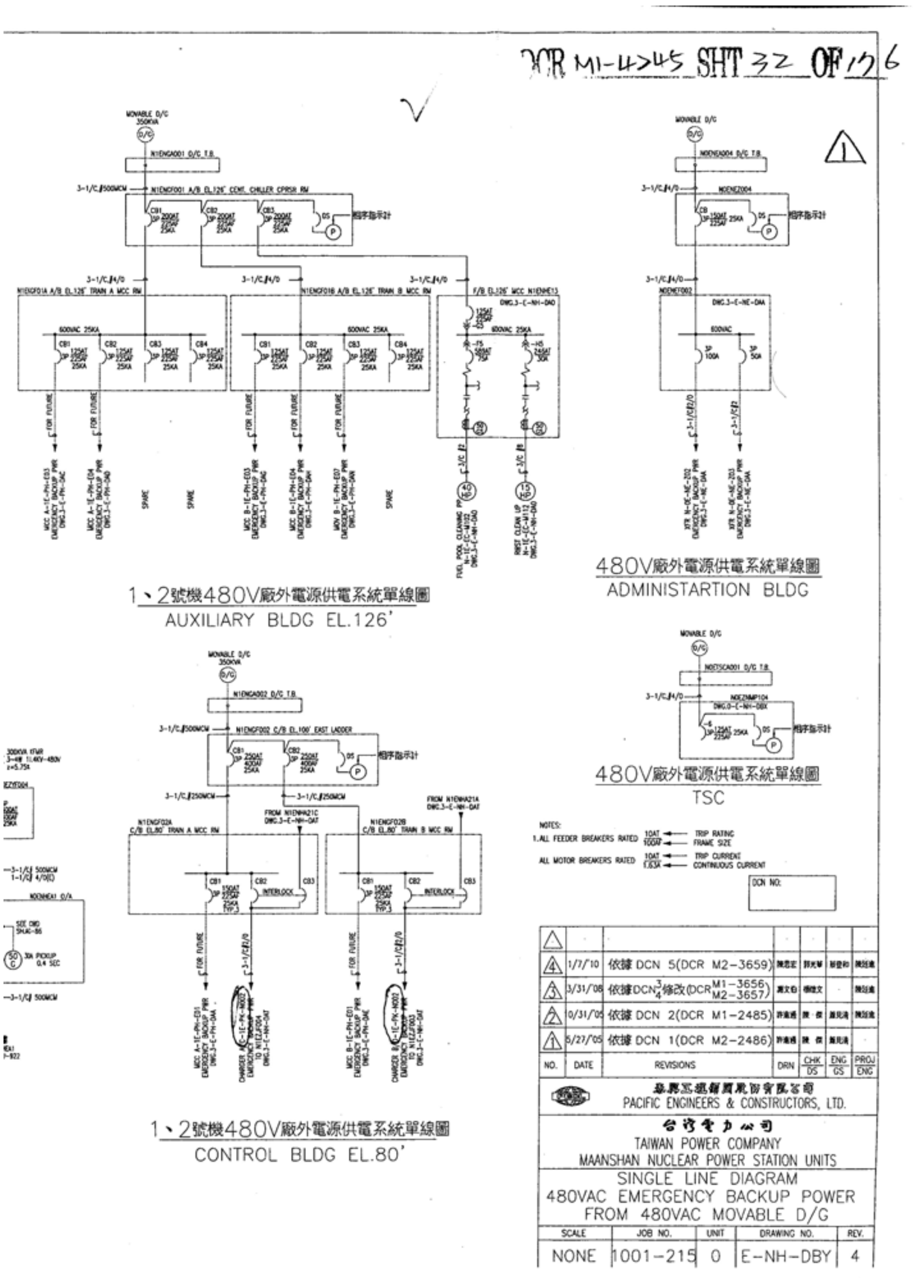
No.	Load	WATTS(kW)	Remark
1	KC-M006/M007	24.2	
2	BH MOV	9	
3	A1/2JZAP031	1	
4	A1/2JZAP033	1	
5	EC-M102/M112	40.6	
6	PA UPS	4	
7	C-PKN001	44	
8	D-PKN001	44	
Total		179.8	

E.1 DCR M1-4245/M2-4246 Load Distribution N-NGF002

Load	Power Name	Power Location	Modification	Power Source
A-AP-M100 A-GK-F022/F023 A-QB-F001	A-PHE01B2, A-PHE01A4&E3, A-PHE01A2	Control building EL.80’ A- train MCC room	Distribution panel N-NGF02A will be installed in A-train MCC room to provide emergency power to MCC train A. The load of control room lighting is 10kVA.	The generator distribution panel N-NGF002 provides power to the listed loads
A-PK-N002	N-NHE21F4	Access Control building EL.73’ -train MCC room	Power is supplied to A-PK-N002 fromN-NGF02A. C-PK-N002 is replaced by C-PK-N001.	
B-AP-M101 B-GK-F024/F025 B-QB-F002	B-PHE01B2, B-PHE01A4&E3, B-PHE01A2	Control building EL.80’ B- train MCC room	Distribution panel N-NGF02B will be installed in B-train MCC room to provide emergency power to MCC train B. The load of control room lighting is 10kVA.	
B-PK-N002	N-NHE21B2	Access Control building EL.73’ -train MCC room	Power is supplied to B-PK-N002 from N-NGF02B. D-PK-N002 is replaced by D-PK-N001.	

E.2 NG-F002 Moveable Diesel Generator load

No.	Load	WATTS(kW)	Remark
1	AP-M101	10.3	
2	GK-F024	15.8	
3	GK-F025	42.4	
4	A-PKN002	45	
5	B-PKN002	45	
6	QB-F001	10	
7	QB-F002	10	
Total		178.5	



5.1.4 Loss of ultimate heat sink

1. The ultimate heat sink of Maanshan station is South Bay (sea water). Nuclear Service Cooling Water (NSCW) system takes sea water from South Bay as cooling water, after heat exchange, the heat is dissipated into South Bay. Normally, decay heat is removed as follow:
   (1) The steam from SG is released into condenser through the steam dump valves on main steam line, or discharged into atmosphere through PORV (power operated relief valves) on main steam line to remove the heat.
   (2) The water in steam generator can be made up by motor-driven AFP or turbine-driven AFP from CST, DST and raw water reservoir.
   (3) If RCS pressure decreases to less than 30kg/cm^2, heat can be removed by RHR system via Component Cooling Water (CCW) system in conjunction with NSCW. Temperature and pressure will continue to decrease by the operation of these 3 systems.
2. NSCW pumps and equipment for sea water intake screening are located in Seismic Category I structure. The structure of NSCW pump room has regular inspection and improvement monitor program to ensure the structure integrity.
   (1) Based on FSAR description, the capacity of NSCW intake pool is 350,382 ft^3 (Total capacity of intake pool and pump house, from EL.-8.2’ to EL.-27’. The bottom of intake pool is EL.-28’; pump house is EL.-36.5'). This capacity can provide the required water of two units for 30 minutes. It is estimated (FSAR) that the period of local tsunami is 49 minutes and the period of receding is about 25 minutes. Therefore during receding period, sea water will be filled before stored water is used up.
   (2) Supporting system: power, traveling Screen, spare parts (including supporting system)
      a. Traveling screen rotates in vertical direction. It is driven by chain, and if necessary, can be manually rotated. AC power is provided from the safety train A-1E-PH-E06 and B-1E-PH-E06.
      b. The station has regular maintenance program, spare parts, e.g., traveling screen sprocket, traveling screen chain, and screen mesh, are adequate for three outages.
   (3) Based on FSAR Section 3.8.4.1.8, the nuclear service cooling water structure , e.g., intake water tunnel, intake pool, and pump house, are Seismic Category I structures . The design basis for ground horizontal acceleration is 0.4g. Thus, the possibility of intake water tunnel damaged by earthquake is very low. The wall of tunnel bank is strong structure located on rock. The possibility of collapse due to earthquake to block pump suction is also low.
   (4) Status of intake structure (latest inspection date and results) and inspection period
      a. Unit 1 inspection date: from November 19, 2010 to December 06, 2010. Inspection result: Some concrete pieces were flaked off and were repaired. The report of inspection and repair had been submitted to AEC. (AEC No.1000002133, Feb. 17, 2011)
      b. Unit 2 inspection date: from November 16, 2009 to November 30, 2009. Inspection result:

Some concrete pieces were flaked off and were repaired. The report of inspection and repair had been submitted to AEC. (AEC No. 0980021026, December. 29, 2011)

c. Inspection period: every 5 years (Inspection is performed during outage, thus, approximately once every 3 cycles)

5.1.4.1 Design provisional autonomy of the site before fuel degradation

In case of loss of ultimate heat sink, water can be made up to SG by operating AFP and steam can be released from SG (2nd side heat sink) to reduce RCS pressure and temperature.

1. Steam generated in SG can be released into atmosphere through PORV (power operated relief valve) located on main steam line. Thus, atmosphere serves as heat sink to absorb heat generated in reactor.
2. Water can be made up into SG by running motor-driven or turbine-driven AFP. The water is taken from CST, DST or raw water reservoir as listed on Table 5.1-2.

Table 5.1-2 Capacity of steam Generator Water Sources (each unit)

	Source	Structure material	Seismic Category	Methods of makeup	Elevation	Driving force
1	CST 2838 ton (750000gallon)	reinforced concrete, liner SA-240-304L stainless steel	0.4g	piping	Above sea level 15m	gravity
2	DST 378ton (100000 gallon)	A-240-304L stainless steel	0.15g	piping	Above sea level 15m	gravity
3	Fire water storage tank 1419 ton × 2 (375000 gallon × 2) (common to both unit)	A-283-C carbon steel	0.15g	piping	Above sea level 15m	gravity
4	Raw water reservoir 50000 ton × 2 (common to both units)	reinforced concrete	0.15g	piping	Above sea level 51.5m	gravity

Note: The original seismic design class of Item 2~4 meets the requirement of Building Technical Rules issued by Ministry of the Interior.

3. If NSCW system is unavailable but CCW system is available, CCW system water is adequate to cool CCP (During CCW circulation, system water will be cooled by environment). Continuous operation of CCP will provide water injection to RCS and to RCP shaft seal. Seal LOCA can be prevented, thereby avoiding core fuel uncovered.

5.1.4.2 Foreseen actions to prevent fuel degradation

1. If both motor-driven and turbine-driven AFP are unavailable, the other diesel engine-driven AFP can be operated to make up water into SG.
2. When all types of AFP are unavailable, diesel engine fire pumps can be operated to makeup water into SG.
3. If the the other unit is not damaged, supports from the other unit include:
   - CST and DST can be connected to AFP to provide water source.
   - The diesel engine driven AFP of the other unit can be connected to support making-up water into SG.
4. If both units are damaged, supports available from offsite:

   Make up water into CST, RWST, SFP, and RCS by fire engines. The station has one 7-ton fire water tank vehicle. The 4th battalion of Pingtung County Fire Bureau has four squads (Hengchun, Cherchen, Manchu, and Fangshan). They have two 10-ton and two-12 ton water reservoir vehicles; one 3-ton and four 3.5ton water tank vehicles; and also have four 1- ton small water tankers. Offsite water sources can be taken from No.2 and No. 3 deep wells, Longluan lake, and sea water.
5. The required pre-stage time for above mentioned operations:
   (1) Starting diesel engine-driven AFP: two men for 1hour for each unit.
   (2) Connected to fire system to makeup water into SG: two men for 30minutes.
   (3) CST connection: one man for 15minutes.
   (4) DST connection: one man for 15minutes for each unit.
   (5) Fire engine intake water from Longluan lake: three men for 1hour.
6. Availability of qualified operators to perform the above action:
   (1) For manpower required in normal operation and emergency repair, including station staff, supporting personnel from offsite organizations, and contractor staff, station has completed name list. All those people have been trained on radiation prevention and other related fields.
   (2) Every maintenance division has supporting manpower list, which is established based on mission assigned, professional specialty, etc. The man power list includes name, phone number, and address. People around Hengchun area can be the first priority of supporting manpower.
7. Confirming timing of cliff-edge effects

   The available volume of CST is 2,680 tons which is adequate for 40 hours. The available volume of DST is 378.5 tons which is adequate for 6 hours. The total is 46 hours. If AFP takes water from raw water reservoir (100,000 tons), it is adequate for 32days for two units.

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

1. If a far beyond design basis tsunami occurs, the intake structure may be damaged or seriously blocked. This will lead to loss of ultimate heat sink. Reactor decay heat will be removed by making up water into steam generator and releasing steam from steam generator.
2. Steel grating was installed on the top of NSCW intake pool to prevent large litter and debris, carried over by tsunami from intruding into intake pool, and prevent failures of NSCW pumps.
3. Measures to prevent flooding, such as water tight walls and doors, have been completed. The NSCW pump motors and related electrical components are physically separated from each other to prevent common cause failure of all motors because of flooding. After improvement, elevation of pump motor room to prevent tsunami intrusion is the same as the elevation of pump house exhaust fan, both are at12.9 meters.
4. Larger trashes (limbs, rubbish) at sea water intake are removed manually from grating.
5. If traveling screen fails, trash is removed manually at sump and fixed travel screen to ensure that NSCW pump has clean water source. (The station has one 20-ton and one 60-ton cranes, and one 15-ton truck to support garbage removal. SOP 1451 has defined the procedures for intake pool emergency trash removal).
6. The station has 5 spared NSCW pump motors that can be used for emergency replacement. SOP 1451 has defined the process to perform the emergency replacement. This work can be completed in 7 hours. (2 hours for transportation and 5 hours for replacement)
7. If onsite water is not enough, water can be made up to CST, RWST, SFP, and RCS by fire engines. The station has purchased one chemical foam fire engine with capacity of 7 tons (delivered); one water tank fire engine with capacity of 12 tons (scheduled for deliver before June 30, 2012). Offsite water sources can be taken from No.2 and No. 3 deep wells, Longluan lake, and sea water.

5.1.5 Loss of the ultimate heat sink combined with station black out (SBO+DBE)

5.1.5.1 Design provisional autonomy of the site before fuel degradation

1. If SBO occurs, ultimate heat sink will be lost at the same time. Refer to Section 5.1.3.3 for design provisional autonomy of the station.(Diesel engine driven AFP is not in original design. It was added after the site SBO, which occurred on March 18, 2001.) Thus, core heat is removed by 2nd side heat sink reduce to primary side temperature and pressure.
2. If SBO occurs at full load operation, together with loss of 2nd side heat sink(reactor heat cannot be removed through SG, AC power cannot be recovered to operate CCP to maintain RCP seal water), reactor core could be damaged within 2 hours.

5.1.5.2 External actions foreseen to prevent fuel degradation

1. If SBO occurs, ultimate heat sink will be lost, a description of External actions foreseen to prevent fuel degradation can be found in Section 5.1.3.4 and 5.1.4.2. The core heat is removed by 2nd side heat sink to reduce primary side temperature and pressure.
2. Ths station has reviewed the issue on maintaining 2nd side heat sink to remove primary side heat on SBO, and worked on improved measures , described as follows:
   (1) Each unit has one diesel engine driven AFP. The diesel engine is rated 480HP, 1800rpm, and has 6 cylinders. The discharge pressure of this pump is 860psig; the rated flow is 360gpm.Water intakes is from CST, DST or raw water tank. Diesel engine driven pump of Unit 1 and 2 can be connected to each other. If steam generator pressure drops to 60kg/cm^2, they can be started to makeup water into SG.
   (2) Connected to fire water system, diesel engine fire pump can be used to make up water. The rated flow of the fire pump is 1,500gpm. If the pressure of steam generator drops to 9kg/cm^2, this pump can be started to makeup water into SG.
   (3) Fire engines can be used to make up water. The flow rate and discharge pressure is approximate 250gpm and 6~10kg/cm^2, respectively. Once SG pressure drops to 6 kg/cm^2, fire engines can be started to inject water (Figure 5.1-3) into SG. (Follow plant procedure 1451 "Ultimate Response Guideline")
   (4) Along with the 3 SG water makeup methods mentioned above, operator can manually open SG PORV locally to release steam into atmosphere to reduce SG pressure.

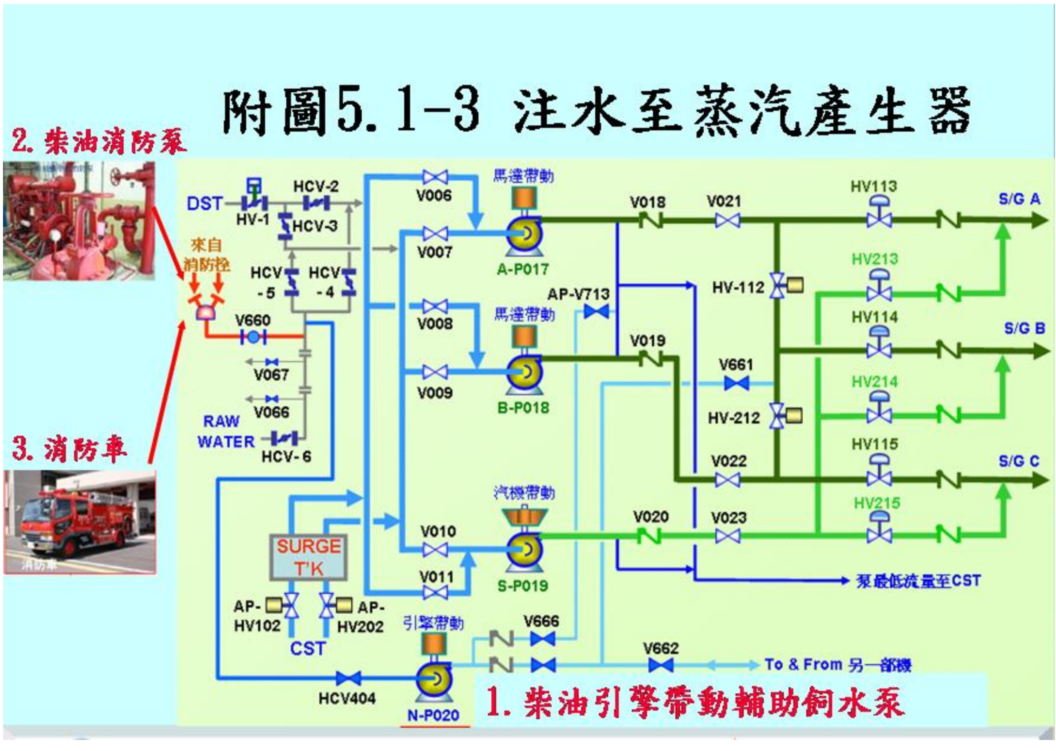


Figure 5.1-3 Injecting Water into Steam Generator

3. If the primary temperature and pressure can not be reduced by operating SG or RHR system, reactor pressure has to be released to facilitate injecting water into reactor directly. The actions are described as follows:

   (1) Reactor pressure is released to pressurizer relieve tank by operating PORV on pressurizer.

   (2) Reactor pressure is released to pressurizer relieve tank by operating the vent valve on reactor head. (The 480V mobile diesel generator will be connected to safety train battery charger for providing DC power, as described in Appendix 5.1-1)

   (3) Follow plant procedure 1451 "Ultimate Response Guideline".

4. Supports from offsite if all onsite equipment is unavailable:

   If sea water from intake tunnel is not available, the water sources which can be considered as backup heat sink are shown in the following table.

Table 5.1-3 Water Sources of Backup Heat Sink

	Source	Structure material	Seismic Category	Methods of makeup	Elevation	Driving force
1.	2000 ton raw water tank	reinforced concrete, no cover	0.15g	piping	Above sea level 54.3m	gravity
2.	5000 ton fire water tank	reinforced concrete, with cover	0.15g	piping	Above sea level 70.5m	gravity
3.	50000 ton raw water reservoir (x2)	reinforced concrete, no cover	0.15g	piping	Above sea level 51.5m	gravity
4.	No. 2 and No. 3 deep well	Steel pipe	N/A	piping	Above sea level 50m	Electrical power distribution system
5.	Longluan lake	Natural lake	N/A	Temporary water tank truck and fire hose	Dike top above sea level 18.5m	Mobile water pump
6.	Sea water	natural	N/A	Temporary water pump and fire hose	Dock above sea water level 3~5m	Temporary water pump

Note (1): The original seismic design class of Item 1~3 meets the requirement of Building Technical Rules issued by Ministry of the Interior.

(2): Total capacity of No.2 and No.3 deep well is 2.56 tons/minute.

(3): Fire engine or temporary water pump can take sea water at pump house dock. The 4th battalion of Pingtung County Fire Bureau has four squads (Hengchun, Cherchen, Manchu, and Fangshan). They have two10-ton and two 12-ton water reservoir vehicles; one 3-ton and four 3.5tons water tank vehicles; and also have four 1ton small water tankers.

5. Confirming timing of cliff-edge effects

The available volume of CST is 2,680 tons which is adequate for 40 hours. The available volume of DST is 378.5 tons which is adequate for 6 hours. Total is 46 hours. If AFP takes water from raw water reservoir (100,000 tons), it is adequate for 32 days for two units.

The Nuclear Safety Department of Taiwan power company completed Ultimate Response analysis report on September 2011. This report used advanced accident analysis program RELAP5-3D to simulate the scenario and process in performing the measures defined in Ultimate Response guideline. The minimum flow rate of sea water or raw water to be injected into SG or reactor in different scenarios is calculated quantitatively. The core fuel temperature has to be ensured not higher than the temperature that fuel cladding begins to oxidize (1500°F). The analysis has the following conclusions:

(1) Assuming auxiliary feedwater system, both motor-driven auxiliary feedwater pump (MDAFP) and turbine-driven auxiliary feedwater pump (TDAFP), is operable prior to SBO (10 minutes period before event occurred), then the 2nd side water level of SG can be maintained at nearly normal level. If TDAFP still can be operated normally within one hour after SBO event, pressure relieving at 2nd side can be performed. After that, if TDAFP fails and emergency pressure reducing operation is required, 2nd side can be maintained in a low pressure (12kg/cm^2) and high water level favorable state. Performing emergency pressure relief via PORV at this state, reactor cooling water can be maintained at natural circulation amount (about 4.36% of initial flow rate before SBO event). Fuel will be fully covered by core cooling water and fuel cladding temperature is well below the temperature of oxidation (1500°F).

