EU STRESS TEST FOR CS NPP

(Rev.1b)

Taiwan Power Company

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EU STRESS TEST FOR CHINSHAN NPP - LICENSEE REPORT

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1. General data of site/plant

1.1 Site characteristics

Chin Shan Nuclear Power Plant (CSNPP), also known as First Nuclear Power Plant in Taiwan, is located at the north end of Taiwan and fronts on the East China Sea to the north. In terms of geographical coordinates, the Chin Shan site lies at latitude 25 ^{o}18'N and longitude 121 ^{o}35'E. CSNPP is about 28 km away from Taipei city. The west side is adjacent to Chien-Hua Creek. The plant site spreads about 200 meters from east to west and 1.5 kilometers from south to north with a total area of about 233 hectares. The elevation of the whole plant varies from 5 to 20 meters above mean sea level. There are mountain ridges along the east and west sides of the CSNPP. The southern side of the plant is the so called Tatun Mountains.

1.2 Characteristics of units

Two Boiling Water Reactors (BWRs), product line number designated as BWR-4, are installed at CSNPP with the rated core thermal power originally licensed at 1775 MWt for each unit. These two BWR-4s were designed and furnished by General Electric (GE). Unit 1 and reached its initial criticality on October 16, 1977 and Unit 2 on November 9, 1978, respectively. CSNPP successfully implemented "Measurement Uncertainty Recapture power uprate" (MUR PU) for unit 1 on February 24, 2009 and for unit 2 on July 9, 2008. As a result, the rated core thermal power for each unit has been slightly increased to 1804 MWt. In November 2012, both units performed Strength Power Uprate to 1840 MWt.

Unit Design Operation Parameters

# of Fuel bundles	bundle	408
# of Control Rods	rod	97
RPV Height (Internal)	in	815
RPV Diameter (Inner)	in	203
Containment Type	MARK-I	

1.3 Significant differences between units

By design, redundancy is provided for each safety system by two or more separate divisions or trains, designated as Division (or, Train) A, Division (or, Train) B, etc. The term division (or, train) means that all components and support equipment necessary to complete the intended safety function of each system is contained within the division (or, train). The arrangement of the redundant 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:

One 4.16kV/4000kW air-cooled Emergency Diesel Generator (commonly referred to as the 5th EDG) was initially designed as a swing EDG. That is, the 5th EDG could be deployed as alternative AC power source for emergency power demand required by either unit 1 or unit 2, but not both, if both water-cooled EDGs at either unit should be unavailable. However, after the Fukushima Nuclear Accident, the Station Blackout Procedure 535 has been revised so that under appropriate control and management, the 5th EDG can be deployed to simultaneously supply power to the safety related 4.16kV Essential Bus of both units 1 and 2.

1.4 Results of probabilistic safety assessments [1]

CSNPP completed its Living Probabilistic Risk Assessment (PRA) in 1995. From then onwards, the parent company, TPC, is committed to revising and updating this Living PRA every three years to reflect plant design changes and operating performance. As of yet, four revisions have been made to the Chin-shan Living PRA. The plant Living PRA 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 major categories of initial events, namely plant internal events, earthquakes, floods, fires and typhoons. The results of the most recent assessment are summarized as follows:

(1) The total average Core Damage Frequency (CDF) at full power operation is estimated to be 1.8E-5/RY. The total average CDF during a typical refueling outage is estimated to be 6.2E-6/RY.

(2) The total average Large Early Release Frequency (LERF) at full power operation is estimated to be 6.5E-6/RY.

(3) Contribution to the total average CDF at full power operation are: 14.2% (2.6E-6/RY) from plant internal events, 30.6% (5.6E-6/RY) from earthquakes, 0.2% (3.0E-8/RY) from typhoons, 54.7% (1.0E-5/RY) from floods, and 0.2% (4.1E-8/RY) from fires.

(4) Contributions to the total average LERF at full power operation are: 12.3% (8.0E-7/RY) from plant internal events, 53.6% (3.5E-6/RY) from earthquakes, 0.2% (1.4E-8/RY) from typhoons, 33.7% (2.2E-6/RY) from floods, and 0.2% (1.1E-8/RY) from fires.

Reference

[1] Taipower internal document,「安全度評估同行審查建議及異常事件損害成本評估研究完成報告」，民國96年修訂版.

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 threat of design basis earthquake to Chin Shan NPP is evaluated based on an assumption that a magnitude 7.3 earthquake which previously occurred near Banqiao in 1909, would hypothetically happen along the inferred Hsinchuang fault (also known as Chin Shan fault) at the nearest distance of about eight (8) kilometers from Chin Shan NPP. For conservative design, the Hsinchuang fault was inferred to exist in the northernmost part of Taiwan, although it was not considered active according to geologic and seismic criteria adopted by the United States Nuclear Regulatory Commission (USNRC). The horizontal acceleration value of the Design Basis Earthquake was inferred to be 0.3g based on this assumption and the relationship between distance and intensity attenuation derived from the historical earthquake events in Taiwan. The horizontal acceleration value of the Operating Basis Earthquake is 0.15g (half of the DBE).

2.1.1.2 Methodology to evaluate the DBE

The approaches adopted for determining the design basis earthquake (safe shutdown) for nuclear power plants are noted:

1. Tectonic Province Method

   Since Chin Shan NPP was built in the earlier days, the tectonic province method was not adopted in determining the Safe Shutdown Earthquake (SSE) value.

2. Geologic Structure Method

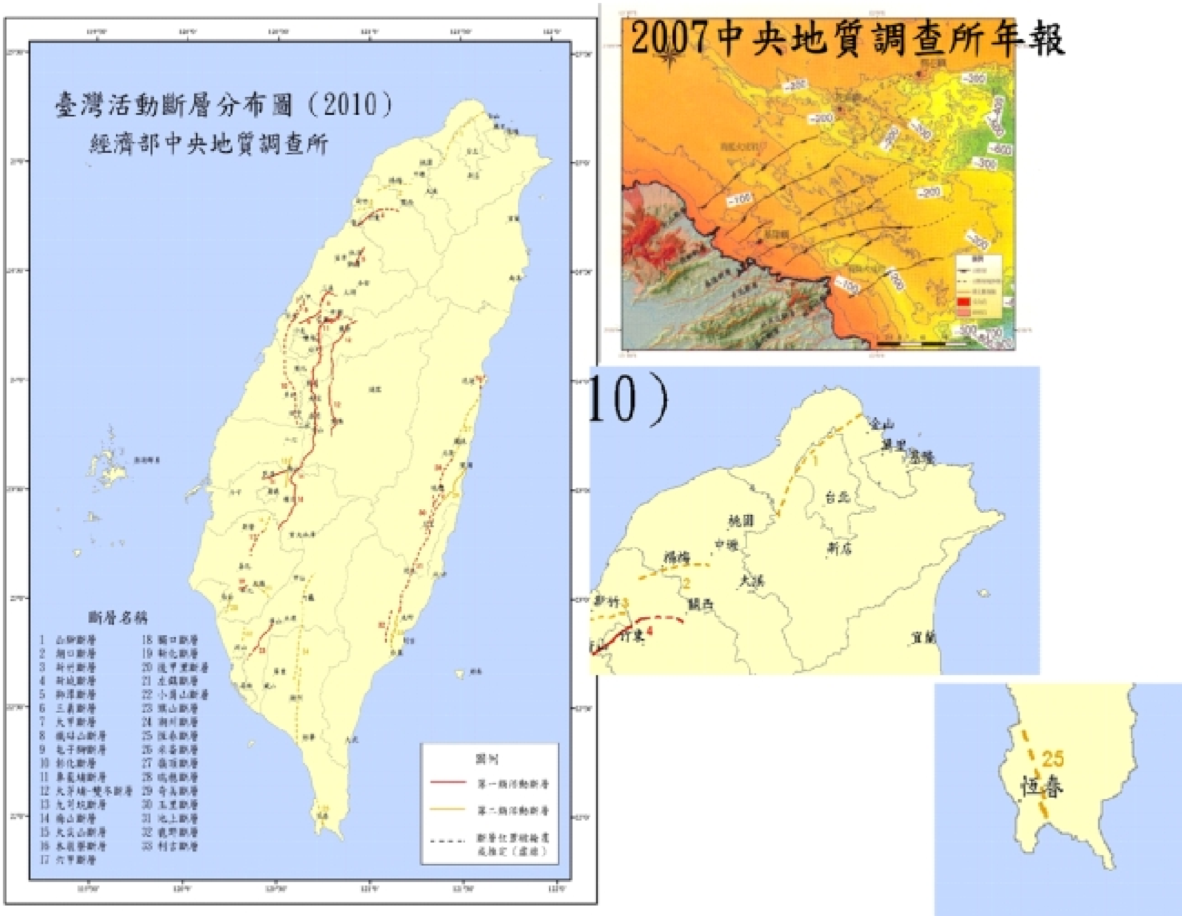
   The DBE is defined by indentifying if the faults nearby the plant site are of potentially active ones, based on the core drilling data, as well as by referring to the distance between the said faults and the plant site, and by analyzing the records of historical earthquakes near by the plant site. The possible maximum ground acceleration at the site is then inferred from the analyses of the extent of the injuries.

   During the planning phase for Chin Shan NPP, a Richter magnitude 7.3 earthquake of epicenter intensity X (MM scale) and focal depth of 20 km, which occurred near Banqiao in 1909, was assumed to be hypothetically happening, due to staggering movement, along the inferred Hsinchuang (or called Chin San) fault at the nearest distance of about eight (8) kilometers from Chin Shan site. For reason of conservatism, the said Hsinchuang fault is considered as an active one, regardless of the fact that it is actually an inactive fault. By referring to the relationship between distance and intensity attenuation for the historical earthquakes occurred in Taiwan, as well as the analyses results of the extent of injures, the resultant intensity at the Chin Shan site was

VIII to IX (MM scale). The design basis of the SSE was then determined to be 0.3g, with the return period of one (1) million years, based on the related transformation relationship between the earthquake intensity and the ground acceleration.

2.1.1.3 Conclusion on the adequacy of the DBE

1. According to American nuclear regulations, the buildings seismic design basis shall be determined by taking account of the potential adverse impact on the nuclear power plant resulting from the possible active faults (This means those have ever been activated at least once in 35,000 years, or twice and more in 500,000 years), based on the geology and seismology conditions within 320 km from the site. The said seismic design basis is then inferred by the domestic and foreign specialists with reference to the record of historically maximum seismic data.
2. As per the special issue No.19 issued by Central Geological Survey Institute, Ministry of Economic Affairs in July, 2007 (figures shown below), the Shanchiao fault is of a normal shape fault, which trends SSW to NNE, and can be divided into two parts: The south part extends from Shulin District of New Taipei City northward to Beitou District of Taipei City, with 13 km in length; while the north part extends from Beitou northward to Chin Shan District of NewTaipei City, with 21 km in length. The latest activated time of the above Shanchiao fault may be back to 10,000 years from today, and is temporarily classified as Category 2 active fault.



Taipower commissioned National Central University to perform the third 10-year seismic safety evaluation project for Chin Shan NPP, based on the geology and seismology data published by Central Geological Survey Institute. According to the preliminary result (completed in July, 2008), the ground acceleration at foundation bedrock of the Reactor Building of Chin Shan NPP, transferred from an earthquake induced by the above mentioned Shanchiao fault, is 0.19g, which is below the design basis earthquake value of 0.3g for Chin Shan NPP(see Table Nos.2-1 and 2-2).

Table 2-1

Fault	Length under the Land	Length under the Sea	Depth of Epicenter	Magnitude (ML)	Calculated ground surface acceleration
Shanchiao Fault	34 km	16.6km	10km	6.8	0.34g

Table 2-2

The ground surface acceleration inferred from the ShanChiao fault	0.34g
The acceleration at foundation bedrock inferred from the Shanchiao Fault	0.19g
The design acceleration at foundation bedrock	0.3g

Based on the discussions under the above two paragraphs, it is concluded that the design basis earthquake (DBE) value of 0.3g is still adequate for Chin Shan NPP, and can be adopted as the design basis of the safe shutdown related systems, structures and components(SSC).

2.1.2 Provisions of the plant to protect against the DBE

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

1. The seismic structures of the safe shutdown equipment related buildings of Chin Shan NPP are reviewed as follows:

   (1) The structures of the major buildings in Nuclear Island of Chin Shan NPP are classified into two categories: category I and category II. The 0.3g is adopted as the seismic design basis for the seismic category I structures. The seismic categories of the structures are sorted according to category of the equipment as listed in the following Tables 2-3 to 2-5:

Table 2-3

Equipment \ Parameters		Elevation (above sea water level) meter	Seismic category	Waterproof measures
Power Source	Outside Power Source	Startup transformers train A:14m, train B:16.4m	II	None
	Emergency Diesel Generator	11.2m	I	*
	5th Emergency Diesel Generator	11.2m	I	*
	Gas Turbine	21.2m	II	None
Water Source	Essential Service Water Pump	11.2m	I	Inside Essential Service Water Pump House
Flood Discharge Channel	Chien-Hua Creek	Outlet top :8.3m~22.3m Outlet bottom:1.9 ~16.9m	II	N/A
RPV Cooling (Flooding)	Emergency Core Cooling System	Inside containment	I	*
	Fire Protection Water (Raw Water)	Upper pool bottom: 65m Lower pool bottom:62m	II	N/A
	Sea water (to be injected into Reactor Core)	None	None	None
Reactivity Control	Control Rods	Inside containment	I	*
	Standby Boron Liquid Control System	Inside containment	I	*
	Standby Boron Injection	Inside containment	I	*
CTMT /RPV Integrity	Containment Nitrogen Filling System	11.2m	II	None
	Hydrogen Monitoring System	Inside containment	I	*
	Hydrogen Recombining System	Inside containment	I	*
	CTMT Gas Exhaust	Inside containment	I	*
	Standby Gas Treatment System	Inside containment	I	*

* The adequate sandbags have been prepared, capable of being piled up to one (1) meter high at the main entrances of the buildings for protecting the inside systems and equipment.