(2) As SG pressure drops to 60psia, raw water or sea water is injected into SG. Analysis is performed for five different injection rates ranged from 500gpm to 2,000gpm. The longest and shortest time, at which SG water level begins to increase by the reading of narrow range water level indicator, is 24.3 hours (500gpm) and 2.81 hours (2,000gpm), respectively. The time for water level to increase to normal level (50%) is 38.2 hours (500gpm) and the 3.2 hours (2000gpm), respectively.

(3) NSSS long-term equilibrium pressure is about 500psi. The amount of NSSS natural convection flow rate is about 4.3%. The amount of injected water at the time of reduced accumulator pressure is about 24% of its original amount. The maximum fuel cladding temperature is 441°F.

(4) Assuming RCP shaft seal leakage (Seal LOCA) occurs 0 hours after SBO, primary side

will lose cooling water at 75gpm. Analysis result shows that due to continuous loss of core cooling, core will not be covered and fuel cladding temperature will increase. About 8 hours after SBO, core water level will drop to the top of fuel. About 9 hours after shaft seal leakage, fuel temperature begins to increase rapidly.

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

1. RCS standby make up water path:

   (1) RWST→ gravity→ RHR pump →RCS
   (Figure 5.1-6. All the valves in this path are normal open)

   (2) RWST → BH-V001 → BH-P020 → BH-V061 → BH-V063 → BH-V712 → BG-V799 → RCP seal injection (Figure 5.1-7)

   (3) Fire engine → BL-V023 down stream blind plate → BL-V014 → BG-V242 → CCP → SI inlet piping (valves can be opened manually) (Figure 5.1-8) (Quick connector installed on blind plate is completed before December 31, 2011)

   (4) The station has purchased two 4.16kV mobile diesel generators. Connection interface will be provided to supply power to onsite 4.16kV buses. This can supply power to CCP for making up RCS and RCP seal injection.

2. Containment standby water injection:

   (1) RWST→ gravity →BH- HV102, 101, HV202, 201→ recirculation sump (Figure 5.1-9)

   (2) Fire water system → fire valve KC-XV111→ 3 branches KC-XV113, XV114, XV115→ inject into containment (Figure 5.1-10)

   (3) Fire engine→BN-V005 upstream blind plate→BK-V031, V032, HV107, HV207 → containment spray piping (Figure 5.1-4) (Quick connector installed on blind plate is completed before December 31, 2011)

   (4) Maanshan has one water tank fire engine with capacity 7 tons. The station has procured one chemical foam fire engine with capacity of 7 tons (delivered); one water tank fire engine with capacity of 12 tons (scheduled for delivery before June 30, 2012).

   (5) The 4th battalion of Pingtung County Fire Bureau has four squads (Hengchun, Cherchen, Manchu, and Fangshan) fire pump provisions: two 10-ton and two-12 ton water reservoir vehicles; one 3-ton and four 3.5ton water tank vehicles; and also have four 1-ton small water tankers.

3. RWST standby make up water path:

   Fire engine→BN-V005 upstream blind plate →RWST (Figure 5.1-11) (Quick connector installed on blind plate is needed. Scheduled completion on December 31, 2011)

4. CST stand by make up water

   (1) Raw water → AL-HCV006 → blind plate → AL-HCV005 (or AL-HCV004) → AP-HV102/HV202 → CST (Figure 5.1-12)

   (2) Fire engine → AP-V020 upstream blind plate → CST (Figure 5.1-13) (Quick connector installed on blind plate is completed before December 31, 2011)

5. SG standby makeup water source

   (1) 50000 ton raw water reservoir → AM-V1145/V1139 → AM-V1060 → AM-V1167 → AM-V1273 → AL-HCV006 → AL-HCV004/AL-HCV005 → AFW PUMP → S/G

   (2) 2000 ton raw water reservoir → AM-V1151/V1152 →AM-V1171/V1208 → AM-V1173 → AM-V665 → AM-V664 →AM-V666 →AL-HCV006 → AL-HCV004/HCV00 5→ AFW PUMP→S/G

   (3) 5000-ton fire water reservoir → KC-V1115→KC-V1116 → AM-V1035 → AM-V1033 → AM-V1032 → AM-V1031 →AM-V1172 →AM-V1173 →AM-V665 → AM-V664 → AM-V666 → AL-HCV006 →AL-HCV004/HCV005 → AFW PUMP→S/G

6. SG pressure release: In case of no AC power and compressed air, SG PORV can be manually operated to release SG pressure.

7. RCS pressure release: Pressure is released from pressurize (PZR) PORV or from reactor vent valve. The 480V mobile diesel generator provides AC power to PK battery charger. Then DC power can be maintained.

8. Containment pressure release: By GT-HV401A → GT-HV402 → GT-F017 → atmosphere. (Figure 5.1-5) (480V movable diesel generators supply AC power to MOV)

   The operation of above mentioned power supply, air supply, and supporting systems, and also the decision making mechanisms, shall follow plant procedure1451 "Ultimate Response Guideline". The station personnel have been well trained for this procedure.

9. Examine the seismic capability and integrity of raw water reservoir and connected piping

   (1) Based on the results of Seismic Evaluation Task Force, enhanced or improved measures will be implemented.

   (2) In order to improve raw water pipeline reliability, maintainability after event and efficiency of piping replacement, underground raw water pipelines will be moved to above ground. (Scheduled completion on December 31, 2012)

(3) Together with underground raw water piping design modification, improve local flexibility of raw water main pipe. At specific locations, add elastic pipe to absorb pipe displacement induced by earthquake and to prevent pipe rupture. (Scheduled completion date December 31, 2014.)

(4) Together with underground raw water pipe design modification, evaluate the possibility to add a flow control valve between raw water reservoir A/B and main raw water pipe to prevent water loss in case main raw water pipe is broken.

(5) Measures for Raw water pipe break: follow plant procedure 1451 "Ultimate Response Guideline". (Isolate to prevent water loss and landslides, and repair.) The station personnel have been well trained and exercised.)

With the above measures to increase robustness of the plant, time to core damage is improved from 18 hours to having no core damage.

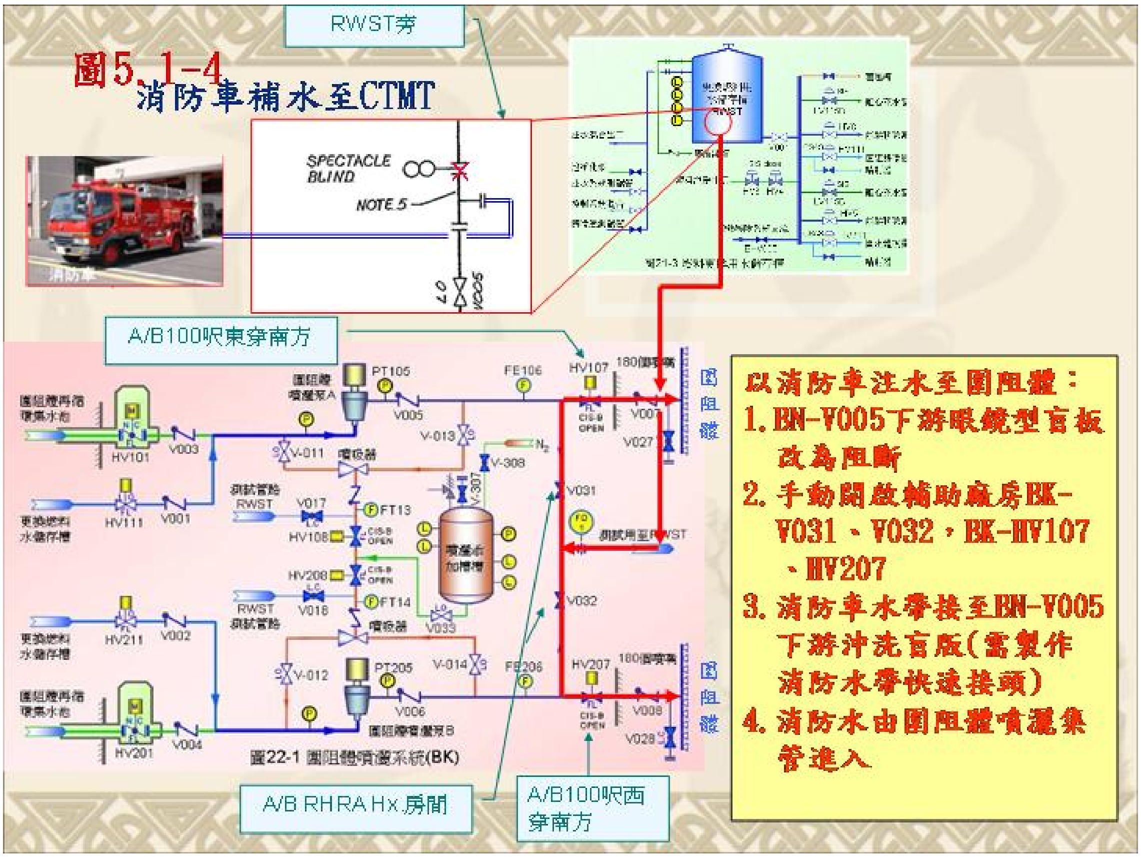


Figure 5.1-4 Paths of water makeup from Fire Engine to CTMT

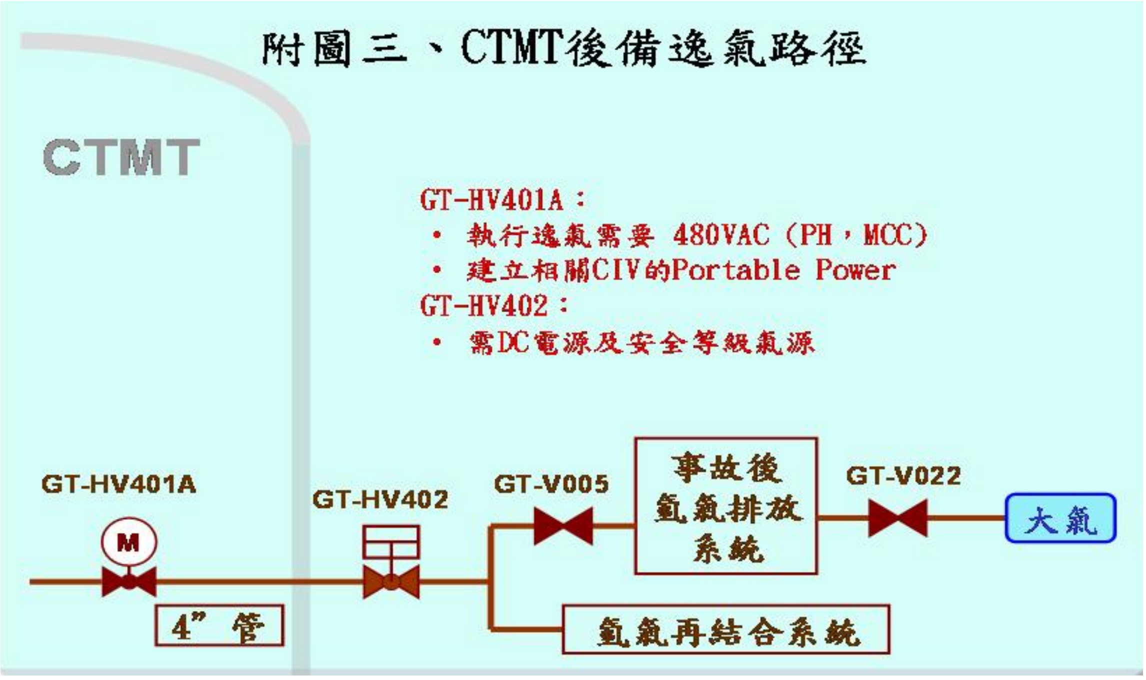


Figure 5.1-5 CTMT Backup Venting Path

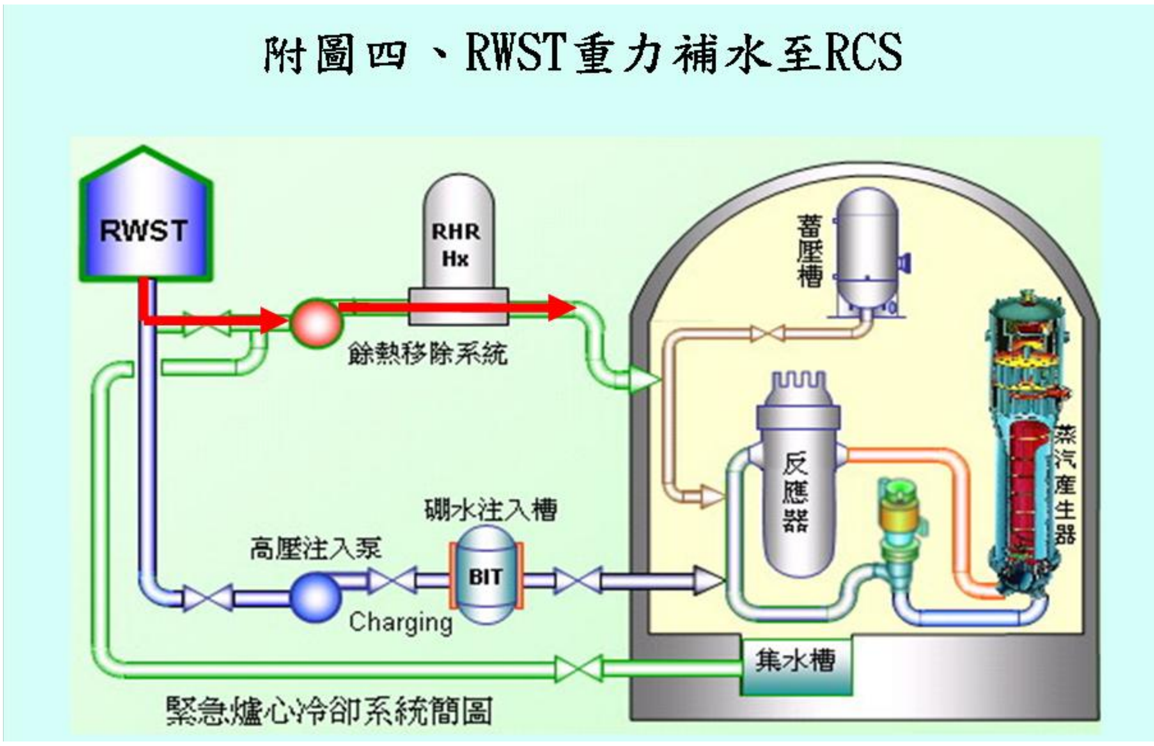


Figure 5.1-6 RWST Makeup Water to RCS by Gravity

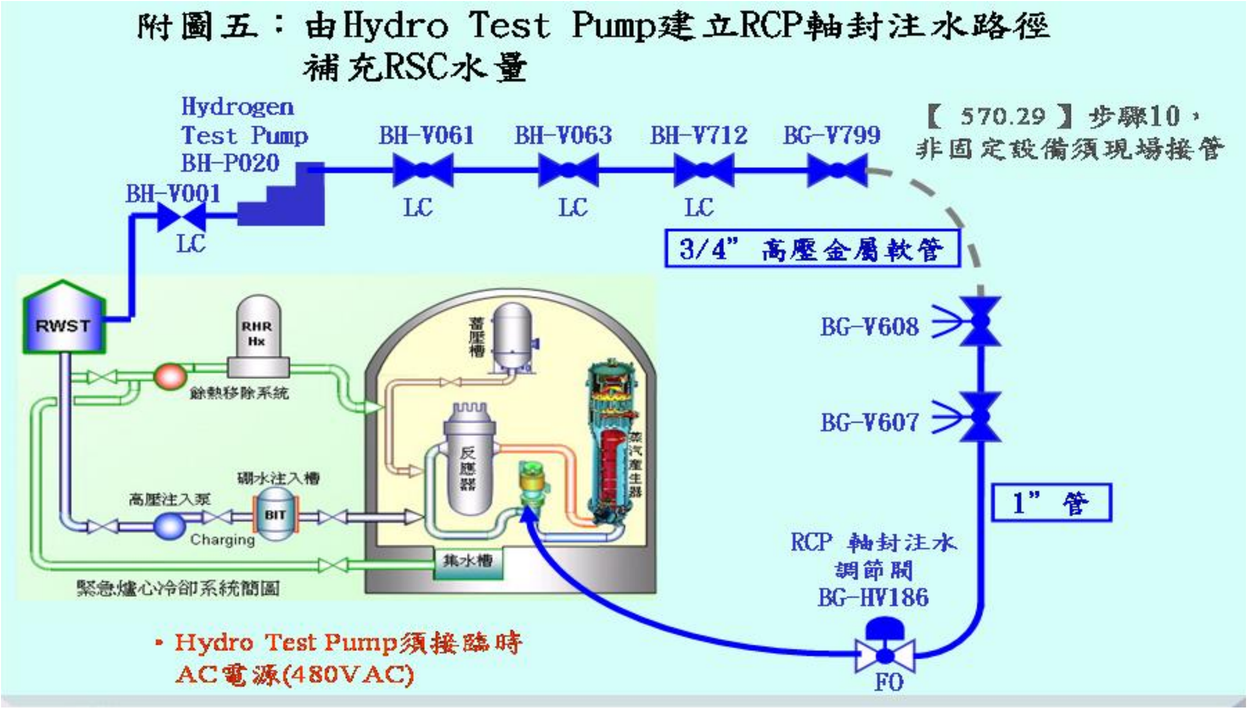


Figure 5.1-7 RCS Water Makeup by Hydro Test Pump (RCP Seal Injection Path)