Table 2-4 Major Water Storage Tanks for Chin Shan NPP

Item	Tank	Volume (ton)	Seismic Category	Structural Body Material	Elevation (above sea water level) meter
1	CST(unit no.1)	1893	I	S.S. tank body	11.2
2	CST(unit no.2)	1893	I	S.S. tank body	11.2
3	DST(unit no.1)	189	II	Aluminum tank body	(-)0.25(Inside bldg)
4	DST(unit no.2)	189	II	Aluminum tank body	(-)0.25(Inside bldg)
5	3,000 ton raw water reservoirs (quantity:2, shared by both units)	6,000	II	Reinforced concrete	78
6	100,000 ton raw water reservoirs (upper + lower reservoirs = 100,000 ton)	100,000	II	Reinforced concrete	62

Table 2-5 Major Oil Storage Tanks for EDG and GT for Chin Shan NPP

Item	Oil Storing Tank	Seismic Category	Volume	Elevation (above sea level) m	Structural Body Material	Anti-overflow Dike (for collection of leaking oil)
1	EDG Oil Day Tank(unit no.1)	I	1,200 gal	11.2m (bldg. floor)	Steel tank body	Inside bldg.
2	EDG Oil Day Tank(unit no.2)	I	1,200 gal	11.2m (bldg. floor)	Steel tank body	Inside bldg.
3	EDG Oil Storage Tank	I	850,000 gal	19.7m (tank bottom)	Steel tank body	Yes
4	5th EDG Oil Day Tank	I	1,300 gal	20.2m (bldg. floor)	Steel tank body	Inside bldg.
5	5th EDG Oil Storage Tank	I	61,000 gal	11.2m (site region)	Steel tank body	Yes
6	GT Oil Day Tank(quantity:3)	II	1,800 m^3 (total)	25.9m (oil tank floor)	Steel tank body	Yes
7	35,000 m^3 Oil Storage Tank	II	35,000 m^3	110.8m (oil tank floor)	Steel tank body	Yes

(2) The key structures, systems and components (SSC) required for achieving safe shutdown of Chin Shan units are as follows:

A. Structure:

a.	Unit No.1 combination structure building:	seismic category I
b.	Unit No.2 combination structure building:	seismic category I
c.	Essential service water pump house bldg:	seismic category I
d.	5th Diesel Generator building (housing the oil storage tank and the oil day tank) :	seismic category I
e.	Condensate water storage tank (including foundation):	seismic category I
f.	850,000 gallon EDG oil storage tank (including foundation):	seismic category I
g.	EDG oil day tank for Unit No.1:	seismic category I
h.	EDG oil day tank for Unit No.2:	seismic category I
i.	Main stack:	seismic category I

B. The key systems and their supporting systems:

a. Emergency Core Cooling System (ECCS): seismic category I

(a) Low Pressure Coolant Injection System (LPCI, Subsystem of RHR)

(b) Core Spray System (CS)

(c) High Pressure Coolant Injection System (HPCI)

(d) Automatic Depressurization System (ADS)

(In case a pipe rupture occurs in the non-seismic class I nitrogen piping which is connected to the nitrogen bottles, the SRV still can be actuated 5 times by having a seismic class I check valve equipped in between the nitrogen accumulator and the instrument nitrogen piping so as to assure no leakage from the nitrogen accumulator).

Power Source (EDG) : seismic category I

Cooling Water Source (ESW): seismic category I

b. Reactor Core Isolation Cooling System (RCIC): seismic class I

125V DC Source: seismic category I

Cooling Water Source (CST): seismic category I

c. EDG (Nos.1~4 and 5th D/G): seismic category I

Diesel oil storage tank and fuel oil transfer system: seismic class I

Air Starting System: seismic category I

(starting air compressor, non-seismic category I Air Dryer) (air cooled 5th D/G)

d. Combination Structure Cooling Water System (CSCW): seismic category I

Power source (EDG): seismic category I

Cooling water source (ESW): seismic category I intake structure

e. Essential Service Water System (ESW): seismic category I

Power source (EDG): seismic category I

Cooling Water Source: seismic category I intake Structure, seismic category I

Channel Structure

f. Essential Chilled Water System (Nos.3~5 Chiller)
Power source (EDG): seismic category I
Cooling water source (CSCW): seismic category I

g. Residual Heat Removal System (RHR)
Power source (EDG): seismic category I
Cooling water source (ESW): seismic category I intake Structure

The above listed structures and equipment required for safe shutdown are all of seismic category I ones, which are capable of maintaining their availability under the design basis earthquake (DBE) condition, so as to assure that the units can be safely shut down without any doubt.

2. The seismic design of the Reactor Buildings (fifth floor) for Chin Shan units Nos. 1and 2 are reviewed as follows:

(1) A fixed type 90 ton (main hoist load) overhead crane with single-failure-proof design feature is provided on the fifth floor of Reactor Building. This overhead crane is designed to be capable of meeting the two major requirements: (a) The crane shall be able to safely hold the Critical Load, but not necessarily to maintain its operability, when an SSE event occurs; (b) Even if there is a single failure of the component, the crane shall not lose its braking and holding capabilities for handling the Critical Load.

Normally, the above crane is parked and locked at the north end of this floor, with its trolley and hook to be placed far from the upper space of the fuel storage pool and the reactor core.

Regardless of the fact that this crane does not belong to the safety related equipment, it still has been qualified as seismic category I structure, so that no adverse impact on the safety related systems caused by this crane resulting from an earthquake will be expected.

On the contrary, by taking the advantage of single-failure-proof design feature, the said crane can promote a safer correlation with other safety related systems.

(2) The refueling platform is seismic category I structure. Under the normal condition, this platform is parked and locked on the lower floor region which is located between the fuel pool and the reactor core, with the rails of the supporting structure of the said platform placed along the fuel storage pool and both sides of the reactor core. Therefore, it is evident that no falling accident during an earthquake event will be expected.

(3) The fuel storage pool structure which is made of reinforced concrete with a stainless steel liner on its interior surface is a part of the seismic category I Reactor Building. The normal water level (NWL) of fuel storage pool is EL.136.50 feet. According to the design data of the fuel storage pool, the water level in the pool is maintained as high as at least 7.88 feet above the top of fuel element. This will assure that the spent fuels are well protected with adequate water to prevent them from being damaged due to earthquake.

2.1.2.2 Main operating provisions

The major operating provisions for protection of the Reactor Core or Spent Fuel Storage Pool from being damaged after an earthquake event are as follows:

1. All key structures, systems and components (SSC) including Reactor Core and Spent Fuel Pool as required for safe shutdown of Chin Shan units are designed based on the DBE value, so as to be strong enough to prevent the SSC (including Reactor Core and Spent Fuel Pool) from failure against a DBE event.

   Nevertheless, the following post-earthquake procedures are prepared and revised in accordance with EPRI report NP-6695 issued in December, 1989: "Guideline for Nuclear Plant Response to an Earthquake" for use as a basis in performing the response action and plant inspection after an earthquake:

   (a) Post-severe-earthquake emergency response procedure (Procedure No. 512.1)

   (b) Post-severe-earthquake overall plant inspection procedure (Procedure 512.2)

   (c) Post-severe-earthquake inspection of overall plant key structures and equipment before restart-up (Procedure No.512.3)

2. The purpose and brief description of the above listed procedures and the emergency operation related procedures for Chin Shan units are as follows:

   (1) Procedure No. 512.1 "Post-severe-earthquake Emergency Response Procedure"

   Purpose: To provide a guideline for the plant operator to take a timely action in response to an Earthquake.

   Brief description:

   A. In case, the intensity of an earthquake exceeds OBE or SSE value, besides the steps in Procedure No.5.2.6.1/5.2.6.2 shall be executed, in the same time, the Ultimate Response Guideline (URG) shall be taken to rapidly depressurize RPV down to 35 kg/cm^2 as per Procedure No.1451, followed by a quick cold shut-down action (referring to Attachment 2-1 of the same procedure). In addition, a plant survey shall be performed in accordance with the above Procedure 514 to see if the plant has been invaded by a tsunami.

   B. If the unit is under operation:

      - Confirm the reactor core was automatically scrammed by the severe-earthquake Automatic-rapid-shutdown signal of the RPS.
      - If the reactor core did not scrammed as it shall be, the reactor shall manually be shut down rapidly.
      - Implement the actions in accordance with the Procedure No.207 "Reactor Scram".
      - Perform, as soon as possible, a survey of all the equipment relating to consequence mitigation of the accident as per the check list stipulated in Part 2 of Procedure No.512.

   C. If the units are shut down:

- The shift manager shall notify the maintenance personnel to perform a detailed inspection of the whole plant in accordance with Procedure No. 512.3 "Post-severe-earthquake inspection of overall plant key structures and equipment before restart-up."
- The shift manager shall notify the Plant General Manager to request the headquarters for setting up a dedicated (special) task force to provide the full assistance to the plant in performing the detailed inspection and testing of the building structures and equipment after a severe earthquake occurs.
- The emergency mobilization requirements (plan) shall be determined as per Procedure No. 1401-H series "The emergency response operation basis requirements for coping with the natural disasters and other situations which may affect the plant safety "
- The seismograph system shall be reset within 24 hours, and the control tracks of the same shall be calibrated within 5 days.
- Collect and transmit all the seismic data to the headquarters for safety evaluation.
- Perform functional tests for such equipment as required.
- Prepare and submit ROC AEC, within 14 days, a special report containing the description of the magnitude of the earthquake, the seismic response spectrum, the impact on the safety function of the units, and etc.

D. In case, the seismic monitoring system is inoperable, a repair application form shall be filled out and sent to the instrument and control (I&C) section for repair. A special report shall then be prepared and submit to ROC AEC within 14 days.

(2) Procedure No. 512.2 (Post-severe-earthquake overall plant inspection procedure)

Purpose:

A. After a severe earthquake, any possibility of damage and malfunction of the equipment/ structures, which may be induced by an earthquake, shall be surveyed, inspected, tested and evaluated to confirm if the unit can still continue its operation, or has to be orderly put to shutdown condition.

When the earthquake intensity exceeds OBE value, the URG shall be taken in the first time to rapidly depressurize the reactor by shutting down the units automatically or manually. However, since the major accident consequence mitigation related equipment may be damaged either by a multiple accidents mode induced from a severe earthquake, or by the flooding/spraying water due to pipe rupture or initiation of the water sprinkler systems, or by a fire hazard resulting from the oil tanks or lubricating oil tanks.

This situation may prevent them from performing their intended function. In this regard, the site survey shall be carried out as soon as achievable to find out the potential vulnerable spot, and the timely remedy actions shall then be taken either by using other facilities as a substitution, or by taking a prompt action to repair the said abnormal equipment, so as to minimize the possible risks, and assure the operation safety of the units.

B. The inspection work contained in part 1 of this Procedure shall be essentially finished within 12 to 24 hours since the earthquake event happens, depending on the availability of the manpower. In case, the earthquake intensity exceeds the operating basis earthquake (OBE) value, the inspection work contained in part 2 of this Procedure shall be executed on a first priority basis.

Brief description: When the severe-seismometer is actuated but not reaches OBE:

A. The operator shall take a prompt action to check and verify the status of the control panel in the main control room, in accordance with the stipulations in PART 1 (main control room check list) of this procedure. When the unit is in the operation mode, the variations of the reactor power and generator output shall be closely monitored. The proper measures shall be exerted to stabilize the operation condition of the unit as per the standard operating procedure, abnormal operating procedure, and emergency operating procedure and operation technical specification for Chin Shan units.

B. After the severe earthquake, the operator shall start to perform an overall plant survey of all accessible regions, such as reactor bldg/combination structure, T/G bldg, electrical equipment, peripheral equipment, radwaste bldg and switchyard, according to the check lists in PART 1 of Procedure 512.2. The major action items in performing the above survey shall include:

a. The leaking situation of the piping systems.

b. The damage situation status of the low pressure tanks.

c. The damage situation of the switchyard equipment.

d. The actual liquid level of the tanks whose level indication have experienced variations.

e. The rotating equipment which is suffering high vibration, high bearing temperature and abnormal noise.

f. The damage situation of the equipment hit by the nearby or falling objects.

g. The phenomena of turnover, sliding, displacement of the typical equipment resulting from distortion or looseness of their anchor bolts.

h. The damage situation of the attached pipes including soft pipes, stub pipes and electrical conduits.

i. The damage situation of the piping, and the displacement of the piping supports.

j. The damage (distortion) situation of the electrical cabinet or instrumentation cabinet including the inside components such as relays and circuit breakers.

k. The cracking or peeling phenomena of the concrete.

l. The availability status of the major relays, circuit breakers and other electrical components which are sensitive to vibration.

m. The non-fixed equipment possibly falling on the safe shutdown related equipment

n. Whether the equipment may not function either due to water flooding, induced by pipe rupture or due to water spray, actuated by water sprinkler system.

o. Whether the equipment may not function due to the fire hazard, induced by oil tanks or by lubricating oil tanks.

C. After a severe earthquake occurs, a detailed overall plant survey will be performed according to Procedure No.512.3 (Post-severe-earthquake inspection of overall plant key structures and equipment before restart-up), subject to the result of the evaluation done by the headquarters' special task force or by the SORC of Chin Shan NPP.