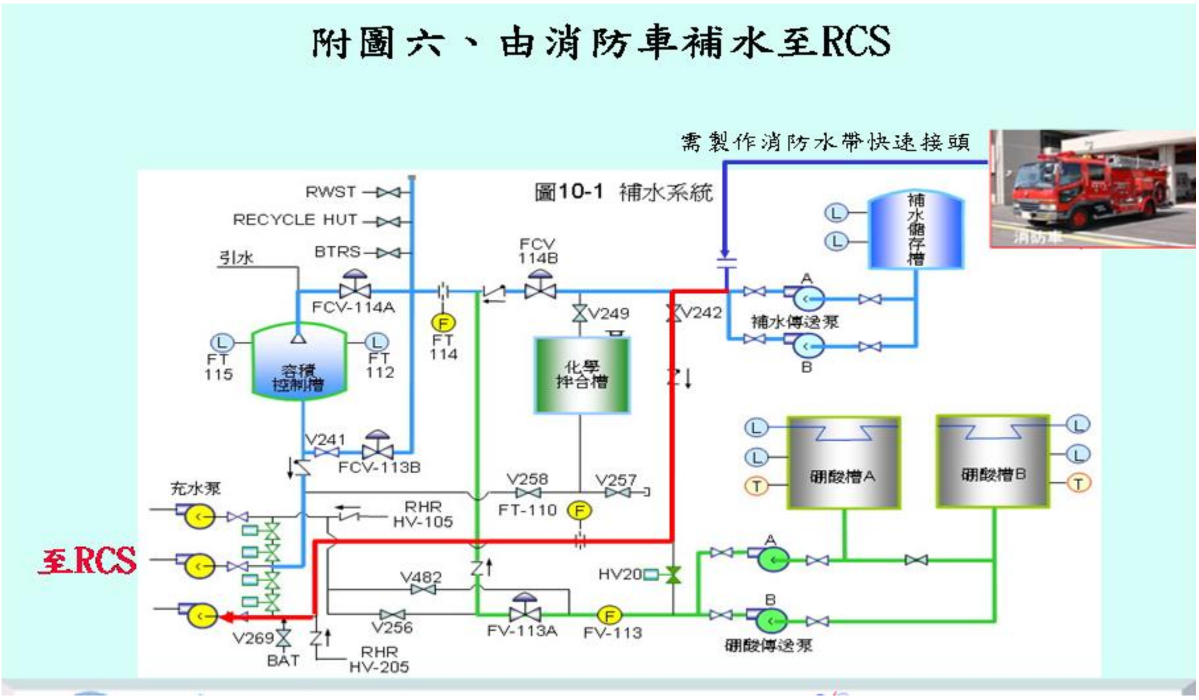


Figure 5.1-8 RCS Water Makeup from Fire Engine

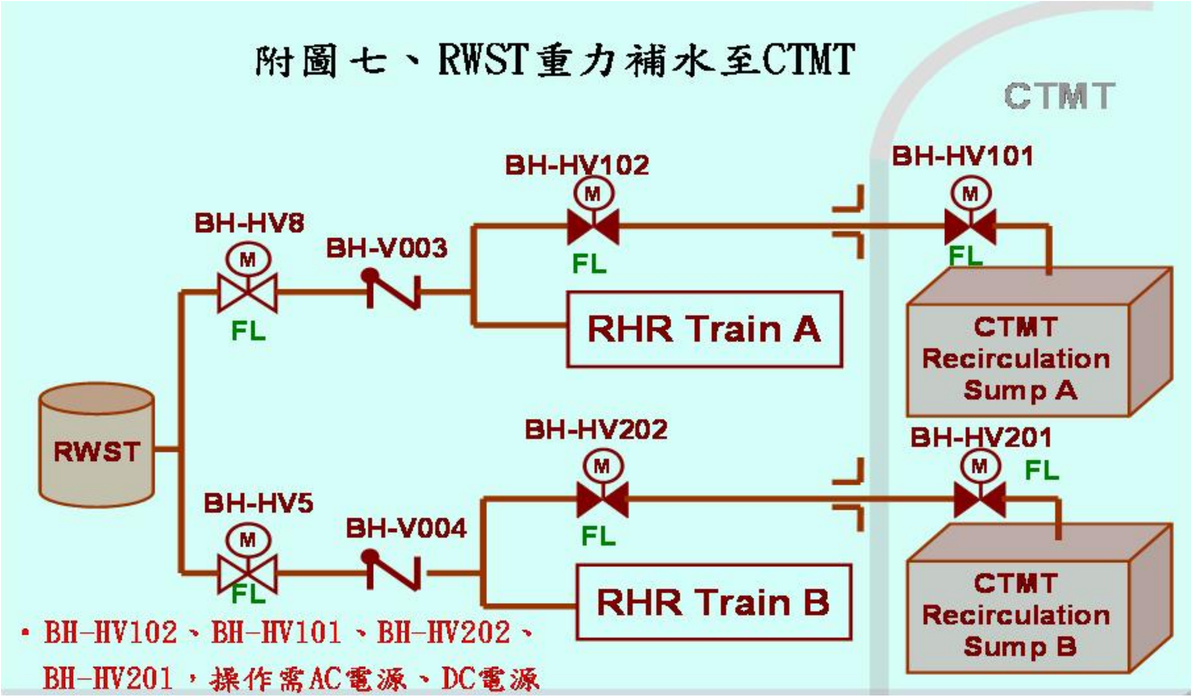


Figure 5.1-9 Makeup Water to CTMT from RWST by Gravity

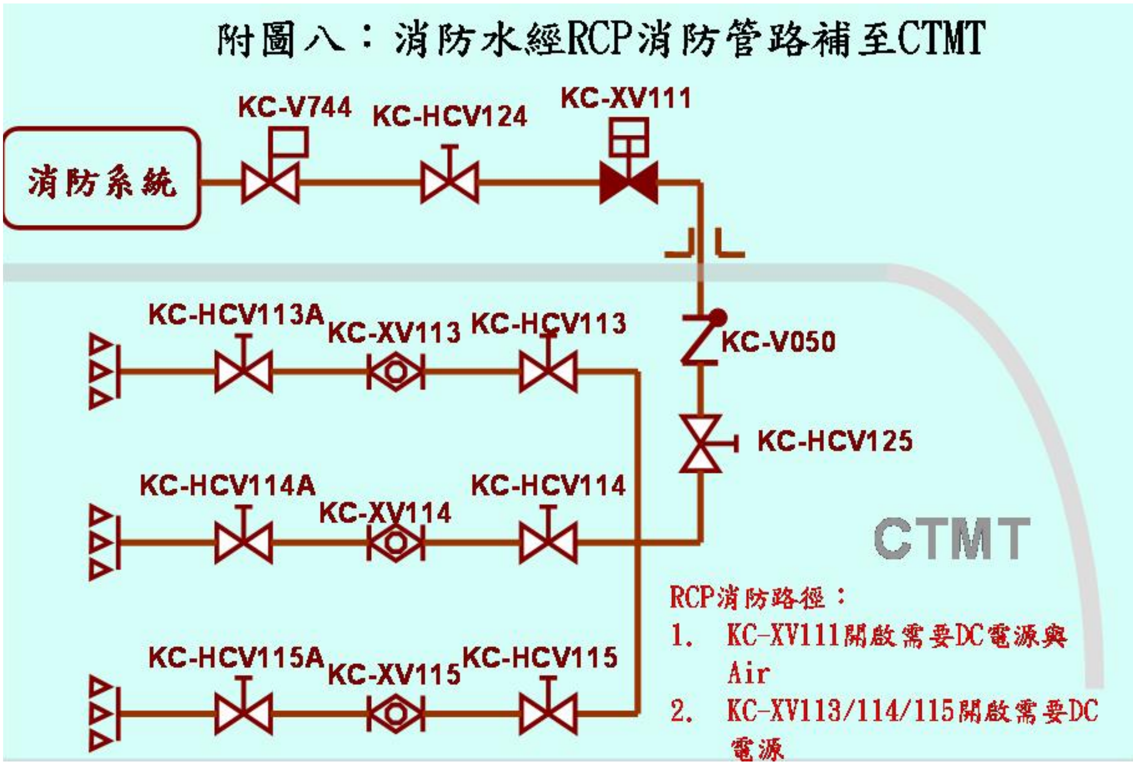


Figure 5.1-10 Fire Water Makeup to CTMT through Fire Water Pipe

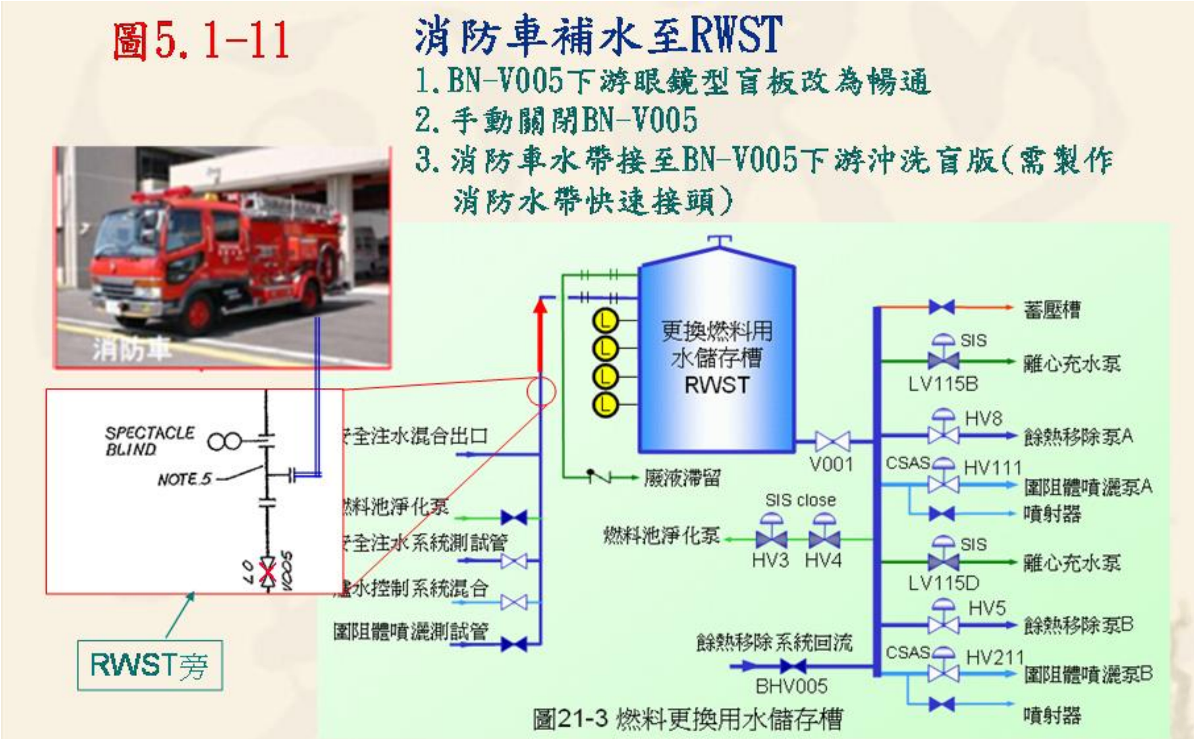


Figure 5.1-11 Makeup Water to RWST from Fire Engine

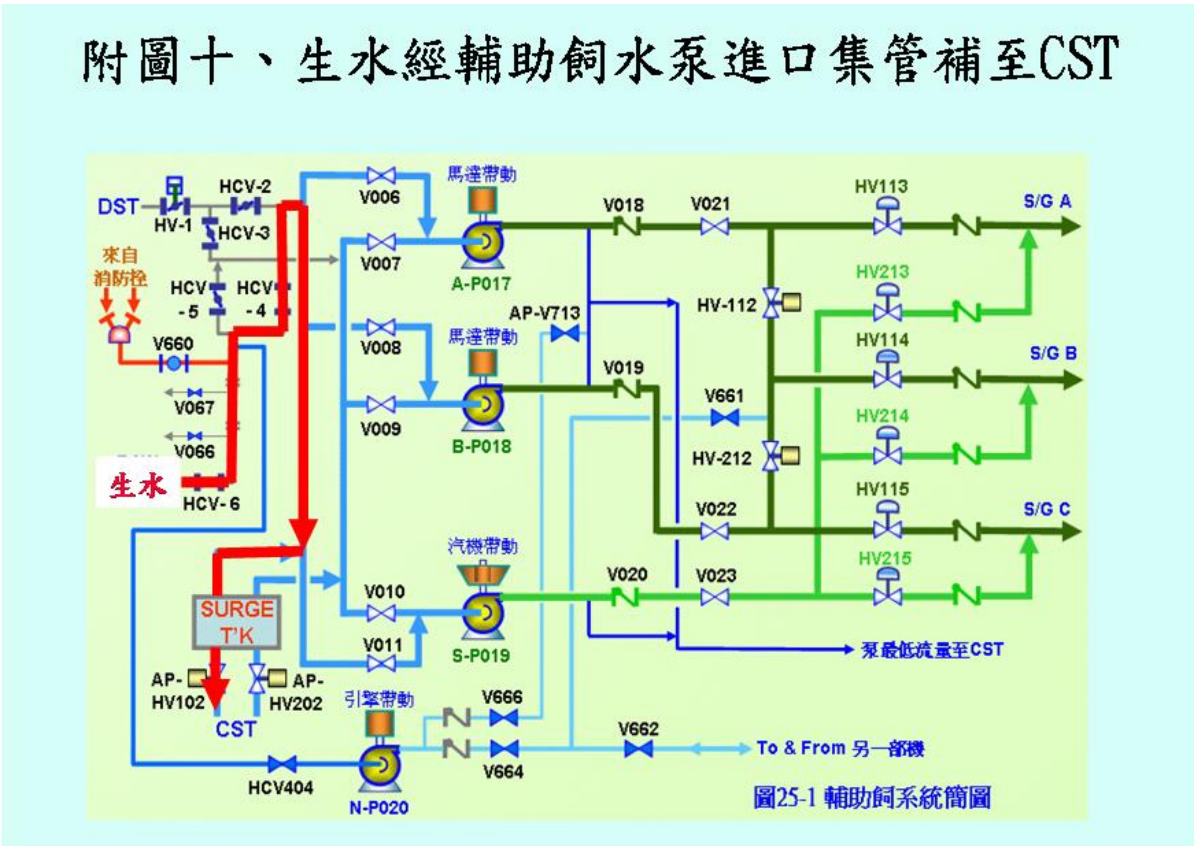


Figure 5.1-12 Raw Water Makeup to CST through Auxiliary Feedwater Pump

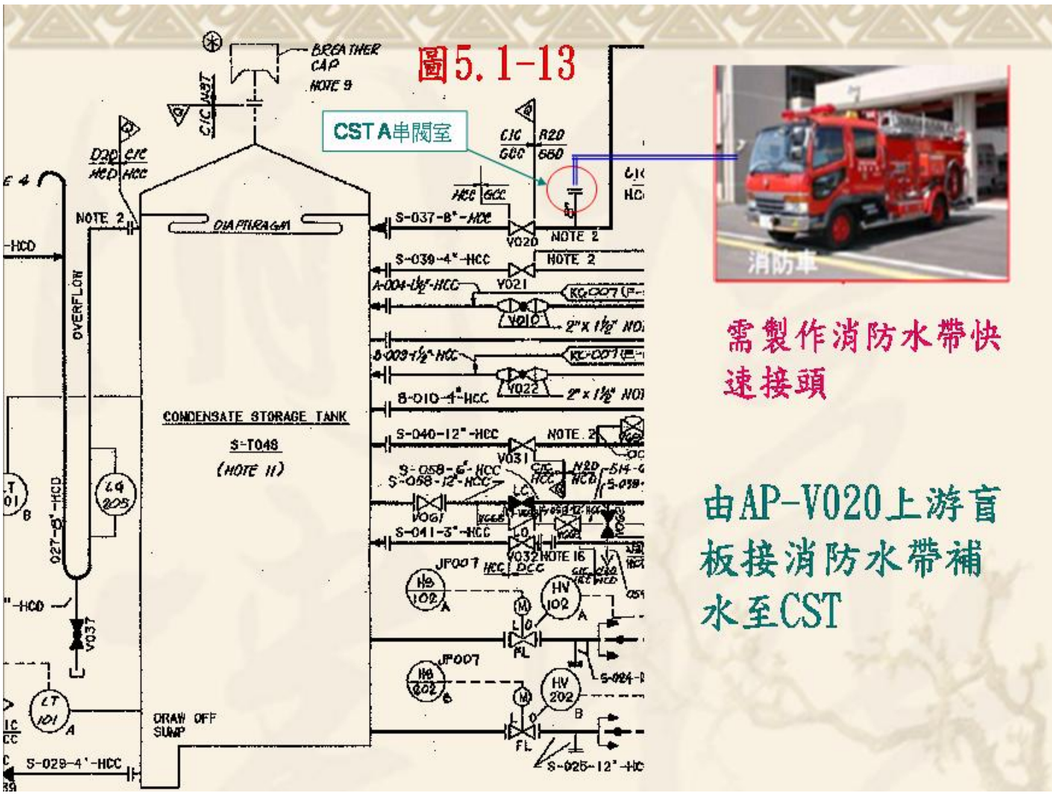


Figure 5.1-13 Makeup Water to CST by Fire Hose via AP-V020

5.2 Spent fuel pool

Each unit has one spent fuel pool (SFP) located in fuel building. It is a Seismic Category I reinforced concrete structure. The inner surface is lined with stainless steel. Seismic Category I stainless steel fuel rack are located in SFP to store spent fuel. Based on current design basis, the spent fuel pool cooling and water makeup systems are described as follows:

1. Cooling system

   Each unit has two trains of independent SFP cooling system. Each train has 100% capacity of cooling water pumps, heat exchangers and associated pipelines; all of these are Seismic Category I design. Power of SFP Cooling water pump is supplied by safety-related buses A/B-PB-S01. In case of loss of off-site power, power can be provided by emergency diesel generator or gas turbine generator. Component Cooling Water (CCW) system provides cooling water to SFP heat exchanger, then, heat is transferred to Nuclear Service Cooling Water (NSCW) system from CCW. Finally heat is dissipated into ultimate heat sink (South Bay). The power of CCW and NSCW pump is also provided by safety-related buses A/B-PB-S01. In normal operation, each train is designed to have the capability to remove the heat generated by following sources: the total fuel assembly off loaded 150 hours after reactor shutdown, 72 fuel assemblies off loaded during previous cycle, and all the spent fuels historically off loaded. Any train of SFP cooling system can remove a total of 2,160 fuel assemblies heat load and maintain pool temperature less than 140°F. The maximum design capacity of SFP cooling system is to remove all the following heat loads: the total fuel assembly off loaded 150 hours after reactor shutdown, 72 fuel assemblies off loaded 36 days ago, and all the spent fuels historically off loaded. For the maximum loads, SFP cooling system can maintain pool temperature less than 150°F.

2. Makeup water system:

   (1) Normally, makeup water to SFP is from Deminerlizer Storage Tank (DST) at a rate of 215 gpm. The capacity of DST is 100,000 gallons. If boric acid has to be made up, the make-up is from Refueling Water Storage Tank (RWST), through SFP purification system, to SFP. The boric concentration in RWST is 2400~2500ppm. The capacity of RWST is 460,000 gallons and make-up rate is100gpm.

   (2) In case of emergency, the two independent, Seismic Category I design CST transfer pumps with capacity 210gpm are used to make up water. Water is supplied from Seismic Category I Condensate Storage Tank (CST). The capacity of CST is 750,000 gallons. The power of CST transfer pumps is provided by safety-related buses A/B-PB-S01. In case of loss of off-site power, power can be provided by emergency diesel generator or gas turbine.

   Spent Fuel Pool Cooling System has two independent trains. Each has 100% capacity and has full capability to perform cooling function. During normal operation, pool level will decrease due to pool water vaporization or valve/pipe leakage. If both trains of SFPCS are unavailable, pool water temperature will increase and vaporize rapidly, thus decreasing pool water level. In these cases, make-up water can be performed by incorporating related system to prevent spent fuel from degradation.

5.2.1 Loss of off-site power (LOOP)

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

In case of loss of the offsite power, EDG-A and EDG-B will provide emergency AC power to safety-related electrical buses A/B-PB-S01. From A/B-PB-S01, power is provided to SFP cooling pumps and emergency make-up pumps. These cooling and make-up function can be started by operator , as necessary, in order to prevent fuel degradation.

SFP water level and temperature instrument power is supplied from non-safety-related system. If the offsite power is lost, power can be provided from non-safety-related battery set for 2 hours. During this period, operator can shift the power source to safety-related buses A/B-PB-S01 to maintain monitoring function of related instruments. However, if operator does not perform this action, after 2 hours, control room will lose the capability to monitor pool water level and temperature.

5.2.1.2 Autonomy of the on-site power sources

The power of SFP cooling and emergency make-up system is mainly provided by EDG-A and EDG-B. Therefore, the cooling and emergency make-up system operable duration depends on how long EDG-A and EDG-B can be operated.

The operation duration of EDG-A/B fuel system and startup air system is described in Section 5.1.1.2.

SFP water level and temperature instrument power is supplied from non-safety-related system. If the offsite power is lost, power can be provided from non-safety-related battery set for 2 hours. During this period, operator can shift the power source to safety-related buses A/B-PB-S01 to maintain the monitoring function of related instruments. If operator does not perform this action, after 2 hours, control room will lose the capability to monitor pool water level and temperature. However, if operator has performed this shift action, the duration of the monitoring instrument is dependent on the operation of EDGs (refer to Section 5.1.1.2).

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

The time of on-site power supply can be prolonged by supplying make-up fuel from auxiliary boiler fuel storage tank or gas turbine 35,000 kiloliters fuel storage tank. Detail description is described in Section 5.1.1.3.

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

The measures to increase the robustness of EDG –A & B, such as inspections to increase reliability, evaluation to improve building elevation and flooding prevention, and designating a parking area for storing crane and hoist, are described in Section 5.1.1.4.

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

5.2.2.1 Design provisions

If loss of off-site power and on-site back-up power occurs, gas turbine generator, 5th diesel generator, or the 3rd power source can provide AC power to safety-related buses A/B-PB-S01. Then, power can be provided from these buses to SFP cooling and emergency make-up water pumps. These pumps can be started by operator as necessary to protect spent fuel from being uncovered.

The description of supporting power, e.g., gas turbine generator, 5th diesel generator, and the third power source is described in Section 5.1.2.1.

5.2.2.2 Battery capacity and duration

The description of the battery of gas turbine generator and 5th diesel generator is described in Section 5.1.2.2.

5.2.2.3 Autonomy of the site before fuel degradation

Autonomy of gas turbine generator and 5th diesel generator is described in Section 5.1.2.3.

5.2.2.4 Foreseen actions to prevent fuel degradation

The measures of offsite support for gas turbine generator and 5th EDG is described in Section 5.1.2.4

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

The measures to increase robustness of gas turbine generator and 5th EDG is described in Section 5.1.2.4

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

If the offsite power, back-up power (EDG) and all other supporting power occur, the unit will be in the status of long term SBO event. Under this scenario, SFP cooling and emergency make-up water system will be unavailable due to loss of power. The pool water level and temperature instrument are still workable for 2 hours (non-safety related battery will provide DC power). The spent fuel in pool can be prevented from degradation by the following methods:

1. The newly procured 4.16kV 1500kW mobile diesel generator (Section 5.2.3.5 Item 2) can provide power to safety-related buses A/B-PB-S01. Power can be provided from A/B-PB-S01 buses to SFP cooling and emergency make-up water pumps. These pumps can be started by operator if needed.
2. Pool water vaporization will remove decay heat from spent fuel. By the measures of enhancing pool water make-up capability (Section 5.2.3.5 Item 3 to Item 8), SFP water level can be recovered timely.

5.2.3.1 Design provisions

1. The design provision for SFP loss of cooling is described as follows:

   Based on Maanshan SFP Re-racking Thermal Hydraulic Analysis Report, assuming 157 fuel assemblies offloaded 150 hours after reactor shutdown; previous offloaded 72 fuel assemblies have been cooled for 1 year, and SFP is fully occupied (totally 2160fuel assemblies), the pool water temperature increasing rate will be 5.94℃/hr in case of loss of SFP cooling. It will take 6.7 hours for pool water to boil. (Calculation is based on initial pool temperature 60 ℃. Normal pool temperature is 30℃.) The time that pool water level drops to10 feet above the top of spent fuel is about 40 hours.

2. Evaluation of SBO event:

   Based on FSAR Section 15.9, assuming no AC power is available in the 8 hours after SBO. Under this assumption, the station SBO scenario depends on the results of performing the measures defined in “EOP570.20 Loss of all Essential AC Power Operation Procedure”.

Based on the above conservative assumption, AC power is available in 8 hours after SBO , and SFP cooling and water make-up function can be recovered. The estimated time that pool water level drops to 10 feet above the top of spent fuel assembly is about 40 hours. Therefore, based on the design basis, there is enough time for operator to take response actions to prevent spent fuel from degradation if SBO event occurs.

5.2.3.2 Battery capacity and duration

SFP cooling and water make-up system is not designed with DC battery. However, SFP water level and temperature instrument power can be supplied from non-safety-related battery set for 2 hours. After 2 hours, control room will lose the capability to monitor pool water level and temperature.