D. The results of the above survey:

a. If the equipment/structures have no major damage:

(a) If the unit is still in the operation mode, the necessity for shutdown shall be assessed according to the conclusion of the above survey results. The units shall be shut down under the following conditions:

- The earthquake has caused the radiation to be released to the environment.
- The earthquake has caused the system or equipment to be inoperable, and the unit has to be shut down as per the stipulations in the operation specification.
- The earthquake has caused the system or equipment to be so damaged that the safe stable operation of the unit is affected.

(b) If the unit is not required to be shut down, the following steps shall be taken:

- Reset the seismograph within 24 hours, and verify its control tracks within 5 days.
- Perform the functional test of the equipment as required.
- Prepare and submit ROC AEC, within 14 days, a special report containing description of the magnitude of the earthquake, the seismic response spectrum, the impact on the safety function of the unit, and etc.
- In case, the seismic monitoring system is found to be inoperable, a repair application form (referring to ITS Table 16.6.9-2) shall be filled out, and send to the Instrument and Control (I&C) Group for repair. A special report shall then be prepared and submit to ROC AEC within 14 days.

(c) If the unit has to be shut down:

- Confirm the availability of the following equipment as required for unit safe shutdown including:
  - ✓ RHR system (including pumps and heat exchangers)
  - ✓ Major water source (such as CST)
  - ✓ Make-up water systems (Condensate water system, Feed water system,

RCIC, ECCS and etc.)

- ✓ In-site emergency power (EDG, batteries, AC/DC bus, related circuit breakers and relays)
- ✓ Monitor the important I&C equipment for safe shutdown

- Shutdown reactor according to procedure

(d) After the unit is shut down, the following subsequent measures shall be implemented:

- Reset the seismograph within 24 hours, and verify its control tracks within 5 days.
- Perform the functional test of the equipment as required.
- Prepare and submit ROC AEC, within 14 days, a special report containing description of the magnitude of the earthquake, the seismic response spectrum, the impact on the safety function of the units, and etc.
- In case, the seismic monitoring system is found to be inoperable, a repair application form (referring to ITS Table 16.6.9-20) shall be filled out, and send to the Instrument and Control (I&C) Group for repair. A special report shall then be prepared and submit to ROC AEC within 14 days.

(e) The unit may be re-started up, after the results of all the tests as required per the Operation Specification have proved to be satisfied with the requirements.

b. When the equipment/structures have proved to be significantly damaged by the earthquake attack, the operator shall immediately stop the power operation of the unit, and take subsequent actions stipulated under section 5.2.6.1/5.2.6.2 of Procedure 512.1.

When the earthquake intensity reaches beyond OBE value:

A When the intensity of the earthquake reaches above OBE value, besides taking various measures stipulated in section 5.2.6 of Procedure 5.12.1, the operator shall work with the maintenance personnel, as soon as possible, to perform survey of the major equipment relating to mitigation of the accident consequence, according to the reactor bldg check list, combination structure bldg check list, administration bldg check list and peripheral equipment check list in PART 2 of Procedure 512.2.

B. The major action items in performing the above survey are the same as that listed under paragraph B of the above case (when the severe-seismometer is actuated but not reaches OBE). After the earthquake, any malfunction of the related equipment shall be indentified as soon as possible, so that a proper remedy action can be taken either by using other facilities as a substitution, or by taking a prompt action to repair the said abnormal equipment.

(3) Procedure No. 512.3 (Post-severe-earthquake inspection of overall plant key structures and equipment before restart-up)

Purpose:

A. This procedure is intended for use in performing a detailed inspection of overall equipment/structures for Chin Shan NPP, when a severe earthquake exceeding OBE occurs at plant site, or when the earthquake does not exceed OBE, but the result of the evaluation report done by the headquarter special task force or by the plant SORC warrants such inspection, based on the significance of damage made to the equipment/ structures.
B. In principal, the execution of the overall plant inspection (20%) of the major equipment/ structures shall be completed within 24 hours. If the scope of inspection has to be extended, it will principally be finished in one (1) to two (2) weeks. In case, the RPV head needs to be removed for in-core inspection, the inspection completion date may need to be further extended to one(1) months, or even more.

Brief description:

A. Perform visual spot-inspection of the overall plant major equipment/ structures in accordance with the check list in Procedure No.512.3 "Post-severe-earthquake inspection of overall plant key structures and equipment before restart-up."
B. The technical support center (TSC) or headquarters special task force identifies the damage class, based on EPRI report NP-6695 "Seismic Damage Classification of NPP Equipment"
C. Maintenance Groups make preliminary judgments as to whether safety related equipment has sustained damage.
D. The I&C Group makes judgment as whether the seismometer has been damaged.
E. Confirm the availability of the all the equipment as required for normal operation, by implementing various verification tests of the repaired equipment or structures.
F. The unit re-start shall be subject to ROC AEC's approval of the post-severe-earthquake re-start evaluation report issued by TSC or headquarters special task force.
G. Maintenance Groups perform the augmented visual inspections.
H. The technical support center (TSC) or headquarters special task force re-identifies the damage class, based on the results of the above augmented visual inspections as per "Seismic Damage Classification of NPP Equipment" stipulated in EPRI report NP-6695.
I. A dedicated task force will be set up by headquarters for further devoting to the related long term evaluation work.

2.1.2.3 Indirect effects of the earthquake taken into account

1. For those safety related SSC that are vulnerable to the attack by an earthquake, the seismic category I consideration is normally taken into account in design of the same, so that they can withstand the impact resulting from a DBE event without jeopardizing their structure integrity.

2. If an earthquake induced in-plant flooding occurs:

The in-plant flooding event as a result of a rupture of the water containing facilities such as the pipe, tank body inside the buildings has been analyzed by Nuclear Engineering Department, TPC in December, 1988. The combination structure building and turbine building were covered in the scope of the above analysis work. Based on the said analysis report, it was concluded that the postulated flooding event did not have any adverse effects on the safe shutdown capability of Chin Shan units.

The sump pumps have been equipped in the floor sumps of all the safety related buildings; and the sump water level can be monitored from the main control room in any time under normal operation condition. Due to the safety consideration, in case an abnormal water level condition occurs, the sump pump will be automatically started. A start-up test performed at Chin Shan NPP on April 8, 2011, showed that the related sump pumps were all operating properly as required. During loss of normal power supply, since emergency equipment areas still have “mechanical” contacting type flood alarms. Main control room can monitor that areas’ flooding condition and arrange diesel-driven drainage pumps to pump out the water.

3. If an earthquake induced fire event occurs:

(1) Chin Shan NPP has completed the testing, maintenance and inspection of the fire protection related facilities (including automatic fire water sprinkler systems, automatic carbon dioxide extinguishing systems, foam extinguishing systems, automatic halon extinguishing systems, and both the indoor and outdoor hydrants) as per the fire protection system maintenance procedure, and no any defects was found.

(2) The fire protection facilities located in the safety related regions are all of seismic category I ones; but the equipment and the fire piping at the fire water source end are not qualified to meet seismic category I requirements. As an alternative, Chin Shan NPP will actively enhance the reliability of the fire protection related piping by increasing the frequency and the scope of the patrolling operation at the plant site.

(3) Chin Shan NPP has been carrying out the following plant betterment measures to further improve the reliability of the fire protection system:

A. To replace the original buried raw water pipes and fire protection pipes with trenched or above ground ones.

B. To upgrade the seismic resistance capability of the raw water reservoir body and the related pipes.

C. To connect the interconnecting pipe between the upper and lower reservoirs (totaling 100,000 ton) with the raw water yard ring header so as to serve as a back-up cooling water source for RPV, drywell, suppression pool and spent fuel pool. (Completed after Jun 30, 2011)

(4) The eight(8) newly purchased large size fire pumps can take water from various back-up

sources. (Completed after Jun 30, 2011)

4. When a loss of outside power event occurs:

(1) Each unit is equipped with two (2) redundant safety grade EDG's capable of providing adequate power source as required by the emergency cooling water system, when a loss of outside power event occurs.

(2) The 5th EDG is of safety grade, air cooled, and serves as a replacement power source for both units 1 and 2, in case any one of the existing four (4) EDG's fails to perform its intended function.

(3) All of above-mentioned EDG's are made in compliance with DBE design requirements, and capable of maintaining their operability against DBE. According the lesson learned from Fukushima event, Chin Shan NPP has issued MMR-C0-0407 to install water tight doors at the entrance of the 5th EDG building and floodgates of combination structure building to protect the EDG's from being damaged resulting from flooding accompanied with the earthquake. (Completed after Jun 30, 2011)

5. When the earthquake cause outside environment to hinder or delay the personnel and equipment to arrive at the plant site:

(1) When the event occurs in the office hours:

A. As it may happen that the operators to be on duty are hindered to arrive at the working place to take over his job, the trainee in the Simulator Center, and the operators in the standby shift with total members of around ten personnel or so (most of them hold the valid operation licenses) will serve as the back-up operation manpower to take over and assist the operation of the units.

B. Besides the maintenance manpower available in various disciplines at the plant, the vendor under long term contract normally maintains maintenance manpower of more than 100 personnel stationed nearby the plant site. This should satisfy the maintenance need under an emergency condition.

C. According to the organization stipulated in the emergency plan, the in-plant fire brigade will have eight (8) firemen on duty at the second shift. In addition, during the office hours, the emergency back-up fire brigade normally has manpower of twenty (20) firemen available, and can provide assistance in performing the fire fighting services.

(2) When the event occurs in the off-duty hours:

A. According to the site survey, there are total of twenty-three (23) persons dealing with the operation expertise (including Operation Group) residing in the Mao-Lin off-duty dormitory at the plant site. To cope with the difficulties in timely obtaining the replacement manpower for plant operation, the above personnel can be called in, on first priority basis, for providing assistance in supporting the plant operation work. Furthermore, a total of one hundred and two (102) persons dealing with the operation expertise, are residing in the Tanshui off-duty dormitory, and other neighboring country regions, such as Tanshui, Chin Shan, Shimen. They can also be called into the plant to provide help as necessary, before arrival of the outside supports.

B. According to the site survey, there are total of forty-five (45) persons dealing with maintenance expertise (including Mechanical, Electrical, I&C, Machine Shop and HP sections) residing in the Mao-Lin off-duty dormitory at the plant site, who are ready available to be called for performing the equipment repairing tasks.

A total of one hundred eighty six (186) persons dealing with the operation expertise, are residing in the Tanshui off-duty dormitory, and other neighboring country regions, such as Tanshui, Chin Shan, Shimen. They can also be called into the plant to provide help as necessary.

Besides, the vendors under the maintenance contracts with Taipower, also have many of their technical personnel residing in Chin Shan, Shimen and other nearby regions, and are ready to take a prompt response to an urgent request for providing the equipment repairing services as per the provisions of the contract.

C. The fire brigade normally maintains 6 firemen of his manpower at the plant site during the off-duty hours. Since all the firemen under contract are of the residents in Chin-Shan or Shimen regions, so that they can be ready to take a quick response to a mobilization call, in case of an urgent event. Furthermore, the special polices stationed at the plant may also be able to provide additional support in coping with the distressed situation.

D. When the event occurs at off-duty hours, and Taipower employee cannot get to the plant in time, there may have a heavier impact on the need for maintenance manpower. In this regard, the nearby vendors residing in Chin Shan, Shimen and Keelung regions shall be called to provide help, so as to mitigate the shortage of Taipower maintenance manpower.

(3) In case that the transportation road outside the plant was interrupted so as to result in obstruction or delay of personnel and equipment arriving at site, National Nuclear Emergency Response Centre can execute the following response measures when the station requests support:

a. Heavy mechanical equipment can be used to rule out the roadblock.

b. Helicopter which can use the vacant space in the vicinity of the station for landing shall be used for carrying the rescue personnel and the hang type rescue equipment.

(4) CSNPP has procedure 1361 delineating requirements for excavation and backfill work. CSNPP excavation and backfill contracts all require the vendors to include price for transporting the leftover excavated soil to licensed deposit area. CSNPP compound disaster accident prevention

and mitigation facilities and adjacent areas currently have no excavation work. The on going pipe trench excavation work for the addition of redundant raw water piping in on the slope of the small hill on the other side of Chien-Hua Creek away from the plant. The excavation and backfill will not affect the plant safety. The work contract also requires that any leftover soil be transported to licensed deposit area.