5.2.3.3 Autonomy of the site before fuel degradation

1. In the scenario of loss of SFP cooling capability or loss of pool water, plant procedure 597.1 will be followed, and if pool water level or cooling capability cannot be recovered, pool water

temperature increasing rate and the time to boiling shall be evaluated. Supporting methods shall be used to make up water. The "feed and bleed" cooling mode can be established to prolong the time to boiling.

2. Plant procedure 570.20 will be followed to recover power supplied to safety-related bus, and monitor water level. If water level indication (EC-LI109) is less than 35%, notify TSC and try to make up water.

5.2.3.4 Foreseen actions to prevent fuel degradation

1. If the other unit is not damaged, the available supporting equipment, operating time, and manpower to mitigate event is described as follows:

   (1) Make-up water source:

   a. The CST of both units can be connected to provide making-up water to SFP:
   #1 CST←→ 1-AP-V698←→#2 CST

   b. The DST of both units can be connected to provide making-up water to SFP:
   #1 DST←→ 1-AN-V739←→ Backup DST←→ 2-AN-V739←→ #2 DST

   (2) Boric acid:

   a. RWST can be connected to other unit through SFP Purification System to provide ECCS or SFP water source:
   #1 RWST→ 1-BH-HV003→ 1-BH-HV004 (movable air compressor has to be installed to supply air to BH-HV003/HV004)→ 1-EC-V024→ 1-EC-P102/P112 (movable DG has to be installed to supply AC power to EC-P102/112)→ 1-HE-V056←→ 1-HE-V084←→ 2-HE-V084←→2-HE-V056→ (2-EC-V066→ #2 RWST) or (2-EC-V070→ #2 SFP)

   b. SFP can also be connected to other unit through SFP Purification System to provide some water to ECCS or SFP:
   #1SFP→ 1-EC-V019/V020→ 1-EC-P102/P112 (movable DG has to be installed to supply AC power to EC-P102/112) → 1-HE-V056←→ 1-HE-V084←→ 2-HE-V084←→ 2-HE-V056→ (2-EC-V066→ #2 RWST) or (2-EC-V070→ #2 SFP)

   c. If there is water in fuel transfer channel, it can be transferred to other unit through SFP Purification System to provide water source to ECCS or SFP:
   #1 fuel transfer channel → 1-EC-V026→ 1-EC-P102/P112 (movable DG has to be installed to supply AC power to EC-P102/112) → 1-HE-V056←→ 1-HE-V084←→ 2-HE-V084←→ 2-HE-V056→ (2-EC-V066→ #2 RWST) or (2-EC-V070→ #2 SFP).

   The support from the other unit has been confirmed by site survey on April 25, 2011.

   (3) The required time and manpower for above operations:

   a. CST connection: 15minutes and one man

b. DST connection: 15minutes and one man for each unit

c. RWST connection:

◆ Valve operation: 30minutes and one man for each unit

◆ Installation of removable DG: 1 hour and 4 men for each unit (divided into 2 groups)

Note: One group is responsible for the transportation and installation of mobile diesel generator. The other group is responsible for the transportation and installation of movable air compressor.

◆ Installation of removable air compressor: 1 hour and 2 men for each unit.

d. Spent fuel connection:

◆ Operation of connecting valves: 30minutes and one man for each unit.

◆ Installation of removable DG: 1 hour and 4 men for each unit (divided into 2 groups).

e. fuel transfer channel:

◆ Operation of connecting valves: 30minutes and one man for each unit.

◆ Installation of removable DG: 1 hour and 4 men for each unit (divided into 2 groups)

f. Fire engine to take water from Longluan lake: 1 hour and 3men.

(4) Availability of qualified operators to perform the above action:

a. For the manpower required in normal operation and emergency repair, including station staff, supporting personnel from offsite organization, and contractor staff, the station has completed a checklist. All those people have been trained with radiation protection and other related fields.

b. Every maintenance division has supporting manpower list, which is established based on mission assigned, professional specialty, etc. The man power list includes name, phone number, and address. People around Hengchun area can be the first priority of supporting manpower.

2. If both units are damaged and onsite water source is inadequate, water can be made up from fire engine to CST, RWST, and SFP. The station has one 7-ton fire water tank vehicle. The 4th battalion of Pingtung County Fire Bureau has four squads (Hengchun, Cherchen, Manchu, and Fangshan). They have two10-ton and two 12-ton water reservoir vehicles; one 3-ton and four 3.5tons water tank vehicles; and also have four 1ton small water tankers. Offsite water sources can be taken from No.2 and No. 3 deep wells, Longluan lake, and sea water. The supporting manpower from contractors is the total supporting manpower of contractors, who have signed contracts with individual divisions.

3. Taipower is a comprehensive electrical power company. It integrates electrical power generation, transmission and distribution, and sale of electricity. If the station has emergency and loss of the

offsite power, headquarters will take immediate action to recover 345kV or 161kV power system, and provide power to the station onsite safety-related systems.

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

1. The new plant procedure 1451 “Ultimate Response Guideline” has detailed description regarding the responses to beyond design basis accident. The emergency measures for SFP is also included. The procedure defined in this guideline is adequate to protect the spent fuel in the pool. Operators have been well trained for this procedure.

2. Taipower headquarters has procured 4.16kV /1500kW mobile diesel generators (delivered) to serve as the supporting equipment to provide power to safety-related bus. DCR-M0-4325 has been set up to connect the new mobile diesel generator with the existing equipment (The design is completed before December 31, 2011). This DCR will enhance SFP long term cooling and water make-up capability.

3. The station has procured 480V mobile diesel generator to provide back-up power to CST transfer pump and Seismic Category I fire pump. The capability of long term SFP water make-up from CST can be improved. In addition, DCR-M1-4245/M2-4246 has been proposed to improve the interface of existing distribution system and 480V mobile diesel generator (completed before January 31, 2012).

4. The station has procured 480V mobile diesel generator to provide back-up power to SFP purification pump. In addition, mobile air compressors has also been procured to support the supply of working air to AOV. The capability of long term SFP water make-up from RWST can be improved. In addition, DCR- M1-4245/M2-4246 has been proposed to improve the interface of existing distribution system and 480V mobile diesel generator (completed before January 31, 2012)

5. The station has procured mobile diesel engine driven pump. Together with piping modification, this can be used as back-up water supply pump for CST transfer pump and can enhance the capability to makeup water into SFP from CST. The DCR-M1-4304/M2-4305 has been proposed and design modification has been evaluated. (Scheduled completion date is December 31, 2012)

6. It is planned to use diesel engine fire pump to makeup water from fire water tank to SFP, through the fire station in fuel building.

7. It is planned to makeup water into SFP from fire engine or outdoor hydrant via fire hose. Besides, DCR-M1-4269/M2-4270 has been proposed to modify the layout of existing SFP piping system (completed). Through this modified piping system, water can directly makeup into SFP from fire engine or outdoor hydrant.

8. Considering that it is likely people cannot get in and out of fuel building after an event due to high radiation or other environmental factors, DCR-M1-4273/M2-4274 (completed) has been proposed to modify the normal fire water make-up piping. Fire water can directly make-up into SFP from fire engine or outdoor hydrant, through fire hose and external fire piping. People do not need to operate any valve, nor need to go inside fuel building. This modification can enhance the capability of making-up water into SFP.

9. After an event, the SFP structure may be damaged, and pool water level can not be established by any means, thus spent fuel may be degraded due to fuel uncover, a DCR has been proposed (DCR-M1-4372/M2-4373, To be completed before November 30, 2012) to use fire engine or outdoor hydrant to directly spray water into SFP , through fire hose and external fire piping, thus to reduce the spent fuel temperature and prevent spent fuel from degradation.

10. The station has already prepared small mobile generators. They can provide power to exhaust fans and radiation monitors to ensure the proper function of those rescuing equipment or instruments.

11. A review of the key parameters that have to be monitored during SBO has been completed. Those key parameters include spent fuel pool water level and temperature indications. By means of enhancing measures of emergency backup AC power for SBO, it can be ensured that instrument power supply is strengthened.

12. If there is shortage of onsite water source, water can be made up to CST, RWST, and SFP by fire engine. The station has procured one chemical foam fire engine with capacity of 7 tons (delivered); one water tanker fire engine with capacity of 12 tons (scheduled for delivery before June 30, 2012). Offsite water sources can be taken from No.2 and No. 3 deep wells, Longluan lake, and sea water.

13. A review of operation parameters that have to be monitored in main control room is completed. These parameters, including SFP water level and temperature, can be attained by supplying 24VDC working voltage to transmitter, and measuring loop current, and covering it to engineering units. 4. SFP water level and temperature monitoring capability enhancement (E-M1-100125/M2-100126, scheduled completion date is August 31, 2012). New water level and temperature instruments will be installed, and power will be supplied from UPS. If event occurs, key parameters of SFP can be monitored from control room for 8 hours..

15. Implement a crane locking device including parking areas planning and horizontal locking device for the Cask Crane and Fuel Handle Crane in fuel building when they are not in service. The parking areas are designated in such a way that there are no safety related components beneath. Crashing of cranes during earthquakes will not damage any safety related components. Locking device ensures that the cranes will not have a horizontal movement during earthquake, and will keep crane fixed at the safe parking areas.

5.2.4 Loss of ultimate heat sink (access to water from the sea)

5.2.4.1 Design provisional autonomy of the site before fuel degradation

If only ultimate heat sink is lost, but SFP cooling pump and makeup pump still have power to operate, heat generated in SFP cannot be transferred to NSCW. This situation is same as loss of spent fuel pool cooling system, except that normal water makeup is still available. In this scenario, plant procedure 597.1 will be followed to try to recover SFP cooling capability or mitigate loss of pool water. If pool water level or cooling capability cannot be recovered, pool water temperature will increase and temperature increasing rate of pool water, and the time to boiling shall be evaluated. Supporting methods shall be incorporated to make up water. Depending on the scenario, "feed and bleed" cooling mode can be established to prolong the time to boiling.

Other method to prevent spent fuel from degradation is to remove decay heat by pool water vaporization, and using the makeup function, make up pool water in time to keep the pool water level.

5.2.4.2 Foreseen actions to prevent fuel degradation

1. If other unit is not damaged, the available supporting equipment, operating time, and manpower from other unit to mitigate the event are described in Section 5.2.3.4 Item 1.
2. If both units are damaged and onsite water source is inadequate, water can be made up from fire engine to CST, RWST, SFP, and RCS. The station has one 7 tons fire water tank vehicle. The 4th battalion of Pingtung County Fire Bureau has four squads (Hengchun, Cherchen, Manchu, and Fangshan). They have two 10-ton and two 12-ton water reservoir vehicles; one 3-ton and four 3.5ton water tank vehicles; and also have four 1-ton small water tankers. Offsite water sources can be taken from No. 2 and No. 3 deep wells, Longluan lake, and sea water. The supporting manpower from contractors is the total supporting manpower of contractors , who have signed contracts with individual divisions.
3. Confirming timing of cliff-edge effects

   According to Maanshan SFP Re-racking Thermal Hydraulic Analysis Report, the maximum pool water temperature increasing rate will be 5.94℃/hr in case of loss of SFP cooling. It takes about 6.7hour for pool water to boil. The time that pool water level drops to 10 feet above the top of spent fuel is about 40 hours. (As described in Section 5.2.3.1.1)

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

The measures to increase robustness of prevention loss of ultimate heat sink are described in Section 5.1.4.3 Item 2~6.

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

In the scenario of SBO plus loss of ultimate heat sink, the responses are the same as described in Section 5.2.3.

5.2.5.1 Design provisional autonomy of the site before fuel degradation

The design for loss of SFP cooling and the evaluation of SBO are described in Section 5.2.3.1. The descriptions on design provisional autonomy of the site are provided in Section 5.2.3.3.

5.2.5.2 External actions foreseen to prevent fuel degradation

1. Under this condition, unit status is the same as provided in Section 5.2.3. Offsite supports to prevent fuel from degradation are the same as described in Section 5.2.3.4.
2. Confirming timing of cliff-edge effects

   According to Maanshan SFP Re-racking Thermal Hydraulic Analysis Report, the maximum pool water temperature increasing rate will be 5.94℃/hr in case of loss of SFP cooling. It takes 6.7 hour for pool water to boil. The time that pool water level drops to 10 feet above the top of spent fuel is about 40 hours. (As described in Section 5.2.3.1.1)

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

Under this condition, unit status is same as that described in Section 5.2.3 (SBO). Measures to increase robustness of the plant are described in Section 5.2.3.5.

6. Severe Accident Management

6.1 Organization of the licensee to manage the accident and the possible disturbances

6.1.1 Organization plan

6.1.1.1 Organization structure

6.1.1.1.1 Organization of the licensee to manage the accident

1. Current site status

   Station Emergency Control Team (ECT) is the core of the site emergency program. It consists of Emergent Technical Support Center, eight Emergency Working Teams, and one Emergency Public Information Center. They are responsible for all missions and emergency operations during emergency conditions. The emergency plan's mobilized human resource organization chart of the plant is shown in Figure 6-1

   During the severe accident, the TSC, Accident Management Team (AMT) under TSC, and Main Control Room (MCR) shall cooperate to decide the accident mitigation strategy, execute mitigation actions, monitor their efficiency, and adjust the action plans according to the field situations. The followings are the detailed responsibilities of TSC, AMT, and MCR:

   (1) Technical Support Center (TSC)
   TSC is the head of severe nuclear accident management, responsible for accident mitigation plan. During the accident, TSC receives and justifies the situation reports and mitigation suggestions provided by AMT, TSC also decides the strategy and notifies the corresponding teams to execute.

   (2) Accident Management Team (AMT)
   AMT belongs to TSC. It is responsible for understanding the situation and provides mitigation suggestions to TSC according to the Severe Accident Management Guideline (SAMG, MSNPP procedure 1450) for decisions making. After TSC choosing the mitigation plan, AMT guides the mitigation operation of Control Room, monitors the efficiency, and adjusts the operation depending on the situation. AMT includes AMT team leader, Operation Coordination Team, Safety Analysis Team, Reactor Evaluation Team, and Auxiliary Safety Analysis Team.

   (3) Main Control Room (MCR)
   MCR is responsible for supplying reactor situation information, operating systems/ equipment for mitigation, monitoring the negative effects and notifying long term concerns to AMT.

   Whenever the severe nuclear accident is occurred, TSC / AMT will be organized and all emergency reaction operations will be conducted according to Emergency Operation Procedure (EOP) and Severe Accident Management Guideline (SAMG) immediately to handle the accident through assessing every contingency measure of SAMG, and adopting corresponding strategy, in order to mitigate the consequence of the accident.

Before TSC and AMT are in-work, Main Control Room staffs execute necessary treatment directly based on the information from reactor situation monitoring to avoid serious reactor damage, in accordance with the provision of Severe Accident Control Room Guideline SACRG-1 of SAMG.

Whenever TSC and AMT are in operation, accident mitigation control will be transferred from MCR to TSC. Afterwards, MCR staff change their work guide from SACRG-1 to SACRG-2, i.e. switch from active role to passive role, execute the operation according to TSC's decision, avoid the possible negative effect (e.g., to avoid hydrogen burning while operating the CTMT spray) and long term concerns (e.g., the water of CST is sufficient or not), and report the execution status.

2. The improvements after Fukushima accident

   (1) Base on the long time mitigation demand in accident similar to the Fukushima accident, MSNPP reorganizes TSC and AMT into two shifts as shown in Table 6-1 and Table 6-2.

   (2) If the TSC members and the professional engineers of Mechanical Engineering, Electrical Engineering, Instrument & Control, and Repairing Sections cannot arrive the plant because of the traffic interruption or any other reasons, TSC should recall and organize the staff living in dormitory and in Hengchun district according to their professions, in order to execute the missions following the occurrence of accidents. Moreover, a list of the MSNPP supporting contractors' manpower and MSNPP employees had been set up. The list includes detail information about the professional specialties, profession licenses and contact information of these people. TSC can also recall and organize them to carry out the mitigation operation according to the missions required under the commands of OSC Chief.

6.1.1.1.2 Manipulation of the technical support outside the plant

1. Current site status

In MSNPP, the core of severe accident reaction organization is ECT. Nuclear Emergency Preparedness Executive Committee (NEPEC) in Taipower Company (TPC) is our direct outer supporting organization, and Central Disaster Response Center (CDRC) in Government will be the organization for coordinating mitigation supporting resources outside the plant. Emergency Response Organization chart is shown in Fig 6-2.

When severe accident happens, ECT will immediately evaluates the type of the accident and the level of influence, and then maneuver those various technical groups to carry out the corresponding processes. At the same time, ECT shall report to the NEPEC about the evolution of the accident according to the stipulation. NEPEC will support MSNPP according to its own operating procedures. If outside rescue material and resources are required by MSNPP, the external assistance requests will be sent to CDRC and its Forward Command Post (FCP) by NEPEC. The outsourcing resources and material will be dispatched and utilized under the commander of CDRC.

The supporting manpower coming into plant for rescuing shall be totally under the command and control of CDRC and its FCP no matter these supports are from Interior Ministry's Fire Department, Police Department, the Military Department or the other government departments or even institutions from foreign countries.

2. Enhancements after Fukushima accident

As for the employment of the police and the military, MSNPP has signed agreements with military and the police departments in nuclear accident rescue supporting. Regular communications between them are held to fully understand the contents and operations of the agreement.

6.1.1.1.3 Procedures, Training and drill

1. Current plant status

The procedures to respond to the nuclear accident in MSNPP are 500 series responding to abnormalities, which include: 582-seismic responding procedures, 582.1 Nuclear unit scrutiny after strong earthquakes, 584 Operation of units during typhoon, 595.6.2 Operation of high water level of draining pool in the plant", 582.2 Operation of unit during tsunami, 570.20 Station blackout, 586.6 Safe shutdown when the fire alarm. The processes in 500 series procedures are practiced annually for the operators and will be included in the initial stage of the nuclear safety drill.

The procedures for responding to more serious stages of the accidents in MSNPP are procedures 1400 ~ 1428, 1428.1, 1450. The SAMG in MSNPP is procedure 1450. The contents of this procedure are adopted from the SAMG in the standard version of PWROG, and modified according to MSNPP's specific settings and corresponding systems/equipment. The procedure includes Sever Accident Control Room Guidelines(SACRG-1 & SACRG-2), Severe Accidents Guidelines (SAG-1 ~ SAG-8), Severe Challenges Guidelines (SCG-1 ~ SCG-4), Severe accidents Evolution Guidelines (SAEG-1 & SAEG-2). These guidelines are exercised completely in the nuclear safety drill.

2. Improvements after Fukushima accident

For resisting the compound disaster over plant design such as that occurred at Fukushima, which cause the loss of both in-site and out-site AC power or disable the removal of the reactor's residual, MSNPP establishes the "Ultimate Response Guideline" (URG, Procedure 1451) to strengthen the depth of defense. It provides the procedures for integrating the resources inside/outside the plant, for mitigating and controlling the reactor at the first time, and for handling the loss of the cooling capabilities of reactor core and spent fuel pool, and maintaining the integrity of containment.

The URG is designed into 3 levels, the training frequencies of each level are planned as follows:

(1) Level 1 of URG (the arrangements and actions which must be finished in one hour after URG procedure starts up): It is included into the routine training courses of operators, twice a year.

(2) Level 2 of URG (the arrangements and actions which must be finished in 8 hours after URG procedure starts up): it is included into the OSC routine training courses, twice a year.

(3) Level 3 of URG (the arrangements and actions which must be finished in 36 hours after URG procedure starts up): it is included into the OSC routine training courses, twice a year.

The flow chart and the timing to report for the executing of URG are shown in Fig 6-3. The water makeup process to reactor and spent fuel pool is shown in Fig 6-4. URG is also incorporated into the emergency drill which is scheduled to carry out every 3 years.

The training scenarios of the nuclear safety drill are prepared by Atomic Energy Committee (AEC). If there are any scenarios about joint exercises with Fire Agency, National Police Agency, and Army under the command of CDRC, MSNPP will attend and cooperate in these training scenarios.

6.1.1.2 Possibility to use existing equipment

1. Current plant status

Whenever a "severe nuclear accident" occurs at MSNPP, EOPs and SAMG will be initiated and followed to handle the accident. TSC and AMT are established to evaluate the situation and judge the action steps according to SAMG in order to mitigate the consequences of the accident.

For the scenario of spent fuel pools amoralities, procedure 597.1 "Treatment and recovery of spent fuel pool from loss of cooling capability and loss of pool water" is followed to assure the spent fuels are submerged in water and stayed cool to avoid the worse consequences from fuels exposed to air.