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

2.1.3.1 Licensee's organization / process to ensure compliance

The general procedures of periodic inspection, evaluation and remedy of the seismic category I systems/equipment/ structures, as well as the testing and maintenance of the equipment for ~~Chin Shan~~ Chin Shan NPP are covered in Procedure Nos.5121, 5122, 5123, 600 series (periodic inspection procedures) and 700 series (maintenance operating procedures), of which the corresponding periods of maintenance, inspection and testing of various seismic category I structures are listed below:

Table 2-6

Item	System/Equip./Structure	Maintenance Period	Inspection Period	Testing Period
1	Combination structure bldg (unit 1)	N/A	5 years	N/A
2	Combination structure bldg (unit 2)	N/A	5 years	N/A
3	Essential Service Water Pump House Bldg	N/A	Refueling Outage	N/A
4	5th DG Bldg (including diesel oil storage tank and oil day tank)	1.Bldg:N/A 2.Storage T'k: water draining for every 3 months 3.Day Tank: water draining for every 6 months.	1.Bldg:5 years 2.Storage T'k : N/A 3.Day T'k : N/A	1.Bldg:N/A 2.Stor.T'k:N/A 3.Day T'k:N/A
5	Condensate Water Storage Tank (including Foundation)	Water Tank :Vent valves for every refueling Outage. Foundation: N/A	Water Tank : Visual inspection: every outage Foundation: 5 years	Water Tank :N/A Foundation :N/A
6	850,000-gallon EDG Oil Storage Tank(including Foundation)	Oil Tank: water draining, 3 months. Foundation: N/A	Oil Tank : Visual inspection, every refueling outage. Foundation: 5 years	Oil Tank :N/A Foundation :N/A
7	EDG Oil Day Tank (unit 1)	6 month for water draining	Visual inspection for every refueling outage	N/A
8	EDG Oil Day Tank	6 month for	Visual inspection for every refueling outage	N/A

	(unit 1)	water draining		
9	ECCS: a. LPCI(Subsystem RHR) b. CS c. HPCI d. ADS	a. Note 1 b. Note 1 c. Note 1 d. Note 1	a. Note 1 b. Note 1 c. Note 1 d. Note 1	a. 3mon b. 3mon c. 3mon d. 18mon
10	RCIC 125VDC Cooling Water (CST)	RCIC: Note 1 Power: each outage CST: Note 1	RCIC:Note1 Power: Battery:7 days Charger:1month CST:Note1	RCIC:3month Power :each refuel. Outage CST :N/A
11	1.EDG (1~4 及 5th D/G) 2.Fuel Transfer Sys.(FTS) 3.Air Starting Sys. (ASS) (starting air compressor, non-seismic category I Air Dryer) Air Cooled 5th D/G	each refueling outage	each refueling outage	Surveillance test: 1. EDG: 1mon. 2. FTS: 3mon 3. ASS: 1mon
12	CSCW System	Note 1	Note 1	Every 3 month
13	ESW System	every 2 refueling outages	each refueling outage	Every 3 months
14	Essential Chilled Water System (No.3~5 Chiller)	each refueling outage	each refueling outage	Continuously Operating
15	RHR System	Note 1	Note 1	Every 3 month
16	Essential Power: a. Bus 3 b. Bus 4	(a) every 2 refueling outages (b) ditto	(a) each refueling outage (b)ditto	(a) every 2 refueling outages (b)ditto
17	Crane at Rx bldg 5 floor	within 1 month before each refueling outage		
18	Refueling platform	7 days before each lift of fuel bundles		
19	Fuel storage pool	N/A	1 month	N/A

Note 1: The period of maintenance/ inspection of system/ equipment shall be executed as per 700 series procedures for Chin Shan NPP.

2.1.3.2 Licensee's organization for mobile equipment and supplies

The required critical structures, systems, and components including reactor core, and spent fuel pool for unit safe shutdown are documented in the station current licensing basis (CLB) are not damaged under designed basis earthquake and have adequacy capability to shut down the unit in a safe shutdown.

Except the existing general rescue required spare equipment, the station already reviewed the required materials and equipment derived from Fukushima compound disaster accident and already procured two sets of large scale 4.16kV/1500kW mobile container type power truck and 12 sets of medium scale 480V/500kW, 480V/200kW etc. diesel generators as well as many sets of facile type gasoline/diesel generators, air compressors, combustion water pumps etc (some of them not yet delivered) and other sufficient spares for rescue needs (attachment table 2-1 ~2-4 “ CSNPP disaster rescue preparedness materials and facilities excerpted from the station procedure 113.5) .

In order to assure that the storage areas are accessible and equipment and facilities are easy to take not subject to the impact by typhoon and tsunami, the storage areas for above-mentioned equipment and facilities which is arranged by material / spare parts type or by disperse layout all have adequacy security elevation (the elevation of their lay down areas please refer to “the possible level of earthquake subsequent tsunami in Northern Taiwan” assessed by National Scientific Committee in August, 2011). The station also issued PCN to revise the procedure 113.5 to add the chapter “The storage and management of disaster first aid materials and facilities” and category A active materials and facilities such as combustor, generator, and air compressor etc shall be recorded as PM procedure and shall periodically carry out inspection and test; category B active materials and facilities such as cable, water pipe, oil pipe, fuel oil, borax, and gas etc shall be inspected every half a year. The updated procedure has the detailed specifications or control regardless to their category, storage, inspection, test etc so as to in order for sufficient spares to fully support future rescue need. (Completed after Jun 30, 2011)

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

2.1.3.3 Deviations from CLB and remedial actions in progress

According to the station current design, there is no any deviation from CSNPP’s FSAR commitment. If there is any deviation, the station shall follow the following relevant procedures to carry out safety evaluation and take corrective actions:

1. The shift engineer shall issue the repair request form as per procedure 1102.01 and judge if the deviation will impact unit safety or not as per Technical Specification or technical manual. If yes, operator shall announce it to be inoperable and take corresponding actions to put the unit in Limiting Condition for Operation (LCO). The station shall follow the station procedure 113.1&113.2 to report ROCAEC.

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

3. The following procedures will be followed in regards to the need for repair request and NCD etc corrective actions:
   (1) Procedure 112 “Evaluation and review process for the repair works of Potential and Critical

Components & environment which may result in unit trips." shall be followed in case that the repair work may have the unit trip potential of critical components & environment.

(2) Procedure 112.1 "Evaluation and review process for the Potential Dangerous works." shall be followed in case that the repair work may result in operation or maintenance problem or job safety, radiation safety, flooding, and fire etc accidents.

(3) Procedure 1114.3 "The control process for hanging the no operation card" shall be followed to complete the hanging work before the repair work starts.

(4) Procedure 1110.1 "QC engineer's review process for the site work hold point" shall be followed.

(5) Procedure 1119.09 "Code repair and replacement control" shall be followed to do the repair work.

(6) Procedure 1119.08 "Non-Code repair control" shall be followed to do the repair work.

(7) Procedure 1103.01 "Nuclear plant design change request control" shall be followed to do the design change request (DCR) control.

(8) Procedure 1103.04 "Nuclear plant spare parts and component replacement Control" shall be followed to do the replacement work.

(9) Procedure 1102.02 "Instrument and electrical equipment set point change Control" shall be followed to do the set point change control.

(10) Procedure 1102.03 "Temporary equipment change Control (Set point temporary change & temporary pipe or wiring dismantle or jump connection)" shall be followed to do the temporary dismantle or jump connection control.

(11) Procedure 1103.05 "Procedure for Dedication of Commercial Grade Items in Nuclear Safety-Related Applications" shall be followed.

2.1.3.4 Specific compliance check already initiated by the licensee

1. The station promised seismic enhancement items in response to Fukushima accident are as below:

   (1) DCR-C1-3184/C2-3185 "To install an additional loop of exposed Raw Fire Water Pipe". (Completed after Jun 30, 2011)

   (2) DCR-C1-3295/C2-3296- "To upgrade the seismic class of EDG Day Tank oil makeup piping to seismic category I". (Completed after Jun 30, 2011)

   (3) DCR-C1-3310/C2-3311- "To upgrade the seismic class of SFPACS Cooling Tower CT-15A/B associated piping to seismic category I ": This DCR can provide the alternative to reactor, drywell, suppression pool, and spent fuel pool heat removal system in case that compound disaster accident happens. (Completed after Jun 30, 2011)

2. The portion programmed by Head Office

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

(1) Planning phase

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

(2) Investigating phase

“The Replenish program of geological investigation during operation period in nuclear power plants” is contracted to Sinotech Engineering Consultant Company on November 10, 2010 to conduct the work including geophysical survey of the land and the sea surrounding the site, geophysics survey, topographic survey and each kind of tests

(3) Evaluating phase

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

b. TPC is performing ‘Seismic Probability Risk Assessment (SPRA)” in accordance with ASME code 2009 version.

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

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

(2) Except for emergency power, water injection, and cooling system are all designed seismic category 1, a seismic enhancement program for fixed first aid backup equipment and facilities such as raw water reservoir, raw water piping, gas turbine building structures and equipment etc has been proposed to increase the seismic capability of such equipment to assure the capability of sufficient backup power and water sources. (Completed by December, 2011)

C. Except that the review of the report “Geological stability and seismic hazard reevaluation project of nuclear power plant site” is arranged, TPC planned to negotiate with the National Seismic Center to discuss the following programs:

- The assessment of Lungmen’s FSAR and the development of SPRA software for Taiwan nuclear power plants.
- The evaluation experiment as well as its value analysis for Nuclear power station primary

containment crack and damage and air tightness after earthquake.

– The seismic assessment and enhancement for nuclear power station seismic category 2 structures.
– Comparison and assessment of nuclear power station seismic design specification.
– It is assessed to install two sets of seismometer in both units reactor building each floor for nuclear power station seismic monitor and application.

D. Each NPP is equipped with setup to connect with Central Meteorological Bureau Seismic and Tsunami warning System. Its alarm system and maintenance system were already setup. At present TPC is continuously collecting the transmitting data for the reference to relevant enhancement in corporation with Central Meteorological Bureau Seismic Forecast Center in future. (Completed before June 30, 2011)

E. Central Meteorological Bureau Seismic Forecast Center was contacted and negotiated to install an additional seismometer in the underground well at each plant site, including amount, locations and schedule.

F. In addition, TPC is performing a program to upgrade the plant seismic design basis from 0.3g to 0.4g. (Completed after June 30, 2011)

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

TPC calculates the impact effect to each safety related system during earthquake by adopt of seismic hazardous analysis curve and vibratory-proof intensity analysis results according to the analysis data of each NPP's "Operation active state Probability Risk Assessment Report" (Please refer to 1995 TPC active state PRA Report), and the possible accident sequences discussed between the analyzer and the NPP SRO. However, Taipower can't carry out the failure mode and its effectiveness analysis for all equipment and structures because there are too many equipment and structures and the NPP's material resources and manpower are limited so that the screening criteria are determined as follows:

1. The seismic median value for equipment or structures is equal or less than 0.3g (This rule is based on that the probability of vibratory intensity exceeding 0.3g is very low).

2. The High-Confidence-of-Low-Probability of Failure (HCLPF) value of equipment or structures is less than the maximum reasonable ground surface acceleration value which is in relation to site seismic hazards analysis curve. (HCLPF is established as 95% confidence that there is less than 5% probability of failure for the equipment/structure concerned under ground surface acceleration..

It is concluded to obtain the vibratory -proof Intensity Order List for CSNPP Essential Structures / Equipment based on above-mentioned selected principles as follows:

Table 2-7 vibratory-proof Intensity Order List for CSNPP Essential Structures / Equipment

ID No.	Structures/Equipment	Failure Mode
S_{02}	Offsite Power	Insulator Failure
S_{03}	Gas Turbine	Anchor Bolt Failure
S_{04}	Air Accumulator	Anchorage Failure
S_{05}	Power Center Transformers	Anchored Core/Coil Assemblies
S_{06}	Core Support Structure	Support Leg Buckling
S_{07}	Gas Turbine MCC	Functional Failure Of The Skid Mounted MCC's
S_{08}	Condensate Storage Tank	Shell Buckling
S_{20}	5th D/G	Support Failure
S_{09}	Reactor Vessel Support Skirt (Ring Girder)	Vessel To Girder Bolts
S_{10}	4.16-KV Switchgear (Structure Failure)	Base Plug Welds
S_{11}	Fuel Assembly	Collapse Of Fuel Rods
S_{12}	Recirculation Pumps	Snubber Failure
S_{13}	Diesel Oil Storage Tank	Shell Buckling
S_{14}	4.16-KV Switchgear (Relay Chatter)	Relay Chatter
S_{15}	ESWP MCC	Functional Failure
S_{16}	Main Control Boards	Functional Failure
S_{17}	D/G Control Panel	Relay Chatter
S_{18}	480V Power Center (Relay Chatter)	Relay Chatter

＊ Spectrum Acceleration (g)

Note:

These data are abstracted from CSNPP PRA report. Items S1 & S19 in the original report which it is assumed that the Control Room ceiling seismic-proof capability is not so good to lose its partial function are deleted because DCR-C1-1363/DCR-C1-1364 “Improvement of Control Room ceiling” was already completed. Besides, S20 is new added item which is used for the analysis data of the 5th Diesel Generator vibratory-proof intensity.

The analysis methodology by ways of event tree which is used to find out the cliff edge and safety margin in Japanese nuclear power plants is referred by the station. Please refer to attachment 2 of this Chapter “The Chin Shan NPP Stress Test Event Tree Analysis and Assessment” for detail analysis. The plant seismic case study is summarized as follows: It is assumed that earthquake already happened, it shall follow the following steps of each issue in each phase step by step if want to achieve the goal of reactor core shutdown cooling including reactor scram in subcritical condition, DC & instrument control HPCI/RCIC Injection water to RPV, AC power for low pressure water injection operable, and RHR or core spray operable. And also decay heat accumulated inside containment shall be exhausted into the sea. However, in case of loss of AC power or RHR/CS inoperable, the alternative water makeup measure shall be adopted to successfully depress the reactor pressure and seawater or fire water shall be successfully injected into reactor as well as the decay heat can be finally exhausted into atmosphere by ways of Containment Exhaust. There are two cases for the Reactor Core successful Shutdown Cooling in the seismic event tree based no above-mentioned analysis results:

(1) Reactor scram and HP/LP reactor water makeup (including containment cooling) are all successful in case of off-site power loss due to earthquake.
(2) Reactor scram successful and long term alternative reactor water makeup (including Containment Exhaust) are all successful but long term reactor water makeup is failed in case of off-site power loss due to earthquake.

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

(1) The safety margin of successful path 1 must take the minimum safety margin of each headline as representative that is 0.44g (1.05g - o.61g). The cliff-edge as defined takes the minimum safety margin of each headline as representative that is 1.05g.
(2) The safety margin of successful path 2 is expected the lowest less than 1.05g because the vibratory-proof intensity of long term alternative reactor water makeup is the lowest and its seismic median value less than 1.05g that its expected minimum value of cliff-edge is less than1.05g (pending confirmation).
(3) The safety margin of successful path is1.05g because the cliff-edge as defined in this case for each successful cooling path takes the maximum safety margin 1.05g of the seismic intensity of each headline as representative. It means that the plant can not achieve the goal of Core Shutdown Cooling because of reactor unable to scram.