The corresponding procedures for mitigating the severe accidents at MSNPP have already been scrutinized. They can be divided into two categories: one is for the important in-service equipment/systems (fixed, operated in normal or emergent situations); the other is for the equipment supporting emergent situations (usually for handling the emergent situations, fixed or mobile). The scrutiny results categorized with system/equipment are as follows:

(1) Important in-service equipment/systems (fixed, operated in normal or emergent situations)

a. RCS/Containment water injection

- Residual Heat Removal system (RHR)

- High Pressure Injection System
- Medium Pressure Injection System
- Condenser Storage and Transfer System

b. Steam generator make-up and steam discharge

- Main Steam Isolation Systems
- Auxiliary Feed water system
- Feed water Isolation system

c. Containment Cooling system

- Containment Hydrogen analyzer
- Containment Fan Cooler
- Post Accident Hydrogen Purge System
- Hydrogen Recombiner System
- Containment Low Volume Purge System

d. Emergency power

- Emergency Diesel Generator A
- Emergency Diesel Generator B
- The 5^{th} Diesel Generator
- Gas Turbine Generator

e. Residual heat removal (ultimate heat sink)

- Nuclear Service Water System

f. Spent fuel pool cooling systems

- Spent Fuel Pool Cooling System
- Spent Fuel Pool Make-up Water System

All these equipment/systems are periodically tested, maintained according to the procedures under the quality assurance program at MSNPP. And the tests and maintenance are scheduled and recorded in MMCS. All those equipment/ systems are confirmed to remain available. The detailed scrutinization results of important in-service equipment/systems can be found in the attachment 9-1-1 of "Maanshan Safety Defense Inspection Report"

(2) Equipment supporting emergent situations (usually for handling the emergent situations, fixed or movable)

a. The hardware of AMT working environment (including personal computers)
b. Accidents situation reflection parameters showing facilities (including ERF and panel)
c. Spare boric acids
d. Systems/components for supplying raw water into reactor core at urgent condition (including raw water reservoirs, corresponding piping and caps)
e. Quantities and locations list of cross connections and tie line between units on which disconnect, cross-connect, and welding are required for supporting across unit during accident, and described in EOP procedure.

f. TSC diesel generator

g. Fire protection facilities (including water sources, CO_2 storage, mobile electric generators, fire water pumps, water pump, fire engines etc.)

The above equipment is tested/inspected/monitored by walkdown to confirm their availabilities and functionalities according to their active or passive characteristics. They are rechecked during the period of stress test and are confirmed in available conditions. The details results are described in the attachment 9-1-1of "Maanshan Safety Defense Inspection Report".

However, if a compound disaster of earthquakes/tsunami/flood occurs, and causes a long time loss of AC/DC power and ultimate heat sink. The above systems/equipment cannot sustain their intended function for mitigating accidental consequences.

2. The improvements after Fukushima accident

To amend the deficiencies mentioned above, the following improvements are conducted in MSNPP:

(1) To increase the capability of resisting the accidents by creating URG (Procedure 1451) and establishing the back-up rescue facilities by stages according to the urgent level, the URG is divided into 3 stages. Each stage has corresponding rescue strategy to respond to plant's situation. The details are shown in Table 6-4.

(2) To improve tsunami resistance of Service Water Pump Room,

a. Grilled cover are added above the NSCW intake pool to prevent large debris falling into the pool along with the tsunami. (Completed on June 30, 2011)

b. The water proofed door and water retaining wall for isolation protection are added to protect the motor sections of NSCW Pump Room in a way of separation by units and by loops. This could prevent the loss of all NSCW pumps at a time when tsunami attacks. After this improvement, the designed tsunami protection height is increased from 9.12m to 12.9m. (Completed on August 31, 2011)

(3) To strengthen the flood prevention capability of the plant:

a. Either water retaining plates are installed (over 1 m height) or the doors are changed to waterproofed ones at the openings of the important buildings (Scheduled to be completed by November 30, 2012)

b. The discharge capability of flood water from building internals is increased by additional portable pump purchase, 30 diesel engine driven pumps have been prepared to increase the mobile discharge capabilities in additional to the original 20 sump pumps.

(4) To establish the monitoring and controlling capability during total loss of DC power

a. MSNPP has procedures to measure the important parameters during emergency DC power loss. In the control room, the operators use instrument calibrator to measure voltages/current signals from the instrument rack, and convert them to readable engineering units. These important parameters have to be provided to AMT in order to make the correct rescue decisions.

b. MSNPP has already established the procedures (URG appendix 10 “Manual operation of Turbine Driven Auxiliary Feed Water Pump when Loss of DC Control Power”) to manually start and operate the TDAFWP and PORV without the DC power. Manual startup of TDAFWP at site had already been demonstrated through actual drill by operators that are feasible. (Training course: M3173 及 M3173-1, Manual operation of Turbine Driven Auxiliary Feed Water Pump when Loss of DC Control Power)

(5) To strengthen steam generator alternate makeup capabilities

a. Two makeup strategies are established. One is to set up diesel engine driven auxiliary feedwater pumps for supplying water to SG. The other is to connect fire hose to fire engines or fire hydrants. These two strategies are considered to be items with high priority in the operators’ training course, and these trainings are scheduled twice a year.

b. One fire water reservoir vehicle is purchased (scheduled to be delivered on June 30, 2012) to strengthen the capability of mobile replenishing SG.

6.1.1.3 Provisions to use mobile devices (availability of such devices, time to bring them onsite and put them in operation)

1. Current status of the plant

The existing mobile equipment in MSNPP for original designed accident rescue consists only TSC mobile emergency diesel generators and fire engines. Mobile equipment is not used in other rescue operations.

2. Improvements after Fukushima accident

After the accidents happened in the Fukushima, MSNPP creates URG, constructs mobile power gas/water sources for rescue operations. The execution steps of every strategy, locations to reach the equipment, the manpower and required time for alignment are all detailed in URG procedure. By using URG, the working teams can be in-position in specified time schedule and execute the rescue operations.

With regard to the mobile facilities, the station URG had already set up ten kinds of response strategies and its corresponding mobile equipment as follows:

● Strategy MS.1-03 Steam generator water injection using raw water (fire protection water)	Fire-fighting truck
● Strategy MS.1-06 Reactor water injection using raw water (fire protection water)	Fire-fighting truck
● Strategy MS.2-02 Sump pumps drainage operation	Motor driven water pump, gasoline engine driven water pump, diesel engine driven

	water pump etc transported with truck.
● Strategy MS.2-03 Connect the mobile 480V diesel generator	480V mobile diesel generators
● Strategy MS.2-04 Using mobile air compressors to operate AOV in the makeup path from RWST to SFP	Mobile air compressor / Nitrogen Gas bottle
● Strategy MS.2-05 Injection/spray water to spent fuel pool (must be accomplished in 2 hours)	Mobile diesel generators, Mobile diesel engine water pump, Fire water reservoir truck
● Strategy MS.2-06 Supply water into CST from mobile water source	Fire water reservoir truck
● Strategy MS.2-07 Supply water into RWST from mobile water source	Fire water reservoir truck
● Strategy MS.2-08 Connect 4.16kV power vehicles	4.16kV power truck
● Strategy MS.3-01 Remove garbage at the entrance of Essential Service Water	Crane, Truck, large scale hanging basket and sling

All sorts of the equipment storage locations, set-up methodologies, manpower required, tools and schedules are detail planed, therefore they can be dispatched efficiently during accidents and accomplish the rescue operation.

6.1.1.4 Provisions and management of supplies (fuel for diesel generators, water, etc.)

In MSNPP, there is not much difference of the logistical supply management for severe accidents before and after the Fukushima accident.

MSNPP procedure 1411 “the backup service and equipment support procedure” defines in details about the operation processes of logistical supply management during the severe accident. The items are as following:

1. Coordinate the second emergency responding team to support the first team.
2. Dispatch vehicles, materials supply, prepare/ purchase urgent materials, and arrange board and lodging for the rescuers.
3. Finance and accounting support.
4. Prepare the required equipment for now and the future.
5. Collect and understand the situation information outside the plant (e.g., wind direction, transportation paths into/out of plant) for arrangement of the supporting materials and manpower.
6. Apply logistical support to NEPEC.

6.1.1.5 Radiation release management and radiation confining preparation

1. Current status of the plant

The current radiation release management and the radiation confining preparation follow the procedure 1414 “radiation detection”. Radiation are detected at plant buildings, monitor zones and plant boundaries, therefore TSC can decide the best strategy of radioactive material release and arrange for rescue staff a more complete radiation protection actions.

SAMG(procedure 1450), Severe Challenge Guideline SCG-1 “Reducing the release of fission products”, SCG-2 “Reducing the containment pressure”, SCG-3 “Hydrogen burning control”, SCG-4 “Containment vacuum control”, SAG-5 “Reduction of fission products release”, SAG-6 “Control of temperature and pressure of the containment”, SAG-7 “Reducing hydrogen fraction of the containment”, aims at reducing the release of the fission products. However these rescue measures must have power sources or gas sources to carry out their missions.

2. The improvements after Fukushima accident

(1) Increase the containment's venting capability

The serious hydrogen explosions in Fukushima plants are because of the accumulation of large quantity of hydrogen in buildings, therefore we must build up the capability of the containment venting during the loss of all AC and DC power to avoid too much accumulation of hydrogen.

MSNPP's URG establishes two strategies: ”480V mobile diesel generators connection”, “mobile air compressor nitrogen to supply the containment venting valve”. There are detailed planning for storage locations of all sorts of equipment, set-up method, manpower required, tools and schedules, therefore they can be dispatched efficiently during accidents and carried out the containment venting strategy according to the preset schedule.

(2) Increase the storage volume for radioactive liquids after accidents.

There were large amount of radioactive liquid release during Fukushima accident, therefore MSNPP plans thoroughly in procedure 930.2 about the storage facilities of radioactive liquids and disposal schedule, details as Table 6-5.

(3) Enhance the radioactive protection equipment for repair work

For the storage quantities of those radiation shields and protection clothes available in the accident, MSNPP reorganizes and arranges them in Table 6-6. These quantities and other quantities come from other plants in Taiwan should be enough to fulfill the requirement of rescue operation.

6.1.1.6 Communication and information systems (internal and external)

1. Current status of the plant

MSNPP's current communication equipment include PA broadcasting system, microwave radio telephone systems, plant's internal landline telephone systems, DECT(same as PHS)telephone systems, CHT(Chunghwa Telecom) external telephone system, direct communication intercom and satellite telephone.

(1) Satellite telephone system(battery standby time 48hr, main station located besides TSC leader's seat; one handset kept at the main control room of unit #1, 2, power supplied by TSC's main station) Regular function test is carried out every month. It can be used outdoors if necessary.

(2) PA system's power comes from NH-E26-C2(QF-UPS01), NH-E25-C2(QF-UPS02), NH-E05-B2(QF-UPS03), NH-E12-B2(QF-UPS04), when plant blackout occurs, UPS can supply power to PA to support PA's operation.

(3) MSNPP's exchange center between telephone systems and DECT telephone systems and the exchange center of MSNPP's special long-distance microwave communication systems are located at the first floor of the administrative building. If the whole plant blackouts, the battery can sustain 20 hours.

(4) CHT external telephones don't need additional power, the communication will be available if the circuits are in good conditions.

(5) Direct communications (hot lines) telephones work as TSC talks directly to every support center OSC, radiation HPC, Simulation center control room and unit 1& 2main control room can communicate mutually. Microwave exchange center provides this function. If the whole plant blackouts, the battery can sustain 20 hours.

(6) The information systems, internet and video communications utilize MSNPP's established fiber-optic networks, microwave systems and CHT ADSL. This systems includes battery can sustain 10 hour's continuous operation; The power that CHTADSL needs comes from TSC, the communication will be available if the circuits are in good conditions.

2. Improvements after Fukushima accident

(1) Main frame of the satellite telephones: If the whole plant blackouts, if the battery is used up, the 480VAV mobile diesel generator can provide the power needed for satellite telephones.

(2) PA system: Considering the prolonged situation that battery is used up, the 480VAC mobile diesel generator can combine with the UPS of loud telephones to ensure the continuous availability of the PA system.

(3) DECT telephone system: Considering the prolonged loss of power that battery is used up, MSNPP's 480VAC mobile diesel generator can connect to N1E-NH-F001A, make sure the communication is available.

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

6.1.2.1 Extensive destruction of infrastructure around the installation including the communication facilities

When the facilities peripheral of the plant(including the outside traffic routes) are widely damaged, the plant must rely on the staff and manpower, materials in the neighborhood to proceed the short term urgent rescue and manage to communicate with CDRC and NEPEC about the plant's situation, and request for long term rescue support.

1. Current status of the plant
   (1) Manpower arrangement:
      a. Urgent plan's manpower maneuver:
         (a) In the normal office hours, Shift Operation Manager on duty informs the supervisor to proceed the maneuver according to the procedure 1400「Emergency Preparedness and Response Plan」 and other corresponding procedures to cope with the emergencies.
         The manpower of each maintenance department are inside the plant, also the long term contractors stationed inside the plant can provide the maintenance manpower for about 100, therefore should be enough to meet the maintenance requirement of the emergencies.
         If the operators of the next shift can not arrive at the plant to take over his/her post, the training staff of the simulation center, and the staff of the mobile supporting team (Most of them have reactor operation license) can take over and assist the operation of the units.
         (b) During the holidays or at nights, Shift Operation Manager on duty will inform immediately the Manager on duty for the day-shift and night-shift to support according to the procedure 1400 “Emergency Preparedness and Response Plan ” and the corresponding procedures to proceed the manpower maneuver to cope with the emergency.
         (c) The manpower groups of the maneuver of emergency plan are described in Table 6-1.

      b. Manpower of firefighting:
      The numbers of firefighting manpower belongs to the contractors are 29. Except the leader, 3 firefighting inspectors, 1 multifunction water accumulation pools inspectors, the others are divided into 4 groups with 6 persons in each group. These 4 groups will rotate in 3 shifts in 24 hours, no exception of any holidays. The least number of persons on duty is 6 (including group leader, fire engine driver and firemen), and they carry out their assignments according to the duty table. Moreover, the fire-fighting contractors are all residents of Hengchun district, and they will be informed to enter the plant to assist the

rescue if emergency occurs.

if additional needs require, 58 firemen can be assembled according to the urgent plan 1408 “OSC procedure of maneuvering and responding” , 1420 “procedure of firefighting” when (TSC)establishes.

MSNPP currently carries out one unnoticed communication or maneuver test every 3 months and cooperates with urgent plan to do firefighting exercise or training annually.

(2) Materials arrangement

a. The current firefighting equipment and heavy rescue machines of MSNPP are described in details as in table 2.1.3.2. MSNPP is also equipped with 2 tow trucks, 7 hoist trucks, 10 stackers. They will be utilized in rescuing the plant's peripheral areas during the accident to maintain the normal traffic and make sure a smooth rescue operation.

b. MSNPP is equipped with one firefighting commander vehicle, firefighting equipment vehicle, one firefighting water tank vehicle, one firefighting chemical vehicle, to make sure carrying out the rescue work in time during the accident.

(3) Review of communication capability:

MSNPP's communication system include: plant's cable telephone, microwave communication system, DECT (same as PHS) wireless telephone, PA broadcasting system, Sound Power telephone etc. Except the Sound Power telephone which doesn't need power, the others will require UPS to supply power.

After blackout, the plant's cable telephone, microwave communication system and DECT wireless telephone can sustain 20 hours, PA broadcasting system can sustain 4 hours.

If none of the plant's cable telephone, microwave telephone, DECT wireless telephone, PA loud telephone are available, there are still satellite telephone can reach outside and Walkie Talkie and Sound Power telephone can provide inside communication.

Because of the completeness of the above mentioned communication equipment, MSNPP can reach CDRC immediately, report in details about the damage the rescue situation and request for support about manpower and materials immediately.

2. Improvements after Fukushima accident

(1) Review of Manpower Arrangement:

After reviewing the capability of handling the situation independently if the external rescue resources cannot reach the plant, MSNPP makes the following enhancements:

a. Adds 2 firemen for every firefighting squad starting April of 2012.

b. Prepares a name list of 103 experts of all specialties resided in the Hengchun district, they will be first informed to enter the plant during the accident in assisting the units' operation; contractors with various specialties are all listed correspondingly and permission a acquired to enter the plant to assist the maintenance.

c. Depending on the traffic situations, the reserve maintenance staff (mechanical engineering, electrical engineering, instrument, repairing) reside at Fengshan, Wujia dormitories will be transported by all means into the plant to do the maintenance jobs. Moreover many suppliers of the plant have a lot of technical experts also live in Kaohsiung, Pingtung district. Their maintenance contracts include the urgent repair items, therefore they can be included for supporting if emergencies occur.

(2) Review of materials arrangement:

a. MSNPP purchased one fire-fighting foam vehicle on December 31, 2011, purchase order also placed for water tank vehicle, scheduled for delivery on June 30, 2012.

b. Based on the experience of Fukushima accident, MSNPP review the current resources and list the equipment need to be purchased in 2.1.3.4.7 “establishment planning table for spare parts for equipment, equipment, tools of Maanshan” .

(3) Review the capability of the communication:

a. Main frame of the satellite telephones: If the whole plant blackouts and if the battery is used up, the 480VAV mobile diesel generator can provide the power needed for satellite telephones.

b. PA system: Considering the prolonged situation that battery is used up, the 480VAC mobile diesel generator can combine with the UPS of loud telephones to ensure the continuous availability of the PA system.

c. DECT telephone system: Considering the prolonged loss of power that battery is used up, MSNPP's 480VAC mobile diesel generator can connect to N1E-NH-F001A, make sure the communication is available.

6.1.2.2 Impairment of work performance due to high local dose rates, radioactive contamination and destruction of some facilities on site

6.1.2.2.1 Responding measures to the radioactive protection of rescue operation

1. Current status of the plant

(1) Before the rescue operation, the health physics team will carry out the detection of the radiation, contamination and concentration of the radioactive nuclides in air.

(2) Plan the protection measures according to the radioactive situation on site:

a. Evaluate the possibility of setting up the radiation shielding, to reduce the radiation level at site, therefore reduce the exposure doses of the repair workers.

b. Provide the necessary radiation protective equipment, e.g., protective clothing, respirators, lead clothes etc. Instruct the repair workers how to wear the radiation protective equipment.

c. Evaluate the longest working hour of the workers, control the working time if necessary.

(3) Provide EPD to each repairer personnel, and request him/her to leave the site when alarm occurs to avoid dose rate exceeding acceptable level.

(4) The portable area radiation monitor (ARM) can be set up on site to provide the repairers the instant information, therefore they can evacuate immediately if the radioactive situation deteriorates to protect their safety.

(5) After the repairers evacuated from the working area, they should go the specified location for external exposure detection to make sure no contamination.

2. Improvements after Fukushima accident

For the available radioactive shielding and protection clothes, MSNPP reevaluated the capacities and list them in table 6-4, theses capacities and the supports from other plants in Taiwan should be enough to meet the requirements of the rescue mission.

6.1.2.2.2 Responding measures for the radioactive protection of the control room

(1) Current status of the plant

A. Carry out regularly the detection about the radiation, contamination and the concentration of radioactive nuclides in air of the control room.

B. Plan the protection measures of the control room according to the radioactive situation:

a. Evaluate the possibility of installment of the radioactive shielding to reduce the radioactive exposure rate and reduce the doses received by the staff on duty.

b. Provide the necessary radioactive protective equipment, like radioactive protective clothes, breathing protective masks, lead clothes etc. Instruct the repairer how to use the radiation protective equipment.

c. Evaluate the longest working hour of the shift workers, control the working time if necessary.

(2) Improvements after the Fukushima's accident

A. For the habitability of the control room, MSNPP has purchased 480Vmobile diesel generators to sustain the power supply for the equipment to provide habitability of the control room.

6.1.2.3 Feasibility and effectiveness of accident management measures under the conditions of external hazards (earthquakes, floods)

1. Current status of the plant

The magnitude of the Fukushima accident is beyond the design base, moreover the normal rescue equipment fails to function and no any other mobile rescue equipment is available, therefore the consequences are severe. After review MSNPP has one more air-cooling emergency diesel generator and two more gas turbine generators than Fukushima plant therefore it's less possibly the Fukushima's total loss of AC power will occur in Maanshan. However the mobility and timing effectiveness for contemporary equipment and the rescue facilities could be unable to cope with the complicate situations of compound disasters.

2. Improvements after the Fukushima accident

Since some of the equipment and the rescue facilities were lack of mobility and timing effectiveness, MSNPP has established the URGs, planned and arranged all types of reserve rescue measures. Once a severe accident happens, “Ultimate Response” can be adopted in the shortest time to arrange all the available water resources, to fill water into the steam generator and spent fuel pools in time, and make sure the residual heat removal and integrity of the fuels are maintained, and avoid the release of radioactive materials so that large scale of people evacuation are prevented.

(1) Timing effectiveness
Different from the strategy of EOP/SAMG which evaluate step by step by considering the symptoms of the situation, the strategy of URG is to adopt a decisive action in the shortest time to avoid the deterioration of the situation and regain control of the plant's situation and reach the goal of protecting the safety of the people.

(2) Feasibility
MASNPS has adopted various and multiple rescue protection systems/equipment to respond to all types of standard accidents of design base. When accidents happen beyond the design base, besides aggressively recovering the rescue systems/equipment, plant personnel will also accomplish the above goals by utilizing the mobile facilities(including power, and water resources)which are easily arranged and stored in places unlikely to be damaged by compound disasters.

(3) Effectiveness
The URG established from the various evaluations of the MSNPP has the concept of deep defense in the corresponding strategies and plans; it also sets up various and multiple strategies (like various water resources, power etc)to make sure the effeteness of the rescue operation responding to the compound disasters.

6.1.2.4 Unavailability of the power supply

1. Original status of the plant

In the situation of SBO, the original design of the MSNPP can sustain operation by the power of

125VDC battery to support the turbine driving the auxiliary feedwater pumps for 8 hours. The AC power of the units must be recovered in 8 hours, otherwise the units will lose the function of residual heat removal and the plant will fall into crisis.

2. Improvements after Fukushima accident

The URG of MSNPP can assure to build a backup power within 8 hours and plan further to maintain the turbine driving the auxiliary feedwater pumps to replenish water to the steam generator in order to remove the decay heat of the reactor core.