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

1. According to the initiating events of seismic event trees, the median value for a loss of off-site power caused by DBE earthquake is 0.61g. The critical component which is Skid Anchor Bolt of Gas Turbine has been incorporated in the Gas Turbine seismic evaluation and enhancement program completed by TPC Construction Department. (Completed after June 30, 2011)

2. According to seismic event tree analysis, fuel support structure is damaged due to the cliff-edge of 1.05 g earthquake so as to result in reactor unable to scram. In this condition, ATWS shall be automatically actuated and boron shall be immediately injected into reactor by means of its relevant essential power. After Fukushima accident, borax is additional procured and its mobile injection measure was already prepared and incorporated in the plant procedure. After this enhance measure, reactor can be put in subcritical condition and the plant's cliff-edge will be changed from fuel support structure 1.05g to Condensate Storage Tank (CST) 1.15g. (Completed after June 30, 2011)

3. According to the seismic event tree analysis, one of the successful reactor cooling path is that reactor shall be able to relieve the reactor pressure in order to assure that low pressure water injection can provide with sufficient cooling capacity. The vibratory-proof intensity of reactor pressure relief is designed as 0.79g and its critical component is its Accumulator. The plant already prepared sufficient nitrogen gas bottles and mobile air compressors in the first physical checkup so as to provide SRV emergency backup gas sources to remain reactor pressure relief function in case of Accumulator damaged after earthquake. (Completed after June 30, 2011)

4. According to seismic event tree analysis, one of the successful reactor cooling paths is mobile water injection via BCSS or RHR system by raw water pump, fire water pump, or fire water reservoir truck. Its relevant water injection path and water source was already programmed in Overall Checkup Program Item 4 "Review of Ultimate Heat Sink" and its relevant operation process was also incorporated in unit URG procedure. Moreover, except for seismic-proof enhancement of raw water reservoir as well as raw water pipe, the seismic-proof enhancement of RCIC and RHR A injection paths are evaluated in connection with the new evidence of Shanchiao Fault.(Completed after June 30, 2011)

2.2.2 Range of earthquake leading to loss of containment integrity

The station major enclosure structures are sitting in the primary containment in Combined Structural Building including Reactor Vessel Pedestal, Reactor Concrete Shield Wall, Torus Support Column and Biological Shield Wall. According to the Chin Shan NPP 1990 English version Seismic PRA volume III Appendix C2 "Seismic Fragility Analysis" Table 5-1, the Surface acceleration median value for above-mentioned Structures are very high as follows:

Structure	Surface acceleration median value
Reactor Vessel Pedestal	5.6g
Reactor Concrete Shield Wall	7.5g

Torus Support Column	7.8g
Biological Shield Wall	8.0g

Meanwhile, the probability of containment losing its enclosure capability is very low because Surface acceleration median value for Combination Structure Building is 2.8g in accordance with the seismic margin preliminary assessment report --- a progress report for a currently ongoing project.

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

Chin Shan NPP is located in Shimen District, New Taipei City, Northern Taiwan at longitude 121^{o} 35'E, latitude 25^{o} 18'N. The site which its width is 200m and its length is 1.2 km occupies a land area of 233 hectares.

The site area is divided into two subareas -- Chien-Hua area in west side and Hsiokeng area in east side and they are separated with a hill and are connected through the Chien-Hua Tunnel. ShiaoKern area in east side is a Hsiokeng Creek river valley land. Hsiokeng Creek flows into East Sea from south to north direction through Hsiokeng. The major facilities allocated in this area are Spare Parts warehouse, Improvement Division Building, and Radiation Laboratory etc. Chien-Hua area in west side is a Chien-Hua Creek downstream river valley land. The route of Chien-Hua Creek passing through the site is changed into artificial drainage trench which is built-up with jetty, protection slope and it flows into East Sea from south to north direction through Chien-Hua area. The station's major building and facilities are all allocated in this area. During the site preparation period, the topography of the site by fill of soil is from the south to the north by its elevation from high to low and unit building ground elevation as well as Chien-Hua Creek outlet jetty are all filled to 12m (resurvey by Sinotech Engineering Consultant, Ltd., its elevation still higher than 11m). The major purpose is to prevent from site area flooding in case of natural incidents.

The major buildings and facilities at Chin-Shin NPP are all located in Chien-Hua area where both sides are surrounded by hills. There are three raw water reservoirs with capacity of 2000 metric ton, 1000 metric ton, and 600 metric ton respectively. In case these water pools were damaged due to earthquake, the spate water inundates the site area which its compass areas are so extensive that site flooding will not happen. There are one set of 100000metric ton raw water reservoir and two sets of 3000 metric ton raw water reservoirs allocated in the wind power area in the west side. Because the topography of east side in this area is higher and north side and west side is lower, it is judged that the spate water will flow from high to low in the direction by the north to west. Even if it flow to the east (Building areas), it still flow into the sea through Chien-Hua Creek artificial jetty. Besides, the building ground elevation is gradually lower from south to north, the spate water shall be dumped into the sea so that site area will not be flooded even if there is spate water on mountain.

The Hsiokeng Creek in east side is 4km long and never happen mud/rock slide incidents since site construction. According to the “Soil and Water Conservation Bureau, Council of Agriculture, Executive Yuan Accident Prevention Network” issued data, Hsiokeng Creek is not included and the mud/rock slide potential of 1.5km upstream of this stream is medium. It means that this stream does not belong to mud/rock slide potential stream and there is no land development in this area. Its nearby areas are closely covered with vegetation and its slope protection is good.

The Chien-Hua Creek in west side is 8 km long. According to the Soil and Water Conservation Bureau, Council of Agriculture, Executive Yuan Accident Protection Network” issued data, the mud/rock slide potential of 1.5km upstream of this stream is medium (please refer to attachment 3) and it is 4.2 km far from the site. The Chien-Hua Creek had never happen mud rock flow incidents according to the consult result from the Soil and Water Conservation Bureau Accident Prevention Center and there is no large scale land development in this area except for “CSNPP Spent Fuel Medium Phase storage Program”. The upstream of this stream is contracted out to conduct “Environmental monitoring during the construction of CSNPP Spent Fuel Medium Phase storage Program” according to Environmental impact assessment regulations.

The variance monitor of Chien-Hua upstream basin through satellite image is conducted every half a year and it is never found there is a collapsed variant land in the Chien-Hua upstream basin.

The most serious storming typhoon had recently ever happened in Greater Taipei area are Xangsane Typhoon on 2000/10/31and Nari Typhoon on 2001/9/16. After Nari Typhoon, Chin Shan NPP authorized E & C Engineering Consultant Co. to “Assessment” and E & C cooperated with Jynyin Civil Engineering Consultant Company to conduct “The Mud/rock slide potential Assessment Report of Hsiokeng Creek and Chien-Hua Creek”, the Hsiokeng Creek and Chien-Hua Creek can be attributed as low potential and low risk or medium degree. Even if upstream happen Mud/rock slide incidents, the station is 4.2km away from Chien-Hua Creek and 3.5km away from Hsiokeng Creek, far beyond the scope of mud stone accumulated area. The site will not be impacted.

2.2.3.2 Weak points and cliff edge effects

The station’s three sets of raw water reservoirs located on east of stack area and one set of 100,000 metric ton raw water reservoir as well as three sets of 3000 metric ton raw water reservoirs are all designed as general storage structure so that pool body damage may result in water overflow when beyond DBE earthquake happens. After review of the above-mentioned beyond DBE earthquake subsequent beyond DBF flooding, overflow of those pools shall not result in flooding of Chien Hua area areas so as to impact the major essential building and its facilities. Moreover, after review of the mud rock condition of Chien-Hua Creek and Hsiokeng Creek, the plant will not be impacted by mud rock event.

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

Chin Shan NPP has taken the following enhancement measures to strengthen its protection capability based on that raw water reservoir body may be damaged so as to result in pool overflow:

1. Raw Water Reservoir or Pool Body Damage:
   (1) TPC Construction Department had already taken actions to carry out the seismic assessment of one 100,000 metric ton reservoir and two 3000 metric ton raw water reservoir body and their reinforcement design to promote their seismic capability. (Completed after June 30, 2011)
   (2) The station plans to install water tight doors at the entrances in of 5th EDG Building, and floodgates at the entrances of Combination Structure Building in order to avoid that spate water directly crashes into essential building in case of reservoir or pool body damaged. (Completed after June 30, 2011)

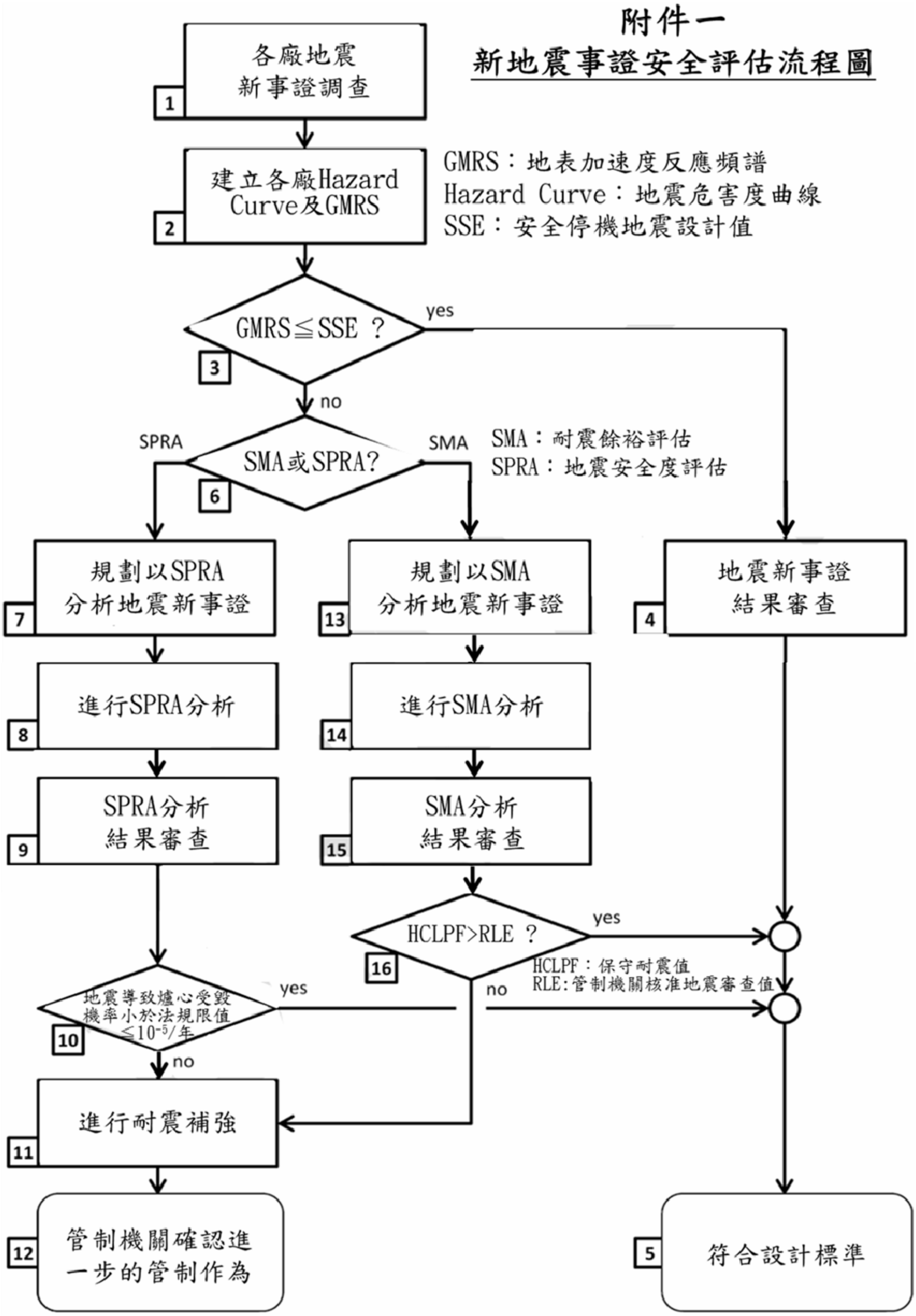
2. Mud rock flow protection:
   (1) The station already revised procedure 104.37 to incorporate Chien-Hua Creek and Hsiokeng Creek into the monitoring scope. (Completed after June 30, 2011)
   (2) The station shall follow the following procedures to announce mud rock potential stream if day raindrop reaches 500mm/day according to Central weather Bureau announced extra storm alert.
   -- 104.37 Chien-Hua Creek mud rock monitor
   -- 106.9.4 Crisis management and response process
   -- The temporary monitor measures of Chien-Hua Creek outlet water level

References:
a. Official Document
1. 經濟部中央地質調查所特刊第十九號(經濟部中央地質調查所)

b. Industrial Document
N/A

c. Taipower Internal Document
1. 「核一廠終期安全分析報告」(台灣電力公司)
2. 「核一廠第三次十年耐震安全評估計劃」(國立中央大學)
3. 「金山核能一廠事故淹水分析報告」(台灣電力公司)
4. 「營運中核能電廠補充地質調查工作」(中興工程顧問公司)
5. 「核能一廠功率運轉活態安全度評估」(核研所)
6. 「小坑溪及乾華溪土石流危險度評估報告」(益鼎公司、精英大地工程顧問有限公司)
7. 104.37 程序書:「乾華溪土石流監測」
8. 106.9.4 程序書:「危機管理及應變作業程序」
9. 112 程序書:「潛在性及關鍵性組件/環境造成機組跳機之檢修工作評估審查作業程序」
10. 112.1 程序書：「潛在性危險工作評估審查作業程序」
11. 113.5 程序書：「災害防救要點」
12. 512.1 程序書：「核能電廠強震後緊急處理步驟」
13. 512.2 程序書：「強烈地震後全廠檢查」
14. 512.3 程序書：「強烈地震停機後再啟動前全廠重要設備結構物查核表」
15. 1102.01 程序書：「設備檢修工作管制程序」
16. 1102.02 程序書：「儀器、電氣設備設定點變更管制」
17. 1102.03 程序書：「臨時性設備變更(設定值暫時變更及臨時性線管路拆除,跨接)工作管制程序書」
18. 1103.01 程序書：「電廠設計修改管制」
19. 1103.04 程序書：「核能電廠備品或組配件更新之技術作業管制程序書」
20. 1103.05 程序書：「核能同級品組件檢證程序書」
21. 1109.08 程序書：「非法規修補(Non-Code Repair)管制程序」
22. 1109.09 程序書:「按法規要求執行機械組件之修理與更換 (Code Repair & Replacement)管制程序書」
23. 1110.01 程序書：「品質人員現場工作停留查證作業程序」
24. 1114.03 程序書：「禁止操作卡管制程序」
25. 1115.01 程序書：「不符合品質案件處理管制程序」
26. 「乾華溪出水口水位監測暫行措施」

Attachment 1 Evaluation Flow Chart for New Seismic Evidence



Attachment 2 CSNPP Seismic case study

The event tree of the CSNPP Seismic case study includes a total of 11 headings, beginning with the initiating event as the first heading and ending with the shutdown cooling condition as the last heading. Each heading in the development of the event tree sequences is described as follows:

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

   For a loss of off-site power event caused by earthquakes please refer to CSNPP Seismic Event Tree EO.EVT. This Initiating event is defined for simultaneously loss of off-site power and gas turbine (that means loss of 345 kV* 69 kV* G/T) as shown in figure 1-1 (this attachment). The median value for a loss of off-site power event caused by earthquakes in the station is 0.61g and its critical equipment (weak point) is G/T Skid Anchor Bolt.

2 Reactor Scram:

   It is conservatively supposed that it will directly result in core melt because Anticipated Triensient Without Scram (ATWS) will happen if loss of off-site power happened and reactor scram is failed. This issue is defined for that Control Rod Drive Mechanism (CRDM) failed to insert control rod as shown in figure 1-1. The vibratory intensity of CRDM is 1.05g and its critical equipment (weak point) is Core Top Guide.

3. DC Power and I & C:

   It is conservatively supposed that it will directly result in core damage because loss of off-site power caused by earthquakes happened and the DC power for steam-driven RCIC system or its instrumentation control power as well as the DC power for RCIC & HPCI pump or its instrumentation control power are all fail although reactor scram is successful. Control power for RCIC pump is fed from 125 V DC Bus 1 and control power for HPCI pump is fed from 125 V DC Bus 6. Moreover, control panels in control room are vulnerable to be failed due to earthquake except for consideration of conventional type relays. RCIC and HPCI shall be inoperable if one of them is lost. This issue is defined for simultaneously loss of 125V DC Bus 1 and Bus 6 (that means loss of 125V DC Bus 1 &125V DC Bus 6 or loss of I&C) as shown in figure 1-1. The critical equipment (weak point) of DC system and I&C is control panel which its vibratory intensity is 2.65g.

4. RCIC and HPCI Water Injection:

   Same as the former item, loss of off-site power caused by earthquakes; steam driven RCIC and HPCI pumps are inoperable due to RCIC and HPCI pump itself or its water supply (CST) failure; although reactor scram is successful. This issue is defined for simultaneously loss of Reactor Core Isolation Cooling (RCIC) and High Pressure Coolant Injection (HPCI) (that means loss of RCIC & HPCI or CST) as shown in figure 1-1. Although the vibratory intensity of RCIC and HPCI is so strong (> 3g), the vibratory intensity of CST is only 1.15 so that the critical equipment (weak point) is CST.

5. Reactor Pressure Relief:

   Loss of off-site power due to earthquake, reactor scram, and early phase high pressure water injection successful, but long term high pressure and low pressure water makeup inoperable due to loss of on-site AC power or RHR / SPCM inoperable and reactor SRV unable to relieve pressure in time so that low pressure water injection system can't inject water to reactor and further result in core melt. The station is designed to equip with 10 sets of Safety Relief Valves (SRV). Under the condition that high pressure water injection system is inoperable and without ATWS, 2 sets of SRV shall be opened to relieve the reactor pressure in order for that low pressure water injection system can inject water to reactor. This issue is defined for equal or more than 9 sets of SRVs failed to open as shown in figure 1-1 of this chapter. The vibratory intensity of Reactor pressure relief is 0.79g and its critical equipment (weak point) is Accumulator.

6. Site AC Power and ECW:

   Loss of off-site power due to earthquake, reactor scram and early phase high pressure water injection successful, but long term high pressure and low pressure water makeup inoperable due to loss of on-site AC power or RHR/SPCM failure, it will result in core melt. The station AC power is equipped with Emergency Diesel Generators DG1A& DG1B, and the 5th Diesel Generator DG-5 for both units common use. DG1A& DG1B are water-cooled type by ways of ESW cooling (also called UHS); the 5th Diesel Generator 5th EDG is air-cooled. RHR/SPCM Heat Exchangers are cooled by CSCW. This issue has two conditions as follows:

A. High Pressure Water Injection is successful:

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

B. Failure of High Pressure Water Injection and Water Makeup

If long term high pressure water injection and water makeup are inoperable, on-site AC power shall feed power to 4 sets of LPCI pumps and 2 set of CS pumps in order for them to carry out low pressure water injection to reactor. However, low pressure water injection and water makeup are reluctant to achieve their intended function if high pressure water injection and water makeup are inoperable because it still needs AC power and SPCM. Therefore, jump directly to item 9 to inquire about alternative core water makeup.

This issue is defined for simultaneously loss of all diesel generators (DG1A & DG1B& DG-5) and its relevant support systems (that is 4.16 kV SWGR + DG1A * DG1B * DG-5+CSCW+ESW) as shown in figure 1-1. The vibratory intensity of AC power is 1.56g and its critical equipment (weak point) is 4.16 kV SWGR.

7. LPCI and LPCS Reactor Water Makeup:

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

8. Containment Cooling and RHR:

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

   This issue is defined for simultaneously loss of RHR and SPCM (that is RHR +ESW) as shown in figure 1-1. The vibratory intensity of Containment Cooling and RHR is 2.65g and its critical equipment (weak point) is ESW.

9. Alternative Core Water Makeup, Fire Water and Seawater:

   Following the above-mentioned issue, Fire water from BCSS system or fire water reservoir truck or RHRSW seawater is used to provide alternative core water makeup as per URG procedure 1451. It is conservatively supposed that it will directly result in core melt if alternative core water makeup is fail. Containment cooling via containment exhaust shall be executed if alternative core water makeup is available. This issue is defined for loss of fire water or fire water reservoir truck or RHRSW seawater as shown in figure 1-1. The vibratory intensity of alternative core water makeup and its critical equipment are pending check.

10. Containment Venting:

    Following the above-mentioned issue, Containment Cooling still depends on Containment Exhaust in case that long term alternative high pressure core water makeup is conservatively supposed to be successfully operated. If Containment Exhaust is fail, it is conservatively supposed that it will result in core melt. This issue is defined for Containment Exhaust failure as shown in figure 1-1. The vibratory intensity of Containment Exhaust is so strong (> 3g) that there is no potential damage from effects of earthquake.

11. Shutdown Cooling -- The terminal issue of this event tree.

    A. Reactor core shutdown cooling is successful so as not to induce reactor core melt.
    B. Reactor core damage due to failure of Reactor Core Shutdown Cooling.

The other initiating events induced by earthquake are all considered and incorporated in the success paths as shown in the attachment 1-1.

Seismic event fragility analysis

In the pressure test for seismic event, system fault tree for all SSC, includes initiating event but deletes item (7) (definitely cause core melt) and item (9) (needs more information) and final term (shutdown cooling), there are 8 Topics, illustrated below:

(1)Initiating event: ceramic insulators for 345kV/69kV are common used, seismic fragility median value is 0.4g, value for GT is 0.61g, therefore initiating event EO is 0.61g.

(2)Reactor Scram: value for ring girder is 1.22g, for core support structure is 1.05g, for fuel assembly is 0.61g, for the other SSC are larger than 3g. Therefore, median value for this topic is 1.05g.

(3)DC power and I&C : median value for 125VDC SWBD is 6.25g, for battery and rack the value is larger than 3g, for control room panel it is 2.65g, therefore it is 2.65g for this topic.

(4)HPCI/RCIC: median value for RCIC is larger than 3g.

(5) RPV depressurize, median value for SRV/ADS accumulator is 0.79g, for valve is larger than 3g, therefore it is 0.79g for this topic.

(6)AC power and CSCW/ESW, median value is 1.56g for 4.16kV SWGR, for EDG-1A/1B is larger than 3g, for 5th EDG is 1.2g, for CSCW is larger than 3g, for ESW is 2.65g, therefore it iss1.56g for this topic.

(7)Containment cooling/RHR: assuming AC power is successful, median value for RHR pump/heat exchanger/valve is larger than 3g, for ESW is 2.65g, therefore it is 2.65g for this topic.

(8) Containment vent: median value for containment vent is larger than 3g, therefore it is 3g for this topic.

Based on the above-mentioned CSNPP seismic case study, it is concluded that there are two kinds of Core shutdown Cooling successful paths as follows:

A. The accident sequences for both reactor scram and long term alternative high pressure core water makeup including containment cooling are all successful under the condition of off-site power loss due to earthquake.
B. The accident sequences for successful long term alternative high pressure core water makeup including Containment Exhaust under the condition that off-site power is lost due to earthquake and high pressure core water makeup is fail but reactor scram is successful.

The safety margin and the cliff-edge of each successful path are described as follows:

A. The safety margin of successful path 1 shall take the lowest value of those issues as the representative that is only 0.44g (.1.05g - 0.61g). The cliff-edge of successful path 1 as defined shall take the lowest vibratory intensity value of those issues as the representative that is only 1.05g.

B. The cliff-edge of successful path 2 is expected the lowest <1.05g because its alternative core water makeup is pending check and its safety margin is expected to be the lowest <1.05g.

C. The cliff-edge of those cases is defined as to take the lowest vibratory intensity of those successful cooling paths which have the highest safety margin as the representative that is the successful path 1 (1.05g).

Event tree analysis for refueling outage:

POS 3 (the time from initiation of RPV vessel opening to the end of cavity flooding) is the highest period of the whole refueling outage, since the decay heat is still high and water inventory is low. There are 4 event trees for POS3, illustrated below:

(1) Initiating event C3E1B (running subsystem of RHR was being isolated): The running (operating) RHR subsystem was being isolated due to any reason, but can be fixed and returned to run within 2 hours. For operators action, they can either fixed the failed subsystem or start to run the backup subsystem.

(2) Initiating event C3E1T (common RHR suction valve being isolated): The common suction valve E11-F008 was being isolated due to any reason, but can be fixed within 2 hours.

(3) Initiating event C3E2B (loss of running RHR subsystem): The subsystem stoped operation due operator wrong action and it can not be fixed within 2 hours. Operatoe must find and run another RHR subsystem to remove decay heat.

(4) Initiating event C3E2T (common RHR suction line lost): The common RHR suction line failed due to any reason and can not be fixed within 2 hours. Operators must find another alternate way to remove decay.

Of the 4 initiating events above, C3E2T is the most severe event, as discussed below:

(1) Initiating event is 2 (two) RHR subsystem failed and can not be fixed within 2 hours. Since seismic median value for this system is larger than 3g, the critical component is power center 3A/4A with value 1.03g.

(2) Heading/Top Event M(S), MSIV isolated: 2 RHR subsystems failed and directly cause the core to melt. However, MSIV was Fail-Close designed equipment, probability of failure to close is very low and can be neglected.

(3) Heading/Top Event DC power and I&C :seismic caused 2 (two) RHR subsystem to failure but MSIV successfully closed. However, SRV failed due to failure of I&C, core was assumed to melt. The I&C was traditionally designed (equipped with traditional EM relay) failure

probability is high if seismic occurred.

(4) Heading/Top Event RPV depressurization R(V): 2 RHR subsystem failed due to seismic and MSIV closed successfully, but RPV failed to depressurize. The low pressure ECCS injection system can not inject water to the core. There 10 SRVs in CSNPP (for each reactor), vibratory intensity is 0.79g, its critical component is accumulator.