(1) The power recovering strategy of URG

a. Strategy MS.1-02"The 5th diesel generator supply AC power to two units": Arrange the 5th diesel generator to supply 2 units when the external power and A/B diesel generators are not available.

b. Strategy MS.2-01 "Using mobile power supply to prolong the DC power supply time": including charging the DC power with the mobile diesel generators, using the 5th diesel generators to supply 2 units (MS.1-02), aligning the 3rd power source, connecting 4.16kV mobile power (MS.2-08).

c. Strategy MS.2-03 "Connect the mobile 480V diesel generator": When all external powers are unavailable and all urgent diesel generators are unavailable, use the 480V mobile diesel generator to charge the DC power and provide backup power to EC-P102/P112, AP-P100/P101, KC-P006/ P007 to be the reserve power.

d. Strategy MS.2-08 "Connect 4.16kV power vehicles": When all the external power lost and all urgent diesel generators and gas turbine generators are unavailable, the 4.16kV power vehicle charge 4.16kV BUS to supply power for the rescue equipment needed.

e. Attachment 14 of URG "Mobile diesel generator's guidelines" includes:

(a) Supply power to water pressure testing pump BH-P020, to establish RCS and replace water injection of the axis seal

(b) Supply power to auxiliary buildings and provide power for the important MOV, hydrogen analyzing equipment and PA loud telephones.

(c) Supply power to fuel buildings and provide power for EC-P102, 122 to makeup water to spent fuel pool

(d) Supply power to control building for providing safety-related batteries charging, control room emergency ventilation and illumination.

(e) Supply power to administrative building and provide power for cable telephones, microwave telephones and PHS wireless telephones

(f) Supply power to TSC

(2) URG builds up the operation capability of turbine driving the auxiliary feedwater pump under the situation of loss DC power condition.

According to the attachment 10 of URG “The operation guidelines of turbine driving the auxiliary feedwater pumps under the situation of loss of control power” , the operation of can be continuously controlled under no DC power condition.

6.1.2.5 The probability of failure for instrumentation control system

1. Current status of the plant

The important instrument and control system and power system are under regular tests according to the operation specifications (Most test periods are 3 months), and regularly maintained according to the preventive maintenance plan. These instrumentation systems and power have been verified for their availability and operability.

However if the compound disasters like Fukushima happen, resulting in the DC power loss of the instruments, the instrument and control system will fail, therefore increase the difficulties and complexities of the rescue missions. For example under the loss of all DC power, if MSNPP decides to manually control turbine driving auxiliary feedwater pumps to makeup water into steam generator, the operators must know the pressure of the steam generators, water level and flow volume of the feedwater and the pressure, temperature and water level of the reactor, otherwise the effeteness of the heat removal will be unknown.

2. Improvements after Fukushima accident

MSNPP based on the situation of total loss of DC power under the accident like Fukushima, the operators will lose the capability of monitoring the important parameters, therefore two improvements are planned:

(1) In URG, two procedures “Monitor the core exit thermal couples under the loss of all DC power condition”, “Monitor the important parameters of the primary and the secondary sides under the loss of all DC power condition” are established.

Utilize instruments' calibrator to provide working voltage of the transporter, to measure the current of the instruments' circuits, and then transform to engineering values. These important parameters include the pressure and water level of the steam generator, flow volume of the auxiliary feedwater, the pressure and water level of RCS, the thermal couple's measurement at the exit of the reactor core, the pressure and water level of the containment, the water levels of the condensed water tank, the levels of Refueling Water Storage Tank (RWST), the temperature and water levels of the spent fuel pool. The measurement locations and instrument calibrators are all arranged in the procedures of URG.

(2) In URG, set up the procedure of establishing the reserve power of the DC recharger.

MSNPP has purchased 480V mobile diesel generator, and set up the procedure of establishing the reserve power of the DC recharger to maintain the continuous power supply for the instruments in the URG strategy MS.2-03 “Connect the mobile 480V diesel generator”.

6.1.2.6 Potential effects from the other neighboring unit(s) at site

1. Current status of the plant

MSNPP has two units, but the original emergency plan did not consider the simultaneous accidents of two units. The manpower TSC and AMT, the repairers that can be maneuvered in the accident, the SAMG status table of the AMT meeting room, the combination of the situations of two units (e.g. two units both in operation, or one in operation and the other in refueling outage) and the capability of the firefighting capability, the current plans are not enough.

2. Improvements after Fukushima accident

MSNPP reviews the situation of simultaneous accidents of two units and propose the responding methods as follow:

(1) Equipment improvements method

a. MSNPP devises the URG based on two units, therefore the quantities of the mobile equipment are enough to cope with the simultaneous accidents.

b. To respond to the simultaneous accidents, MSNPP has improved the SAMG status tables in the AMT meeting room to simultaneously monitor and record the status of two units and write down the adopted mitigation strategies for each unit respectively.

(2) Manpower strengthening method

a. MSNPP has reviewed and arranged two groups of rotating manpower of TSC/AMT in order to deal with the prolonged accident condition, see table 6-1 and 6-2.

b. MSNPP establishes the name list of repair workers with the mechanical, electrical, instrumental skills. These workers are dispatched by TSC according to their specialties to carry out the responding mission of the simultaneous accidents.

(3) Procedure improvement methods

a. Establish attachment 4 of URG “From one power source simultaneously supply power to essential AC buses” which is the strategy of simultaneously supplying power to both units from any one diesel generator (total 5).

b. Since there is not corresponding method responding to the units under refueling outage in SAMG, MSNPP establishes URG strategy MS.2-05 “Injection/spray water to spent fuel pool” to compensate the insufficiency of the SAMG..

6.1.2.7 Strengths on Mitigation Accidents of NPPs in Our Country

1. Current status of the plant

Before Fukushima accident, the nuclear power stations in our country have five superiors more than Fukushima Plant No. 1:

(1) The Emergency Sea Water Pump House for Fukushima Plant No. 1 is outdoor, that for our nuclear

power stations is protected in building.

(2) Unit 1~4 Emergency Diesel Generators for Fukushima Plant No. 1 are allocated in the Turbine Building Basement Floor, those for our nuclear power stations are all allocated in the seismic category I building Ground Floor that their flooding preventive capabilities are relatively high.

(3) Fukushima Plant No. 1 had not equipped with the Fifth air-cooled Diesel Generators, our nuclear power stations had equipped with the Fifth Air-cooled Diesel Generators at ground floor which can provide backup power in case that EDG lost its cooling.

(4) Fukushima Plant No. 1 had not equipped with air-cooled Gas Turbine Generators, our nuclear power stations had equipped with air-cooled Gas Turbine Generators at EL. 22~35 m which can provide backup power in case that EDG lost its cooling.

(5) Fukushima Plant No. 1 had not equipped with Raw Water Pool, our nuclear power stations had equipped with Raw Water Pool of 3.7~10.7 metric tons capacity at EL. 62~116 m which can makeup water to reactor via gravity.

2. Improvements after Fukushima accident

After Fukushima accident, the nuclear power stations in our country had already completed their URG procedures to add the power sources including power truck and mobile diesel generators as well as water sources including review of the available creek water, deep water well, and deep pool water etc.

Regarding these strengths, we plan to proceed following enhancements under the request of ROCAEC: building an anti-tsunami wall at least 6 meters above the design tsunami height, separation and watertightness improvements of essential sea water pumps, watertightness improvements of the diesel generators and swing diesel generator rooms, seismic enhancement for two gas turbines and two 50000-ton raw water reservoirs. After these enhancements, we can assure that our nuclear units will have more capability to safely shutdown during the beyond-design-basis accident.

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

6.2.1.1 Preventive actions to prevent fuel damage and to eliminate high pressure fuel damage

1. The rescue measure to avoid fuel damage

(1) MSNPP has emergency operating procedures (EOP) to cope with design-basis accident to

prevent core damage. Under the loss of core cooling condition, MSNPP will immediately follow EOP(570.00～570.57)to proceed the accident mitigation. Major actions are feeding water to steam generator with pumps (electric/turbine/diesel driven pumps or fire water system/fire engines) and open the power operated relief valve (PORV) of the steam generator to remove the decay heat of the reactor.

(2) Under the condition of loss of SG heat removal, the bleed and feed of the primary system can be used to remove the decay heat of the reactor, however this method will increase the containment pressure, and some pressure reduction measures must be applied. If the above operation of EOP can remove the decay heat of reactor, the fuels damage can be avoided.

Most of the equipment in the EOPs except the diesel-driven auxiliary feedwater pump needs power and cooling water to precede the rescue, if a beyond-design-basis accident occurs, and the units lose all the on-site and off-site AC power and plant ultimate heat sink, both units of MSNPP will lose the decay heat removal capability.

2. Exclude the possibility the fuel damage under the high pressure of reactor core

When MSNPP follows EOP 570.20 under SBO and follows EOP 570.43 and 570.42 under inadequate core cooling condition, both require the reduction of RCS pressure to avoid fuel damage under high vessel pressure condition. Furthermore according to SAMG (procedure 1450), the RCS pressure must be lowered to under 28.12 kg/cm^2 before the reactor failure to avoid high pressure melt ejection and result in direct containment heating.

According to the EOP or SAMG, in order to reduce the RCS pressure, the operator will open steam generator PORV, or open pressurizer PORV. However, both operations require power to proceed. Therefore it will be very difficult to perform this operation under loss of all AC power condition.

6.2.1.2 Risks of cliff edge effects and deadlines

If a beyond-design-basis accident occurs at MSNPP, and result in the loss of all AC power and plant ultimate heat sink, the TDAFWP and SG PORVs will at the first beginning operate to remove the core decay heat. TDAFWP in design can continuously operate with DC power for 8 hours.

Using MAAP5 program to simulate the sequence of events of SBO of MSNPP, assuming that TDAFWP continuously operate 8 hours at the beginning, we obtain the following results: water in steam generators will be dries out at 15.21 hour; the reactor core will be uncovered at 16.97 hours; the temperature of nuclear fuels will exceed over 2200°F at 18.71 hours.

If the scenario is to assume that TDAFWP continuously operate 24 hours under SBO, we obtain the following results: the water in steam generators will be dries out at 41.78 hour; the reactor core will be uncovered at 44.66 hours; the temperature of nuclear fuels will exceed over 2200℉ at 47.14 hours.

During the refueling outage, the RCS mid-loop-operation is the high risk period. During this period, the water level is below the top of the vessel hot legs and the amount of water in the system is only about 180,000 pounds. In the scenario of loss of long-term decay heat removal, the water in reactor will begin to boil pretty soon. On average, the water in reactor will begin to boil in 18 minutes and reactor core will be uncovered in 1.5 hours.

For Power operation and refueling outage, the time of core uncover under the loss of long-term heat removal is 16.97 hours and 1.5 hours respectively.

6.2.1.3 Adequacy of the existing management measures and possible additional provisions

The cliff-edge effect for this accident period is defined as the time that reactor core is uncovered. After review original procedures and equipment at site, it is confirmed that original mitigation procedure and equipment cannot prevent reactor core from being uncovered.

For this weakness, MSNPP sets up URG which includes all kinds of substitute routes of water injection, power and water sources. Once the conditions of Ultimate Response are met, MSNPP will maneuver all available manpower and materials, and arrange all available water sources in the shortest time. If after evaluation the safety-designed water injection and cooling cannot be accomplished, all available water will be filled into steam generator and steam generator PORV will be opened to make sure the decay heat is removed and fuel damage is avoided.

There are several strategies to maintain the capabilities of removing the decay heat in URG:

(1) Strategy MS.1-01 " Manually operate the diesel-driven auxiliary: In this strategy, it is able to align the backup diesel-driven auxiliary feedwater pump to pump water into SGs within one hour of accident.

(2) Strategy MS.1-03 "Steam generator water injection using raw water (fire protection water)": makeup raw water (fire protection water) into SGs, align water sources from 50000-ton/2000-ton raw water reservoirs and 5000-ton fire protection water storage tank and pump water into SGs.

(3) Strategy MS.2-03 "Connect the mobile 480V diesel generator": In this strategy it is able to build up long term DC power to maintain long term operation of TDAFWP.

(4) The replenishing water sources of the steam generator (URG attachment 9): Raw water, Fire hydrant water, Longluan Lake, sea water is listed as long term cooling water sources.

(5) The pressure release of the steam generator (URG attachment 8): if there is no power, and no air for instruments, S/G PORV can be manually opened.

(6) The pressure release of RCS (URG attachment 8):In order to avoid the failure of RCS at high

pressure, the pressure can be released by PZR PORV or the venting valve on the reactor top, the DC power needs to be charged by the mobile diesel generator((URG attachment 14). During the execution of the urgent reactor pressure release, the simultaneous containment venting has to be considered to avoid over pressure of the containment.

Because the strategy of the first stage of Ultimate Response can be arranged in one hour, the water filling in the steam generator can be done in 16.97 hours to avoid the happening of the Cliff-edge effect of the fuel damage.

For the RCS mid-loop operation period during the refueling outage, procedures have been updated to require two accumulators available. In the event that loss of residual heat removal, operator can inject the water from these two accumulators into reactor in one hour and reactor core uncover time can be extended from 1.5 hours to 4.1 hours. Using the guideline in URG, we can establish alternative water injection paths, alternative power and water source, the damage of reactor fuels can be avoided.

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

The target of the plant's EOP is to avoid the fuel damage, however if the damage still happens, the AMT of TSC can follow SAMG to evaluate the plant condition and suggest mitigation strategies.

After the damage of the reactor fuels, MSNPP adopts the same SAMG format of PWROG. After recovery of the mitigation equipment, MSNPP can adopt mitigation strategies such as water injection into steam generators (SAG-1), RCS depressurization (SAG-2), water injection into RCS (SAG-3), water injection into containment (SAG-4) etc. to maintain the removal of the decay heat of the reactor core and assure the integrity of the reactor vessel such that the plant's situation is stably controllable.

6.2.2.2 Risks of cliff edge effects and deadlines

Using MAAP5 to simulate the SBO of MSNPP and assuming TDAFWP continuously operates for 8 hour, we obtain the following results: the temperature of nuclear fuels will exceed over 2200°F after 18.71 hours; the RPV will fail after 22 hours.

The other simulation scenario is that TDAFWP continuously operate for 24 hours, we obtained the following results: the temperature of nuclear fuels will exceed over 2200°F after 47.14 hours; the RPV will fail after 55.72 hours.

Therefore, the occurring time of the cliff-edge effect of the reactor vessel failure should be specified as 22 hours.

6.2.2.3 Adequacy of the existing management measures and possible additional provisions

As the occurring time of the Cliff-edge effect of the reactor vessel fails is specified as 22 hours, after review there are risks that current mitigation procedures and equipment are not able to meet the requirement of 22 hours to be ready to mitigate under the complicated compound accidents.

Corresponding to this weakness, MSNPP establishes URGs to release the containment pressure and injects water into the reactor cavity to maintain the cooling of the vessel bottom head, and reduce the temperature and pressure of RCS as low as possible before vessel failure. These measures are effective to prolong the period of reactor vessel failure.

(1) Injection water into containment (URG attachment 8): Inject water into the reactor cavity to make sure the peripheral of the reactor bottom head are flooded before the time of vessels failure. This can tremendously postpone the time of vessel failure.
   a. RWST→Gravity→BH-HV102, 101, HV201, 202→recycling accumulation water pool
   b. Fir hydrant water system → Fire valve KC-XV111→3 branches KC-XV113, XV114, XV115→pump into containment
   c. Fire engine → Fire hose→BN-V633 upstream pipe BN-005-4″ -HCD fast connector→BN-V633→BK-V031, V032, HV107, HV207→Containment spray pipe

   The above-mentioned water will first fill the sumps/pits below containment bottom floor (100-feet floor), including two normal sumps and two recirculation sumps, and then flood above the bottom floor. There is a 20-cm-diameter reactor cavity vent hole about 25-cm height above 100-feet floor. If the containment water level is raised to more than 40 cm above the bottom floor, we can make sure that the peripheral of vessel bottom head is surrounded by the water inside cavity.

(2) Release pressure of the containment (URG attachment 8): GT-HV401A (mobile power) → GT-HV402 (manually operable) → GT-F017→atmosphere
(3) Strategy MS.1-03 "Steam generator water injection using raw water (fire protection water)": In this strategy, we can align water sources from 50000-ton/2000-ton raw water reservoirs and 5000-ton fire protection water storage tank and pump water into SGs via turbine-driven AFWP or diesel-driven AFWP. Or we can inject water via outdoors fire hydrant or fire engines. In this strategy, the PORV of the steam generator has to be manually opened to reduce the pressure in order for the diesel-driven AFWP or the fire protection water

to inject water into SGs.

(4) Pressure release of the steam generator (URG attachment 8): if there is no power, no instrument air, S/G PORV can be manually opened.

(5) The pressure release of RCS (URG attachment 8):In order to avoid the failure of RCS at high pressure, the pressure can be released by PZR PORV or the venting valve on the reactor top, the required DC power comes from the mobile diesel generator (URG attachment 14). During the execution of the urgent reactor pressure release, the simultaneous containment venting has to be considered to avoid over pressure of the containment.

These strategies are designed to be performed in 22 hours to avoid the happening of reactor vessel cliff-edge effect.

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 risk (inside and outside the containment)

In the severe accident guideline SAG-7 of MSNPP “Reduce the hydrogen density of the containment”, there are three strategies “Premeditated hydrogen burning using available ignition source in the containment”, “Steam-inertia to avoid the hydrogen burning” , “Utilizing the hydrogen recombiner” can be adopted to avoid the large scale of hydrogen burning or explosion.

At high hydrogen density (>6%), the severe challenge guideline SCG-3 “Control hydrogen burning” has to be adopted to release hydrogen through low volume venting system, post-accident hydrogen purge system to avoid the large scale of hydrogen burning or explosion.

If a beyond-design-basis accident occurs and both internal and external AC and DC powers lose, the hydrogen control strategies of SAMG will not function.

6.2.3.2 Prevention of containment overpressure

In the severe accidental guideline SAG-6 “Pressure release of the containment” containment's fan cooler and containment spray system can be utilized to reduce the pressure of the containment to prevent the failure of the containment from over pressure.

If the pressure of the containment reaches 110psig, the severe challenge guideline SCG-2 “Pressure release of the containment” must be adopted to reduce the containment's pressure through containment's fan cooler, containment's spray system, low volume venting system, hydrogen release system after accidents to prevent the containment failure from over pressure.

The station SAMG SAG-6 is to use Containment Fan Cooler and Containment Spray to depressurize the containment pressure to prevent containment from overpressure. The station SAMG SCG-2 is to use Containment Fan Cooler, Containment Spray, Low Volume purge system, and Post Accident Hydrogen Purge System to depressurize the containment pressure to prevent containment from overpressure. The relevant equipment mentioned as above shall have the required AC and DC powers for operation.

If accidents over the design specifications happen and both internal and external AC and DC powers lose, the containment overpressure prevention strategies in SAMGs will not function.

6.2.3.3 Prevention of re-criticality

Using the severe accident guideline SAG-3 “Water injection into RCS”, or the RCS makeup strategies of URGs, the NIS startup rate must be monitored. If the starting rate is larger than 0, the boron density of the water source must be adjusted or water filling must be stopped to increase void fraction to impede the reaction rate.

6.2.3.4 Prevention of base mat melt through: retention of the corium in the pressure vessel

The purpose of the SAG-4 “Injection water into containment” and SAG-8 “Flooding the containment”, are both to assure the vessel bottom head is covered with water before vessel failure. If some molten slag flows to the bottom, they will be cooled and the melting through of the containment bottom can be avoided. Its relevant equipment shall have the required AC and DC powers for operation.

If a beyond-design-basis accident occurs and plant lose both the internal and external AC and DC powers, the containment melting-trough prevention strategies of SAMG will not function.

6.2.3.5 Need and supply of electrical AC and DC power and compressed air to equipment used for protecting containment integrity

All the above mentioned strategies like management of hydrogen risks, prevention of containment over pressure, prevention of criticality, and prevention of the melting-through of the containment need AC and DC powers.

If a beyond-design-basis accident occurs and plant lose both the internal and external AC and DC powers, all the strategies of SAMG will not function.

6.2.3.6 Risks of cliff edge effects and deadlines

The medium value (Am) of containment overpressure failure is 182 psig, the simulation uncertainty (βM) is 0.20, the structure strength uncertainty (βS) is 0.15, and the total uncertainty (βC) is 0.25. Using above data, the calculated containment over pressure HCLPF is 101.7 psig. We use this pressure as the containment failure pressure.

Using MAAP 5 to simulate the scenario of SBO, assuming that TDAFWP continuously operate for 8 hours after the event, we obtained the following results: the accumulated hydrogen in containment will start to burn locally at 19.5 hours; RPV will be failed at 22 hours; containment will be failed due to overpressure at 60.2 hours.

Assuming that TDAFWP continuously operates for 24hours after SBO event, we obtained the following results: RPV will be failed at 55.72 hours; the accumulated hydrogen in containment will start to burn locally at 57.4 hours; containment will be failed due to overpressure at 101.9 hours.

Since the release of radioactive materials happens after the failure of containment, the time that cliff-edge happens can be defined as the failure time of containment, i.e., 60.2 hours.

6.2.3.7 Adequacy of the existing management measures and possible additional provisions

If accident beyond the design base occurs at MSNPP, resulting in the loss of all AC power, all the above mentioned strategies like management of hydrogen risks, prevention of containment over pressure, prevention of criticality, prevent the melting-through of the containment will not function. Therefore, MSNPP establishes the URG strategies as follow:

(1) The station URG MS.2-03 “Connect the mobile 480V diesel generator” and MS.2-08 “Connect 4.16kV power vehicles” shall be followed to establish AC and DC powers, and then URG appendix 8 “Steam Generator, Reactor, and Containment Heat Removal and Pressure Relief Paths under Beyond-Design-Basis-Accident” shall be followed to build up the pressure relief path or to carry out containment flooding by means of fire-fighting truck via Containment Spray piping so as to reach the same depressurization effect. After completion of URG strategy MS.3-01 ” Remove garbage at the entrance of Essential Service Water” and MS.3-02 “Replace NSCW Motor”, the Containment Fan Cooler and Containment Spray System will return to be operable and the containment overpressure will not occur.