(5) Heading/Top Event AC power and CSCW/ESW: this top event definitely caused the core to melt.(PC 3A/4A failed)

(6) Heading/Top Event LPCI/CS ((E)): this topic definitely caused the core to melt. (PC 3A/4A failed)

(7) Heading/Top Event CRD boiling heat remove (S(T)): this topic definitely caused the core to melt. (PC 3A/4A failed)

(8) Heading/Top Event RHRSW containment flooding (F(L)): this topic definitely caused the core to melt. (PC 3A/4A failed)

(9) Heading Shutdown cooling: this is the end of event tree analysis. A means success, B mean core melt

According to the discussion above, seismic caused 2 RHR subsystems to fail, incorporated with loss of shutdown cooling, the cliff edge is the initiation event which is 1.03g. 。

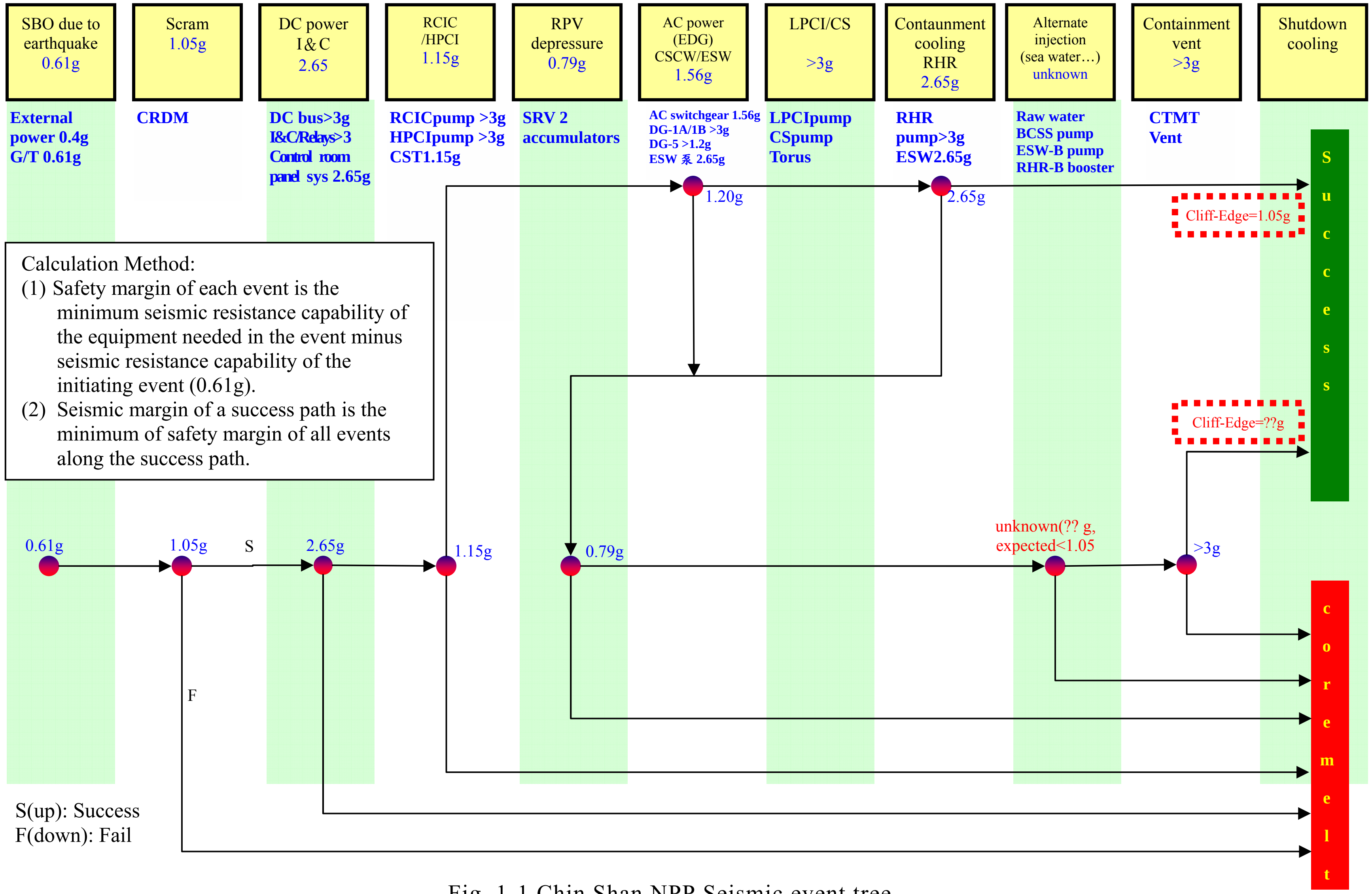


Fig. 1-1 Chin Shan NPP Seismic event tree

Table 1-1 CSNPP Seismic Assessment Event Tree Sequence Check List

Seismic Event tree	Description	Whether consideration of Successful Path in Seismic Stress Test Event Tree
EO	Earthquake and Loss of Off-site Power	Yes
ES	Earthquake and SRV / Accumulator damaged	Yes
EOS	Earthquake and Loss of Off-site Power and SRV / Accumulator damaged	Yes
EO5	Earthquake and Loss of Off-site Power and the 5th EDG damaged	Yes
EO5S	Earthquake and Loss of Off-site Power and the 5th EDG damaged and SRV/ Accumulator damaged	Yes
EC	Earthquake and without ATWS	Yes
ECS	Earthquake and without ATWS and SRV/ Accumulator damaged	Yes
ECO	Earthquake and Loss of Off-site Power and without ATWS	Yes
ECOS	Earthquake and Loss of Off-site Power and without ATWS and SRV/ Accumulator damaged	Yes

Table 1-2　Fragility Analysis (1/4)

Initiating event	EO	System fault tree	345 kV*69 kV*G/T	fragility median value (Am, g)
SSC	Failure mode	Median value(Am, g)	βr	βu
Ceramic insulator (345/69 kV Switchyard)	Support	0.40	0.20	0.24
Gas Turbine (G/T)	Skid Mounted MCC	1.08	0.39	0.30
	Skid Anchor Bolt	0.61	0.08	0.18
Heading	SCRAM	System fault tree	NA	fragility median value (Am, g)
SSC	Failure mode	Median value (Am, g)	βr	βu
Reactor Vessel Support Skirt (Ring Girder)	Vessel to Girder Bolt	1.22	0.27	0.36
CRD Housing Supports	NA	＞3	NA	NA
Control Rods	Insertability	＞3	NA	NA
Control Rods Drive	NA	＞3	NA	NA
Core Support Structure	Shroud Support Leg Buckling	1.05	0.40	0.38
Fuel Assembly	Collapse of Fuel Rods.	1.70	0.34	0.33

Table 1-2 fragility analis (2/4)

Heading	DC power I&C	System fault tree	125VDC1*125VDC6 + I&C	fragility Median value (Am, g)
SSC	Failure mode	Median value (Am, g)	βr	βu
125 VDC Switchboard	Function	6.25	0.31	0.48
125 VDC Batteries and Racks	Function & Structure	＞3	NA	NA
Control Room Panels System	Relay Logic Panel	2.65	0.35	0.38
Heading	RCIC/HPCI	System fault tree	RCIC*HPCI + CST	Fragility Median value (Am, g)
SSC	Failure mode	Median value (Am, g)	βr	βu
RCIC Pump	NA	＞3	NA	NA
RCIC Turbine	NA	＞3	NA	NA
HPCI Pump	NA	＞3	NA	NA
HPCI Turbine	Taper Pins and Anchor Bolts	＞3	NA	NA
CST	Shell Buckling	1.15	0.09	0.33

Table 1-2 Fragility Analysis (3/4)

Heading	RPV de-pressurize	System fault tree	ADS/SRV	fragility Median value (Am, g)
SSC	Failure mode	Median value (Am, g)	βr	βu
Accumulator	Anchor	0.79	0.37	0.48
Valve (ADS AOV)	Function	＞3	NA	NA
Heading	AC power and CSCW/ESW	System fault tree	4.16 kV Switchgear + DG-1A*DG-1B* DG5 + CSCW + ESW	fragility Median value (Am, g
SSC	Failure mode	Median value (Am, g)	βr	βu
4.16 kV Switchgear	Chatter	2.25	0.29	0.34
	Base Plug Welds	1.56	0.32	0.37
DG5	Support	1.20	0.50	0.50
DG-1A/DG-1B	NA	＞3	NA	NA
CSCW Pump	NA	＞3	NA	NA
CSCW Heat Exchanger	NA	＞3	NA	NA
ESW Pump	NA	＞3	NA	NA
ESW Sluice Gate	NA	＞3	NA	NA
ESW Traveling Screen	NA	＞3	NA	NA
ESWP MCC	Function	2.65	0.31	0.44

Table 1-2 Fragility Analysis (4/4)

Heading	Containment cooling/RHR	System fault tree	RHR/SPCM + ESW	fragility median value (Am, g)
SSC	Failure mode	Median value (Am, g)	βr	βu
RHR Pump	Anchor Bolt	＞3	NA	NA
RHR Heat Exchanger	Anchor Bolt	＞3	NA	NA
RHR Valve	NA	＞3	NA	NA
ESW System	NA	2.65	0.31	0.44
Heading	Containment vent	System fault tree	CTV	fragility Median value (Am, g)
SSC	Failure mode	Median value (Am, g)	βr	βu
CTV Valve	NA	＞3	NA	NA

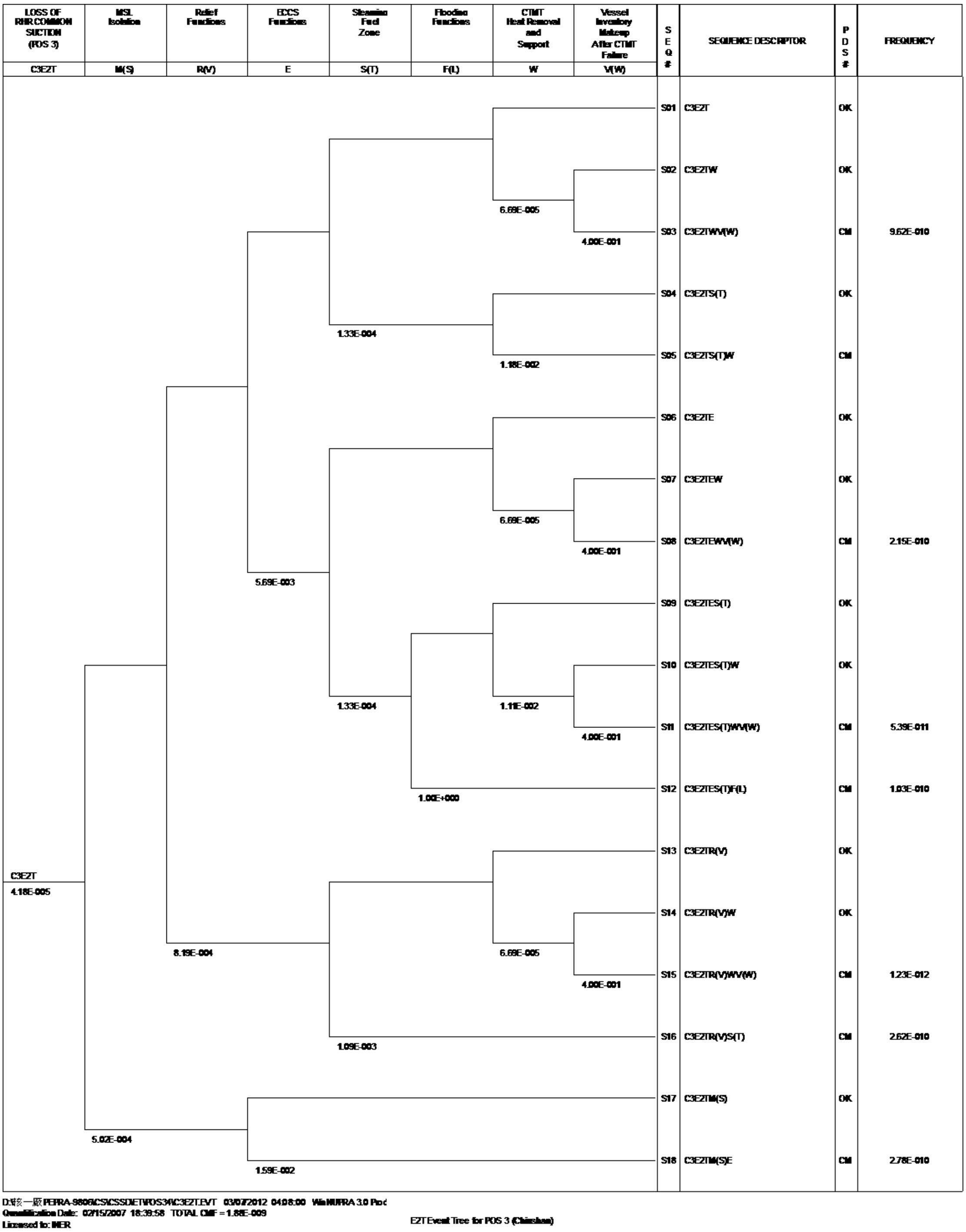


Fig1-2. Event tree analysis for refueling outage7

Attachment 3 Potential Mud/Rock Slide map in Chien-Hua Creek

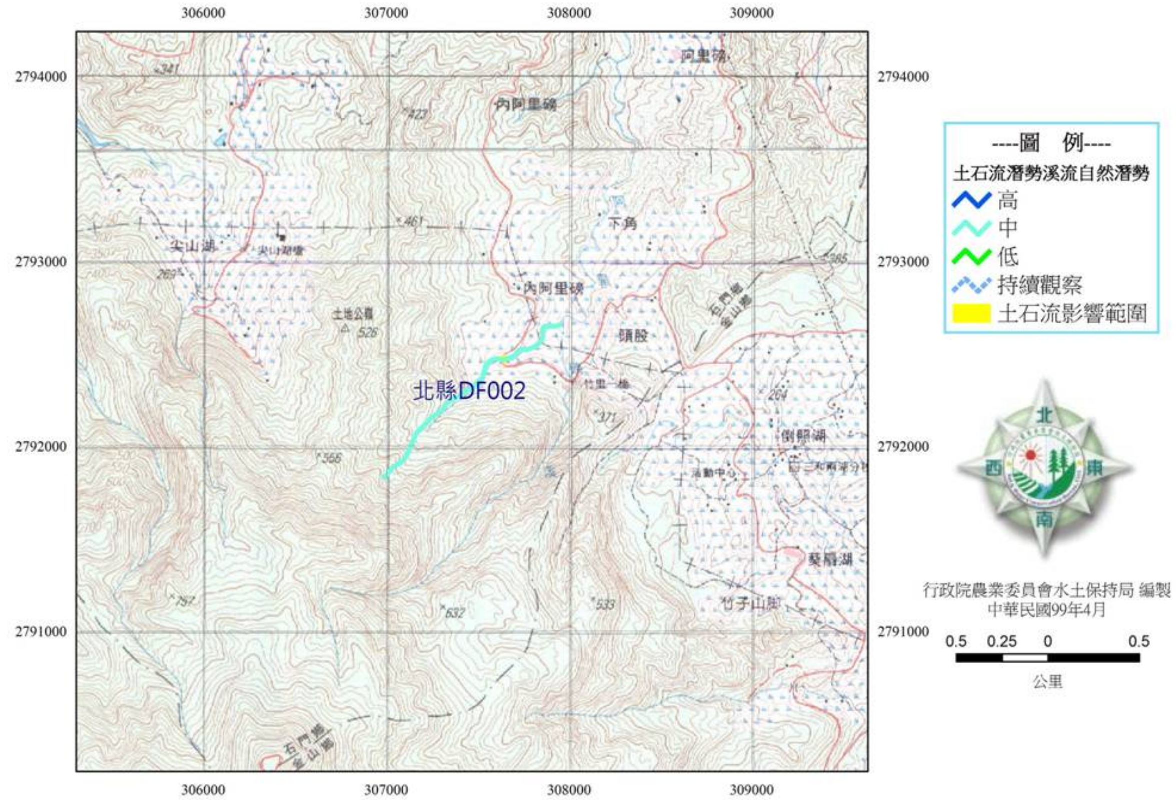


Table2-1 of procedure 113.5 -CSNPP existing first aid required materials and facilities for response to the compound disaster accident (Category A)