(2) The station URG MS.2-03 “Connect the mobile 480V diesel generator” and MS.2-08 “Connect 4.16kV power vehicles” shall be followed to establish AC and DC powers, and then the station URG appendix 8 “Steam Generator, Reactor, and Containment Heat Removal and Pressure Relief Paths under Beyond-Design-Basis-Accident” provides three water makeup strategies, including RWST water makeup via gravity, Fire Water System water makeup via Fire Water System valve KC-XV111, fire-fighting truck water makeup via Containment Spray piping, and we can assure that the reactor cavity is fully filled with water before vessel failure and containment basemat melted through can be effectively prevented.

(3) The station URG MS.2-03 “Connect the mobile 480V diesel generator” and MS.2-08 “Connect 4.16kV power vehicles” shall be followed to establish AC and DC powers, and then the URG appendix 8 “Steam Generator, Reactor, and Containment Heat Removal and Pressure Relief Paths under Beyond-Design-Basis-Accident” shall be followed to reduce the containment temperature and pressure, and avoid the containment early failure.

After completion of URG strategy MS.3-01 " Remove garbage at the entrance of Essential Service Water" and MS.3-02 "Replace NSCW Motor", the Containment Fan Cooler and Containment Spray System will return to be operable, and maintain the containment long-term integrity.

These strategies can be executed in 60.2 hours to prevent Cliff-edge effect of the containment's failure from happening.

6.2.4 Accident management measures currently in place to mitigate the consequences of loss of containment integrity

6.2.4.1 Design, operation and organization provisions

The MSNPP original designs for reducing the release of the radioactive materials include:

(1) The equipment for reducing the release of the containment: containment fan coolers, containment spray, containment low volume purge system, post-accident hydrogen purge system.

(2) The equipment to mitigate the S/G release: Steam dumps to the condenser.

(3) The equipment to mitigate the release from the auxiliary buildings: Containment isolation valves.

(4) Equipment to reduce containment pressure: containment fan cooler, containment spray, containment low volume purge system, post-accident hydrogen purge system.

(5) The equipment of controlling the hydrogen burning:

   a. utilize the steam inertia strategy (PORV of the PZR, venting valves on the reactor vessel head)

   b. The equipment to control the hydrogen burning by ignition on purpose (e.g., supply power to the cooling fan of the control rod drive mechanism to ignite the hydrogen on the top level of the containment)

   c. Venting of the containment (containment low volume purge system, the post-accident hydrogen purge system)

(6) The equipment for vacuum controlling of the containment: open PORV of pressurizer, open venting valves on the reactor vessel head.

(7) The equipment for washing out the released fission products:

- For fission products in the steam generator: AFWPs, main feedwater pump, start-up feedwater pump, condensate pump, diesel-driven AFWP, fire protection water system, fire engines.
- For fission products in the RCS: high pressure and low pressure safety injection system.
- For fission products in the containment: containment gravity makeup flow path,

containment spray pump.

(8) The equipment for submerging the corium in the cavity:

- For corium in the reactor vessel: high pressure and low pressure safety injection system.
- For corium in the containment: containment gravity makeup flow path, containment spray pump.

After loss of the containment's integrity, MSNPP will follow SAMG, operate the above equipment, and reduce the release quantity of the fission products as much as possible. The corresponding guidelines include “injecting water in SG” (SAG-1), “injection water into RCS” (SAG-3), “injection water into containment” (SAG-4), “reduction of the fission products release” (SAG-5), “reduction of the containment pressure” (SAG-6), “reduction of the containment hydrogen fraction” (SAG-7), “flooding the containment” (SAG-8). Furthermore to avoid the large scale of containment failure and large quantity of fission products release, SAMG also contains some severe challenge guidelines like “mitigation of the fission products release” (SCG-1), “reduction of the containment pressure” (SCG-2), “controlling the hydrogen burning” (SCG-3), “controlling the containment's vacuum” (SCG-4).

However, if the compound accidents happen resulting in the loss of the AC and DC power, none of these measures are operable.

6.2.4.2 Risks of cliff edge effects and deadlines

As mentioned above, MSNPP conservatively use the containment design pressure 60 psig as the containment failure pressure.

Using MAAP 5 to simulate the scenario of SBO, assuming that TDAFWP continuously operate for 8 hours after the event, we obtained the following results: the accumulated hydrogen in containment will start to burn locally at 19.5 hours; RPV will be failed at 22 hours; containment will be failed due to overpressure at 60.2 hours.

Assuming that TDAFWP continuously operates for 24hours after SBO event, we obtained the following results: RPV will be failed at 55.72 hours; the accumulated hydrogen in containment will start to burn locally at 57.4 hours; containment will be failed due to overpressure at 101.9 hours.

Since the release of radioactive materials happens after the failure of containment, the time that cliff-edge happens can be defined as the failure time of containment, i.e., 60.2 hours.

6.2.4.3 Adequacy of the existing management measures and possible additional provisions

Based on the fact that the compound disasters may result in the loss of AC and DC power, and the above mentioned rescue measures cannot be performed, MSNPP established URG strategies as follow:

(1) The station URG MS.2-03 “Connect the mobile 480V diesel generator” and MS.2-08 “Connect 4.16kV power vehicles” shall be followed to establish AC and DC powers, and then URG appendix 8 “Steam Generator, Reactor, and Containment Heat Removal and Pressure Relief Paths under Beyond-Design-Basis-Accident” shall be followed to build up the pressure relief path or to carry out containment flooding by means of fire-fighting truck via Containment Spray piping so as to reach the same depressurization effect. After completion of URG strategy MS.3-01 ” Remove garbage at the entrance of Essential Service Water” and MS.3-02 “Replace NSCW Motor”, the Containment Fan Cooler and Containment Spray System will return to be operable and the containment overpressure will not occur.

(2) The station URG MS.2-03 “Connect the mobile 480V diesel generator” and MS.2-08 “Connect 4.16kV power vehicles” shall be followed to establish AC and DC powers, and then the station URG appendix 8 “Steam Generator, Reactor, and Containment Heat Removal and Pressure Relief Paths under Beyond-Design-Basis-Accident” provides three water makeup strategies, including RWST water makeup via gravity, Fire Water System water makeup via Fire Water System valve KC-XV111, fire-fighting truck water makeup via Containment Spray piping, and we can assure that the reactor cavity is fully filled with water before vessel failure and containment basemat melted through can be effectively prevented.

(3) The station URG MS.2-03 “Connect the mobile 480V diesel generator” and MS.2-08 “Connect 4.16kV power vehicles” shall be followed to establish AC and DC powers, and then the URG appendix 8 “Steam Generator, Reactor, and Containment Heat Removal and Pressure Relief Paths under Beyond-Design-Basis-Accident” shall be followed to reduce the containment temperature and pressure, and avoid the containment early failure.

After completion of URG strategy MS.3-01 ” Remove garbage at the entrance of Essential Service Water” and MS.3-02 “Replace NSCW Motor”, the Containment Fan Cooler and Containment Spray System will return to be operable, and maintain the containment long-term integrity.

These strategies can be executed in 60.2 hours to prevent the Cliff-edge effect of the radioactive material release from happening.

6.3 Spent fuel pool

6.3.1 Measures for managing the consequences of a loss of cooling function for the spent fuel pool

By design, MSNPP utilizes Spent Fuel Pool Cooling and Cleanup System (SFCCS) to maintain the water temperature under 35℃. SFPCCS is equipped with 2 groups of cooling pumps with 100%

(13000gpm) flow volume, heat exchanger (48.3×10^6 Btu/hr) and corresponding pipes and is designed as the first grade of seismic-proof. The power of the cooling pumps is supplied from the essential AC buses respectively, can also be supplied by emergency diesel generator and gas turbine generator if loss of external power. Component Cooling Water (CCW) provides SFCCS with cooling water and its heat is transferred to the final heat sink which is Nuclear Service Cooling Water System (NSCW).

6.3.1.1 Before and after losing adequate shielding against radiation

Once the forced cooling capability is lost, the high residual heat will increase the water temperature and lower the water height level of the spent fuel pool; the radioactive doses of pool's peripherals will increase. When the level lower to 10 feet's above the fuels' Top of Active Fuel(TAF), the γ ray from the fuels will produce the "Compton scattering" effect with the air and the concrete in the ambient of the pool, result in the radioactive doses in the pools surroundings to 2~20 mSv/hr, which is the top limit of normal people can endure. Refer to the FSAR of MSNPP, the appropriate radioactive shield of the spent fuel pool is defined as 10 feet height above TAF.

(1) Before the loss of the appropriate radioactive shields

MSNPP responds to the cooling capability loss of the spent fuel pool with the procedure 597.1 "The procedure of recovering the spent fuel pool cooling capability", and decides the appropriate strategy of evacuating the staff according to the strength of measured radiation.

According to the procedure 597.1, it is required to follow the procedure 366.1 "The water replenishing, draining and filtering of the spent fuel pool" to seeks for the water sources and routes to replenish water to spent fuel pool to the normal level (EC-LI109＞34.88%, ＞142'10"). The available replenishing routes are:

a. Replenish water from Demineralized Water Storage Tank (DST). The storage capacity is 100 thousand gallons, water replenishing flow rate is 215gpm. If there are requirements of replenishing the boric acid water, the water will be replenished by the Refueling Water Storage Tank (RWST). The boron density of the boric acid water of RWST is 2400~2500ppm, the storage capacity is 460 thousand gallons, water replenishing flow rate is 100gpm.

b. Replenish water by Condensed Water Storage Tank (CST). It is a tank designed to be the first grade of seismic-proof, storage capacity is 750 thousand gallons). There are two independent CST transporting pumps designed to be the first grade of seismic-proof (each 210gpm).

If the water level or the cooling capability of the spent fuel cannot be recovered for a long time, the water temperature increasing rate and the time required to reach boiling have to be evaluated, set up the replenishing way of feed and bleed depending on the situations to prolong the time for water needed to reach boiling.

Both the water sources and routes for replenishing water to the spent fuel pool mentioned in the procedure 597.1 need power to operate, if compound disasters like Fukushima happen and all AC power and service water heat sink are lost, the plant will lose its rescue capability of cooling the spent fuel pool.

(2) After the loss of appropriate radioactive shields

After the loss of appropriate radioactive shields, the staff may not be able to approach the spent fuel pool or enter the fuel buildings, therefore all the responding actions need to be operated on site cannot be done, however the current procedure 597.1 did not describe how to rescue under these circumstances.

6.3.1.2 Before and after the water level of the spent fuel pool drop to the top of fuel element

This situation is more serious than that of 6.3.1.1, the staff cannot approach the spent fuel pool or enter the fuel buildings, therefore all the responding actions needed to be operated on site cannot be done, however the current procedure 597.1 did not describe how to rescue under these circumstances.

6.3.1.3 Before and after severe damage of the fuel in the spent fuel pool

When the fuels are seriously damaged and fuels are melting, Fuel pellets conglomerate on the pool bottom and melt into a ball. If the fuel pellets' uranium density is less than 5%, without moderator (water), they are not possible to reach the critical mass and sub-criticality are maintained. In addition, the fuel racks contain boron plywood which can absorb neutrons, and there are more margins of maintaining the sub critical status. The experts of US Nuclear Energy Institute NEI point out: If the spent fuel pool dries up, there is no concern of reach the critical conditions again, however large quantity of gamma ray will be released. The report of Safety and Security of Commercial Spent Nuclear Fuel Storage from the U.S. National Academy of Sciences Research Council also conclude the same, therefore under the loss of cooling water, it is very unlikely to reach the critical status of the spent fuel pool.

Since the chemical reaction of zirconium-water reaction producing large quantity of heat and hydrogen, and the fuel temperature will be raised up aggravatingly and the risk of hydrogen explosion cannot be ignored (the explosion is likely to happen as the hydrogen density reach to＞4%).

This situation (6.3.1.3) is more serious than the above mentioned fuel uncover conditions, the staff is not able to approach the spent fuel pool or enter the fuel buildings, therefore none of the responding actions needed to be operated on site cannot be done, however the current procedure 597.1 did not describe how to rescue under these circumstances.

6.3.1.4 Risks of cliff edge effects and deadlines

INER has analyzed the loss of spent fuel pool cooling condition with Computational Fluid Dynamics (CFD) technology. The assumption is all the fuels are moved to the spent fuel pool after 7 days of shutdown, at the same time spent fuel pool loses cooling, the conclusion is the water will boil after 11.23 hours, the water level lower to 10 feet above TAF after 56 hours, reach the top of the fuels bundle after 84.4 hours, and will be heated to 600°C after 8.5 hours of uncover; if continuously not replenished with water, the fuels will reach 1200°C after 18.6 hours of uncover.

After fuel uncover, the decay heat of the uncovered parts can only be removed by the convection of steam and radiation heat transfer, therefore the temperature of the exposed fuels will rise rapidly. If the water level is lower than the top of fuel, the fuels will begin slow zirconium-water reaction after reaching above 400℃. If reaching above 800℃, zirconium cladding will be softened and possibly break and fail, and result in the release of radioactive materials. If reaching above 980℃, zirconium-water reaction will proceed intensively, and large quantity of reaction heat can result in the fire accident of zirconium cladding, and rapidly raise the fuel temperature to 1200℃. At this moment, the zirconium-water reaction will result in the rapid rise of the temperature and therefore serious fuel damage and the release of large quantity of radioactive materials.

According to the analysis of INER, if the pool is immediate sprayed after reaching to 600°C after exposure, it can be guaranteed the fuel damage will not occur after exposure. Nevertheless MSNPP still use the fuel uncover time as the Cliff-edge time of cooling capability loss of the spent fuel pool, i.e., 84.4 hours.

6.3.1.5 Effectiveness of the existing management measures

The MSNPP EOPs and SAMGs can handle the design-basis accidents to guarantee the safety of the units. However, if a beyond-design-basis accident occurs and plant loses all the AC power and service water heat sink, the original plant procedures will not work.

Therefore MSNPP establishes URG(procedure1451), and provide the responding procedure of mitigating the loss of SFP cooling accident. URGs can arrange the available water sources in the shortest time. If the design-basis water replenishing and cooling functions cannot be recovered in a short period, the available water sources will be filled into the fuels pool to assure the fuels are covered by water and avoid the release of large quantity of radioactive materials.

Every rescue stage planned by URG according to the water levels of spent fuel pool is explained as follows:

(1) Before losing appropriate radioactive shield
    Under this circumstance, since there is still available appropriate radioactive shield, the staff can approach fuel pool, evaluate the real situations. The adoptable measures can be referred from 5.2.3.3, 5.2.3.4 and5.2.3.5.

(2) After losing appropriate radioactive shield
    After losing the appropriate radioactive shield, the staff can approach the spent fuel pool or enter the fuel buildings therefore all the responding measures need to be operated on site cannot be done, the alternate water replenishing measures must be adopted:
    a. Refer to item 8 of 5.2.3.5, utilize the fire engine or outdoors fire hydrant via fire

hose connecting to the standby hard replenishing pipe outside the plant to precede the water replenishing of the fuels pool.

b. Refer to item 9 of 5.2.3.5, utilize the fire engine or outdoors fire hydrant via fire hose connecting to the standby hard replenishing pipe outside the plant to spray the fuels pool and also replenish water to spent fuel pool.

(3) Before water lowered to the top of the fuel bundles

Adopt the same measure as “Before losing the appropriate radioactive shield”.

(4) After water lowered to the top of the fuel bundles

Under this circumstance the radiation does rates are too high, the staff will not be able to approach the fuel pool, the management measures are the same as “After losing the appropriate radioactive shield”.

a. When the fuels start to expose and the item 8 of 5.2.3.5 strategy is adopted, utilize the fire engine or outdoors fire hydrant via fire hose connecting to the standby hard replenishing pipe outside the plant to proceed the water replenishing of the fuels pool, the water replenishing volume is 500gpm. After 6.72 hours of water replenishing, the water level can be recovered to the original height.

b. If the water replenishing strategy can be carried out, or the structure of the spent fuel pool is damaged, resulting in the water level cannot be built up, the item 9 of 5.2.3.5 strategy is adopted, utilize the fire engine or outdoors fire hydrant via fire hose connecting to the standby hard replenishing pipe outside the plant to spray the spent fuel pool, the water spraying volume is 200gpm. After 19.92 hours of water spraying, the water level can be recovered to the original height.

c. If the spray strategy cannot build up the water level, according to the INER's analysis, the water should be sprayed immediately when temperature reaches 600°C after fuel uncover. Even if the temperature lowing capability is limited by the homogeneous spray on the pool, the fuel temperature can be controlled and fuel damage is not occurred after fuel uncover.

(5) Before the serious damage of spent fuel pool

Adopt the same measure as “After water lowered to the top of the fuel bundles” and continuously replenish and spray on the spent fuel pool.

(6) After the serious damage of spent fuel pool

All means must be done to recover the spent fuel pool water makeup capability to reduce the fuels temperature and prevent the release of the radioactive materials. At the same time, the hydrogen fraction of the fuel building must be monitored, and the hydrogen control strategy must be adopted to avoid the over accumulation of hydrogen. Corresponding to this, MSNPP has provided the improvement project of adding the monitor system for hydrogen density in the spent fuel pool of fuel building (M1-4286/M2-4287, scheduled to be design complete before Mar 31 of year 2012).

According to URGs, MSNPP will complete the arrangement of the strategy “MS.2-05 Injection/spray water to spent fuel pool” in two hours. Compared with the fuel uncover time 84.4 hours mentioned above, MSNPP has sufficient capability to avoid the situation of cliff-edge effect.

6.4 Implemented safety improvement and further work enhancing robustness

6.4.1 Adequacy and availability of the instrumentation control

1. Current status of the plant

If compound disasters similar to Fukushima accident happened, major instruments will lose their monitoring functions because of interruptions of power supply. The DC power of MSNPP instruments has the capability to cope with SBO for 8 hours, however if the compound disasters like Fukushima accident resulting in the long term loss of AC power and service water heat sink, the plant will plunge into crisis.

2. The improvements after Fukushima accident

There are strategies in the MSNPP URGs to recover or sustain the DC power: URG attachment 4 “Supply 2 buses simultaneously with the same power source”; attachment 14 “Power supply guidelines for mobile diesel generator”. MSNPP is fully confident to recover the instrument power in 8 hours.

Moreover, MSNPP has established following strategies: URG attachment 6 “Monitor the core exit thermal couple under the loss of all DC power”; URG attachment 7 “Monitor the important parameters on the primary and secondary sides under the loss of all DC power”. The operation staff can provide the working voltages with the calibrators under loss of DC power condition to measure the important operating parameters (including parameters of RCS, SG, SFP, and important water tanks), and can support to fully control the unit situations.

6.4.2 The habitability of control room, TSC and the accessibility to the site control and sampling point

1. Current status of the plant

TSC is designed to maintain its availability and habitability during the accident. It has independent power source, radioactive protection, and life necessities.

The main control room of each unit of the MSNPP is equipped with 2 groups of urgent venting system, to maintain the capability of positive pressure and inhale filtering and meet the amenity requirement of NRC NUREG-0696 Functional Criteria for Emergency

Response Facilities. Therefore if there is radiation release (including the fuel buildings) in any accidental situations, the habitability of the main control room can be maintained.

For the site control and sampling point, the safety related facilities and all sorts of equipment are designed not impacted by site radiation condition. If the repair worker must enter to site for urgent repair the safety related facilities and equipment, or take URG strategies to use mobile equipment, the required radioactive protection measures are described in this report section 6.1.2.2

If the compound disasters like Fukushima accident happen resulting in the long term loss of AC power and service water heat sink, the site control and sampling point can still be accessed via current procedures, but the long-term habitability of the main control room and TSC cannot be maintained.

2. The improvements after Fukushima accident

If the accident over the design specifications happen, the units are expected to lose all the AC power inside and outside of the plant, the plant will follow URG attachment 14 ”Power supply guideline of mobile diesel generator” to recover the operation of the control room emergency ventilation system and the TSC ventilation system. At the same time, the AC power recovery via mobile diesel generators can guarantee the long term illumination and instrument monitoring capability of the control room and TSC.

After review, we conclude that the TSC was not designed for the multi-units and natural disasters scenarios. Therefore, we are now planning to build an anti-seismic building to accommodate possible multi-units and natural disasters scenarios. The modification will be completed before 2015.

6.4.3 Hydrogen gas possibly accumulated in the buildings other than containment building

1. Current status of the plant

When the accident over the design base resulting in the insufficient cooling of the reactor core, hydrogen will be produced by zirconium-water reaction and released to the containment via the RCS cracks or other release routes. If compound disasters like Fukushima happen resulting in the long term loss of AC power and hydrogen re-combiner and post-accident hydrogen purge system fail to function, the hydrogen will accumulate gradually inside the containment and possibly cause conflagration and damage the containment.

The only building in the containment of MSNPP that may accumulate hydrogen is the fuel building. The method to prevent the hydrogen accumulation in the fuel building is establishing the venting routes.

2. The improvements after Fukushima accident

MSNPP has provided the improvement project of adding the monitor system for hydrogen density in the spent fuel pool of fuel building (M1-4286/M2-4287, scheduled to be design complete before Mar 31 of year 2012) to build up the capability of monitor the hydrogen of the fuel buildings.

References:

1. TPC MSNPP Safety protection Physic Examination
2. MSNPP Procedure 1451 [Ultimate Response Guideline]

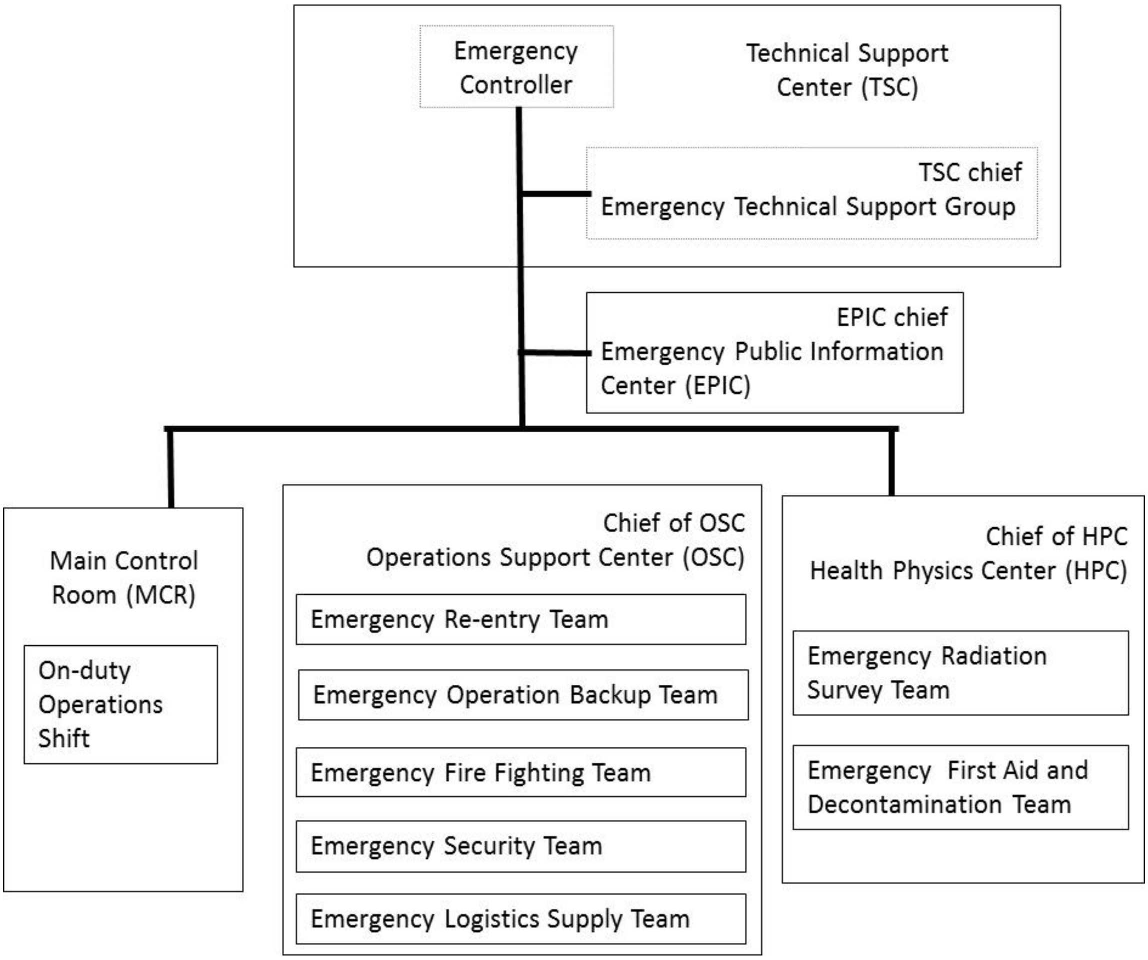


Figure 6-1 Onsite Emergency Organization

Emergency Control Team (ECT)

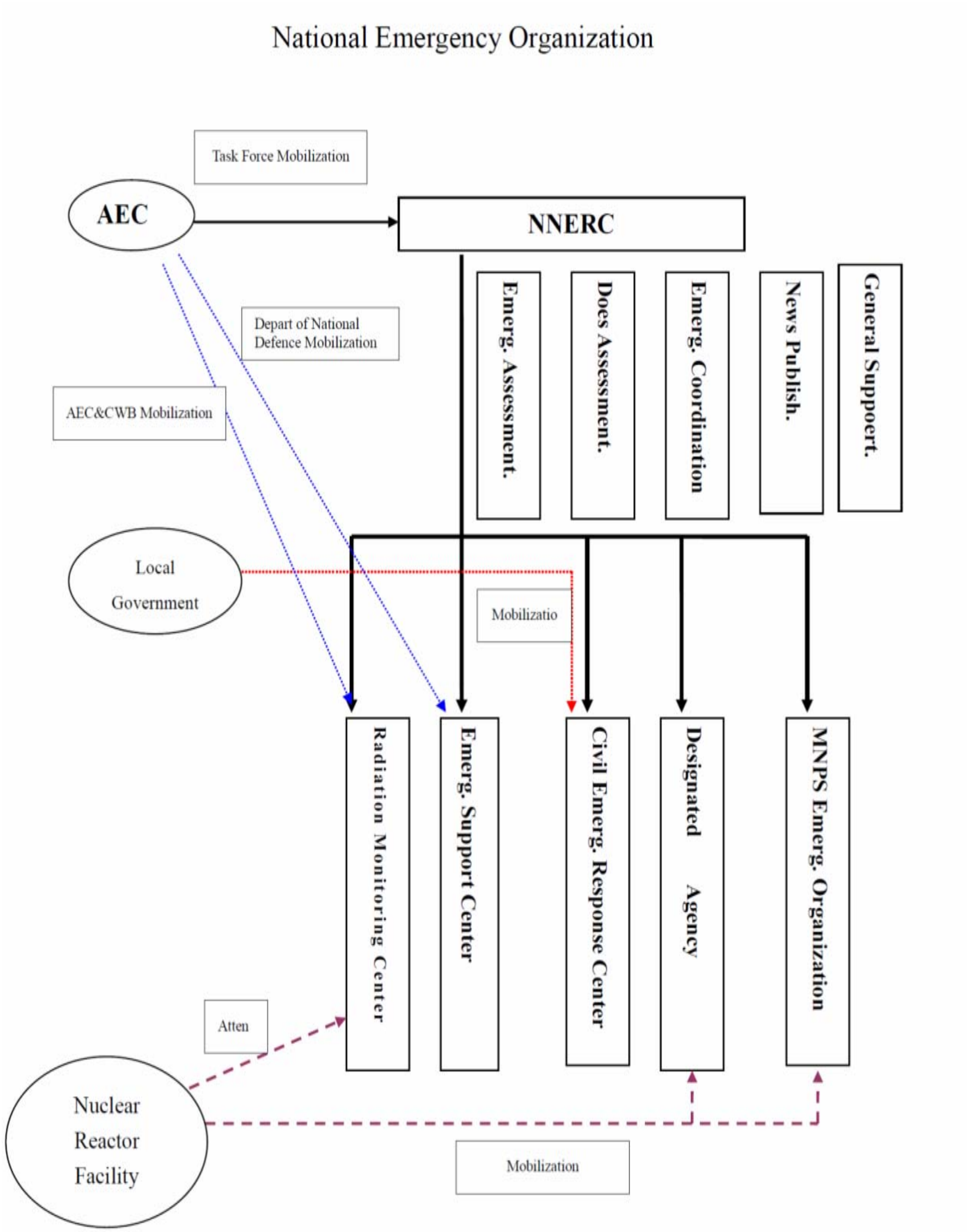


Figure 6-2 Nuclear Accident Response Organization of ROC

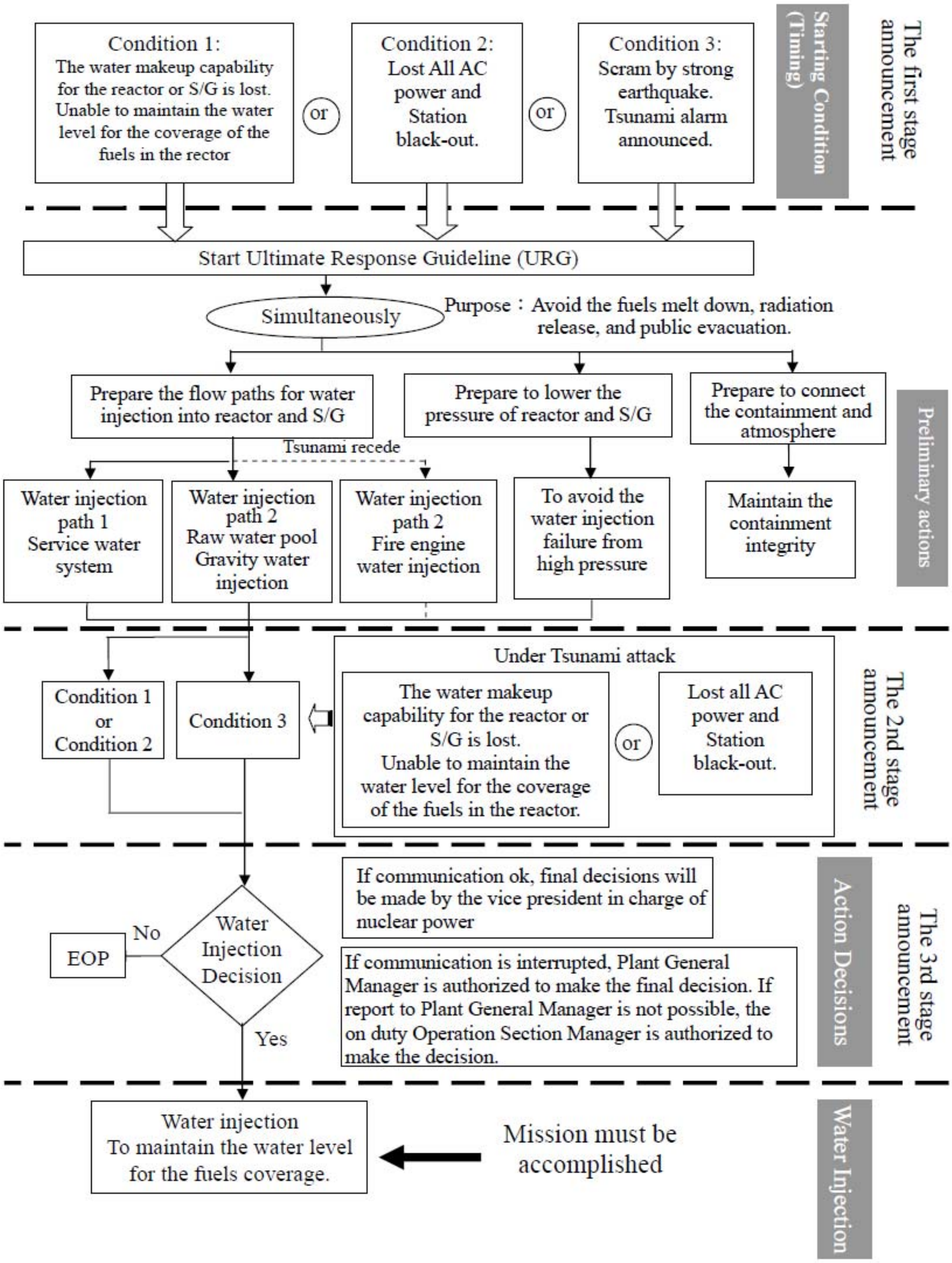


Figure 6-3 The Ultimate Response Guideline (URG) Executive Condition Process and Announce & Report Timing Flow-chart for MSNPP

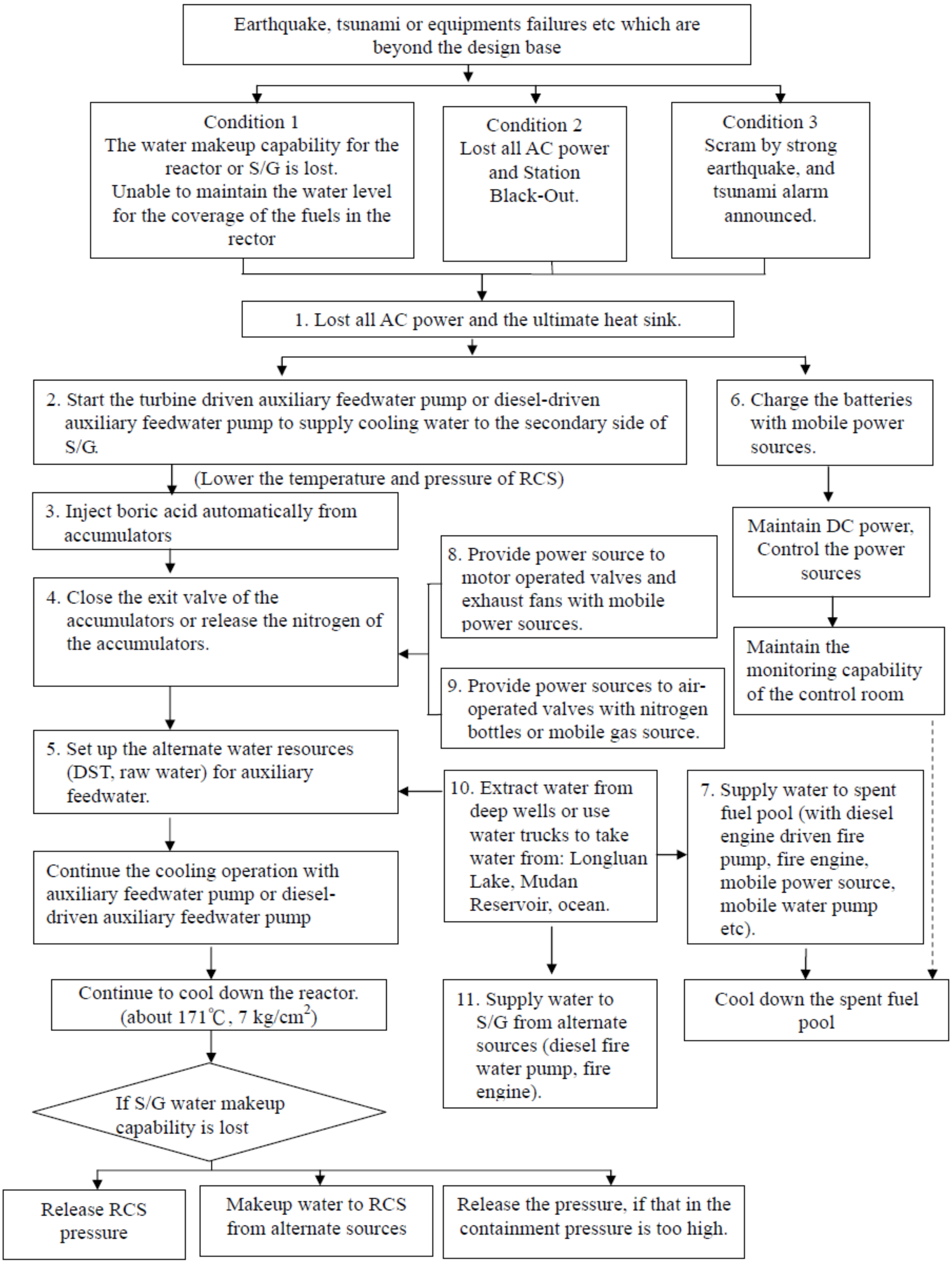


Figure 6-4 Flowchart of Water Makeup Process to Reactor and Spent Fuel Pool

Table 6-1 Group of the maneuver of emergency plan

Item	Team title	members
Ⅰ	TSC	52 persons
Ⅱ	OSC	
Ⅱ-1	Emergency security team	9 persons
Ⅱ-2	Emergency fire brigade	59 persons
Ⅱ-3	Emergency supply team	15 persons
Ⅱ-4	Emergency Re-entry team	124 persons
Ⅱ-5	Emergency backup operation team	14 persons
	Subtotal	221 persons
Ⅲ	Heath Physics Center	
Ⅲ-1	Emergency ambulance and decontamination team	20 persons
Ⅲ-2	Emergency radiation survey team	19 persons
	Subtotal	39 persons
Ⅳ	On-duty operations crew (Control Room)	23 persons
Total		335 persons

Table 6-2, TSC staff rotation list

Job Title	First Group	Second Group	Responsibilities
Emergency controller	Plant General Manager	Operation deputy manager or maintenance deputy manager	Direct the emergent operation of the whole plant
Leader of emergency operation technical support team, concurrent TSC chief	Operation Section Manager	Quality Section Manager	Preside over the analysis and judgment of emergent situation in TSC, conclude the contingent suggestions and procedures. If necessary, advise ECT leader to set up AMT.
Deputy Leader of emergency operation technical support team	Nuclear Technology Section Manager	Nuclear Technology Subsection Chief	Analyze the overall situation, evaluate the effect and damage, assemble AMT.
Member of emergency maintenance technical support team	Mechanical Engineering Section Manager	Repairing Section Manager	Evaluate repairing measure, Recall Emergency Re-entry team to repair.
Member of emergency maintenance technical support team	Electrical Engineering Section Manager	Instrument & Control Section Manager	Report the event progress periodically to the support team outside the plant according to the accident category and radiation situation.
Member of emergency control information management team	Computer Section Manager	Nuclear Safety Information Section Head	Supply meteorological data, pass on accident information.
Member of emergency control radiation protection and environmental chemistry team	Health & Physics Section Manager	Environmental Protection Chemistry Section Manager or Radwaste Management Section Manager	Detect radiation situation and advise if non-emergent staff need to stand by. Supply information about the quantity of released radioactive material and meteorological information.
Member of emergency control information management team	Emergency Plan Senior Engineer	Overhaul Leader or engineer	Assist to evaluate accidents categories and supply accident information.

Table 6-3, AMT staff rotation list

	AMT First Group	AMT Second Group	Responsibilities
AMT leader	Operation Section Manager	Nuclear Engineering Section Manager	Responsible for evaluating the timing of setting up AMT, supervising AMT, providing appropriate decisions to ECT leader, and providing mitigation strategy suggestions.
Operation - Communication group	Leader of the Mobile Supporting Team	Leader of the Mobile Supporting Team	Communicating with MCR to obtain instantaneous data/ information and transferring the data/ information to Safety Analysis Group.
Safety Analysis Group	Safety Analysis Subsection Chief	Engineer of Safety Analysis Subsection	Confirm the transition to SAMGs, and execute SAMGs. Trend the important accident parameters, and evaluate the status of the system.
Reactor Evaluation Group	Nuclear Technology Subsection Chief	Engineer of Nuclear Technology Section	Confirm the shutdown of the reactor, evaluate the fraction of fuel damage and request TSC/NEPEC to predict the release rate.
Auxiliary Safety Analysis Personnel	Engineer of Nuclear Technology Section	Engineer of Nuclear Technology Section	Help AMT to use the supporting figures of SAMG and make predictions for the accidents.

Table 6-4 Checklist for URG 3 Levels

Urgent Level	Strategies	Time limit
Level 1	● Strategy MS.1-01, Manually operate the diesel-driven auxiliary feedwater pumps ● Strategy MS.1-02 The 5th diesel generator supply AC power to two units ● Strategy MS.1-03 Steam generator water injection using raw water (fire protection water) ● Strategy MS.1-04 Reactor water injection from accumulators ● Strategy MS.1-05 Reactor water injection from hydro-test pumps ● Strategy MS.1-06 Reactor water injection using raw water (fire protection water)	1 hour
Level 2	● Strategy MS.2-01 Using mobile power supply to prolong the DC power supply time ● Strategy MS.2-02 Sump pumps drainage operation ● Strategy MS.2-03 Connect the mobile 480V diesel generator ● Strategy MS.2-04 Using mobile air compressors to operate AOV in the makeup path from RWST to SFP ● Strategy MS.2-05 Injection/spray water to spent fuel pool (must be accomplished in 2 hours) ● Strategy MS.2-06 Supply water into CST from mobile water source ● Strategy MS.2-07 Supply water into RWST from mobile water source ● Strategy MS.2-08 Connect 4.16kV power vehicles	8 hours
Level 3	● Strategy MS.3-01 Remove garbage at the entrance of Essential Service Water ● Strategy MS.3-02 Replace NSCW Motor	36 hours

Table 6-5, MSNPP radioactive liquids disposal time and methods after severe accidents

Storage zone	Storage facility	Max storage quantity(Ton)	Storage timing
Storage tank in the plant	3 LRS retention tank and 2 detection tanks, 2 chemical tanks, 2 concentration tanks, 2 BRS retention tank, 2 laundry water tanks	1,430	If there are radioactive liquids release found because of failures of systems, structures and components, first store them in the accumulation pools, tanks in the factory buildings, and release into ocean according to the standard procedures of filtering, sampling, and determining of the release quantity.
Water accumulation tanks in the factory	Accumulation tank, S/G waste water processing tank, waste water storage tank of the dry laundry room, LA sanitary sewage accumulation tanks	980	If there are not enough accumulation pools, tanks to cope with waste liquids release outside the factory buildings, the liquids will be directed to the water accumulation zone for temporary storages, after precipitation or filtering, sampling, and determining the release quantity, then direct the waste water into conduits and release it into ocean.
Auxiliary Building (74～100 ft)	Bottom of Auxiliary Building	28,000 (2 units)	If there are not enough water accumulation facilities and the disposal methods in the plant, by using URG, the waste water can be directed to the auxiliary factory or gas turbine building bottom for temporary storage, after precipitation or filtering, sampling, and determining the release quantity, then direct the waste water into conduits and release it into ocean.
Gas Turbine Building (73～100ft)	Bottom of Gas Turbine Building	60,000 (2 units)	
Total		90,410 tons	

Table 6-6 The storage quantities of radioactive shields, protection clothes of MSNPP

Protection equipment	Equipment types	Current quantity
Portable radiation shield	Lead clothes	115
	Lead blankets	940
Protection clothes	Disposable protection clothes	31200
	Cotton protection clothes	12000
	Disposable shoe sheathes	60000