Item No.	Equipment / facility name & its use	Specifications		Storage Place & its elevation(EL)	Responsible Section
A-12	Diesel Generator for OSC spare	480V/400kW		#5 D/G West side, OSC Spare power, EL 11.3m	Electrical Section
A-13	Gasoline Generator for general spare	110V 220V	/3kVA	G/T Electrical Room, EL 21.9m	SWYD Subsection
A-14	Gasoline Generator for general spare	110V 220V	/3.5kVA	G/T Electrical Room, EL 21.9m	SWYD Subsection
A-15	Gasoline Generator for general spare	110V 220V	/4.1kVA	Tool Room, EL 9.15m	Machine & Tool Subsection
A-16	Gasoline Generator for general spare	110V 220V	/4.1kVA	Tool Room, EL 9.15m	Machine & Tool Subsection
A-19	Gasoline Generator for welding power	110V/180A		Machine Shop, EL 9.15m	Machine Shop Section
A-20	Gasoline Generator for welding power	110V/180A		Machine Shop, EL 9.15m	Machine Shop Section
A-21	Gasoline Generator for welding power	110V/180A		Machine Shop, EL 9.15m	Machine Shop Section
A-22	Diesel Generator for welding power	110V/180A		Machine Shop, EL 9.15m	Machine Shop Section
A-23	Diesel Generator for welding power	110V/180A		Machine Shop, EL 9.15m	Machine Shop Section
A-24	Diesel Generator for welding power	110V/180A		Machine Shop, EL 9.15m	Machine Shop Section
A-25	Diesel Generator for welding power	110V/250A		Machine Shop, EL 9.15m	Machine Shop Section
A-26	Diesel Generator for welding power	110V/300A		Machine Shop, EL 9.15m	Machine Shop Section
A-27	Diesel Generator for welding power	110V/300A		Machine Shop, EL 9.15m	Machine Shop Section
A-28	Diesel Generator for welding power	110V 220V	/320A	Machine Shop, EL 9.15m	Machine Shop Section
A-31	Gasoline Generator for fire fighting power	110V 220V	/3.0kVA	Onsite Fire Station, EL 10.7m	Fire Protection Subsection
A-32	Gasoline Generator for fire fighting power	110V 220V	/3.0kVA	Onsite Fire Station, EL 10.7m	Fire Protection Subsection
A-35	Gasoline Engine Pump for general use	3" § Lift 31M		Tool Room, EL 9.15m	Machine & Tool Subsection

Item No.	Equipment / facility name & its use	Specifications	Storage Place & its elevation(EL)	Responsible Section
A-36	Gasoline Engine Pump for general use	3" § Lift 31M	Tool Room, EL 9.15m	Machine & Tool Subsection
A-37	Gasoline Engine Pump for general use	2" § Lift 30M	Tool Room, EL 9.15m	Machine & Tool Subsection
A38	Gasoline Engine Pump for general use	2" § Lift 30M	Tool Room, EL 9.15m	Machine & Tool Subsection
A39	Gasoline Engine Pump for general use	2" § Lift 30M	Tool Room, EL 9.15m	Machine & Tool Subsection
A-40	Gasoline Engine Pump for fire fighting power	10kg/396Gal/min	Onsite Fire Station, EL 10.7m	Fire Protection Subsection
A-41	Gasoline Engine Pump for fire fighting power	10kg/396Gal/min	Onsite Fire Station, EL 10.7m	Fire Protection Subsection
A-55	Mobile Diesel Hoist	25metric ton	Heavy Machine Shop, EL 8.5m	Machine & Tool Subsection
A-56	Mobile Diesel Hoist	14 metric ton	Heavy Machine Shop, EL 8.5m	Machine & Tool Subsection
A-57	Lift Truck (Diesel Oil)	14 metric ton	Heavy Machine Shop, EL 8.5m	Machine & Tool Subsection
A-58	Lift Truck (Diesel Oil)	7 metric ton	Heavy Machine Shop, EL 8.5m	Machine & Tool Subsection
A-59	Lift Truck (Diesel Oil)	5 metric ton	Heavy Machine Shop, EL 8.5m	Machine & Tool Subsection
A-60	Lift Truck (Diesel Oil)	3.5 metric ton	Heavy Machine Shop, EL 8.5m	Machine & Tool Subsection
A-61	Oil pressure type lift-off vehicle for overhead operation	Load100kg/10M	Heavy Machine Shop, EL 8.5m	Electrical Security Subsection
A-62	Fire Tanker	$10M^3$ Fire water	Onsite Fire Station, EL 10.7m	Fire Protection Subsection
A-63	Chemical Fire truck	Equip with fire foam and powder	Onsite Fire Station, EL 10.7m	Fire Protection Subsection
A-64	Fire Equipment vehicle	Equip with power lighting, pump , generator, destroy tools etc	Onsite Fire Station, EL 10.7m	Fire Protection Subsection
A-65	Ambulance	Equip with first aid stretcher /bed& legal appliance	Onsite Fire Station, EL 10.7m	Fire Protection Subsection

Table 2-2 of procedure 113.5 -CSNPP existing first aid required materials and facilities for response to the compound disaster accident (Category B)

Item No.	Equipment / facility name & its use	Specification / Quantity	Storage Place & its elevation(EL)	Responsible Section
B-08	ESW pump spare motor	4.16kV/400HP	#2 warehouse, EL 18.9m	Electrical Section
B-09	RHR pump spare motor	4.16kV/1000HP	#2 warehouse, EL 18.9m	Electrical Section
B-10	CRD pump spare motor	460V/250HP	#2 warehouse, EL 18.9m	Electrical Equipment Subsection
B-11	CSCW pump spare motor	460V/250HP	#2 warehouse, EL 18.9m	Electrical Equipment Subsection
B-12	Satellite telephone	Full set	#1/#2main Control Room, EL 28m	Electrical Equipment Subsection
B-13	Microwave communication	Full set	#1Microwave Station, EL 85.7m	Electrical Equipment Subsection
B-21	Baffle sand bag	20kg/bag x 4300 pc	Allocate in each unit 37entrances and exits, EL 11.3m	Civil Maintenance Subsection
B-22	Floating material handling tools	Wooden hammer, broom, trash bag etc	Pump house working room, EL 8m	Gas Turbine Subsection
B-29	Oil absorbent boom	Unweave cotton cloth 10'x8" ∮ x10 pieces	850000gal oil tank south side equipment & material room, EL 21.9m	Chemistry Section/ Environmental Protection Subsection
B-30	Manual press type oil pump	55cmx1.5cm ∮ x5 pieces	850000gal oil tank south side equipment & material room, EL 21.9m	Chemistry Section/ Environmental Protection Subsection
B-31	Release & catch agent	Powder Ore x10kg	850000gal oil tank south side equipment & material room, EL 21.9m	Chemistry Section/ Environmental Protection Subsection
B-32	Naphthalene	Non-ionic interface active	850000gal oil tank south side	Chemistry Section/ Environmental

Item No.	Equipment / facility name & its use	Specification / Quantity	Storage Place & its elevation(EL)	Responsible Section
		agent x20 kilo liters	equipment & material room, EL 21.9m	Protection Subsection
B-33	Oil absorbing cotton	Oil absorbing PP Fiber x 200 pcs	850000gal oil tank south side equipment & material room, EL 21.9m	Chemistry Section/ Environmental Protection Subsection
B-34	Bailer, Wooden stack board	PVC Bailer 2Lx10 pcs, Wooden stack board x 2 pcs	850000gal oil tank south side equipment & material room, EL 21.9m	Chemistry Section/ Environmental Protection Subsection
B-35	Empty Iron bucket	55gal x10 pcs	850000gal oil tank south side equipment & material room, EL 21.9m	Chemistry Section/ Environmental Protection Subsection
B-36	Cleanup sump pump	1/6 horse power x 2 sets	#1/#2main Control room, EL 28m	Liquid Radwaste Subsection
B-37	Cleanup sump pump	1/6 horse power x 2 sets	#1/#2#1/#2Radwaste Control Room tool box EL 11.3m	Liquid Radwaste Subsection
B-38	Extension cord	30M each x2sets	#1/#2Radwaste Control Room tool box, EL 11.3m	Liquid Radwaste Subsection
B-39	1" ∮ Plastic tube	25M each x 2 pcs	#1/#2#1/#2Radwaste Control Room tool box, EL 11.3m	Liquid Radwaste Subsection
B-45	Electrostatic protection clothes	Sx1, Mx2, Lx1, XLx1 x 5 sets	O/G 1F Hydrogen production room, EL 11.3m	On-duty Shift
B-46	Computer Network Data / equipment	Converter, Ethernet	Computer room, EL 28m	Computer/Program Subsection
B-51	High class diesel oil	100kilo liters	Hsiokeng #1 warehouse, EL 13m	Material Subsection
B-54	Flash lighter	Flash lighter /head lighter x10	Commodity warehouse, EL 7.4m	Supply Section
B-55	Drinking water, foods, and other life necessities	Based on 104.22 A list (Typhoon arrangement and	Supply Section & Maolin Rest. EL 110m	Supply Section/ General Affairs Subsection

Item No.	Equipment / facility name & its use	Specification / Quantity	Storage Place & its elevation(EL)	Responsible Section
		preparation)		
B-56	Vehicle that delivers staff & workers	40 seats	Parking lot EL 7.5m	Supply Section/ General affairs Subsection
B-57	Big truck	15 metric tons	Parking lot EL 7.5m	Supply Section/ General affairs Subsection
B-58	Dry powder fire extinguisher x 20units	15-pound type	Fire-fighting shift EL 10.7m	Industrial Safety/ Fire Protection Subsection
B-59	Air breather x10units	Capacity 6.5liters, air pressure 300BAR	Fire-fighting shift EL 10.7m	Industrial Safety/ Fire Protection Subsection
B-59	Air breather x10units	Capacity 6.5liters, air pressure 300BAR	Fire-fighting shift EL 10.7m	Industrial Safety/ Fire Protection Subsection
B-61	Smoke ventilator x2units	110V/1HP	Fire-fighting shift EL 10.7m	Industrial Safety/ Fire Protection Subsection
B-62	Maolin fire-fighting water pool	A pool	Maolin warehouse EL 105m	Industrial Safety/ Fire Protection Subsection
B-63	Telescope x1unit	10 times magnification	Industrial Safety Section office EL 24m	Industrial Safety/ Fire Protection Subsection
B-64	Oxygen detector x 5units	0~25%	Industrial Safety Section Office. EL 24M /Ctrl. Rm EL 28m	Industrial Safety/ Worker Safety Subsection
B-66	Anti-electrostatic shoe x 5pairs	Mx2, Lx3	Industrial Safety Section container EL 11.3m	Industrial Safety/ Worker Safety Subsection
B-67	Triangle warning flag x10 units	20m/ unit	Industrial Safety Section container EL 11.3m	Industrial Safety/ Worker Safety Subsection
B-68	Life vest	2 pieces	Inlet pump room EL 5.6m	Industrial Safety/ Worker Safety Subsection
B-69	Life vest	2 pieces	100,000-ton raw water reservoir EL 70m	Industrial Safety/ Worker Safety Subsection

Item No.	Equipment / facility name & its use	Specification / Quantity	Storage Place & its elevation(EL)	Responsible Section
B-70	Life vest	2 pieces	First pumping station EL 21.9m	Industrial Safety/ Worker Safety Subsection
B-71	Life vest	2 pieces	Second pumping station EL 100m	Industrial Safety/ Worker Safety Subsection
B-72	Life preserver	3 units	Inlet pump room EL 5.6m	Industrial Safety/ Worker Safety Subsection
B-73	Life preserver	2 units	100,000-metric ton raw water reservoir EL 70m	Industrial Safety/ Worker Safety Subsection
B-74	Life preserver	2 units	First pumping station EL 21.9m	Industrial Safety/ Worker Safety Subsection
B-75	Life preserver	2 units	Second pumping station EL 100m	Industrial Safety/ Worker Safety Subsection
B-76	Life preserver	2 units	Inlet pump room EL 5.6m	Industrial Safety/ Worker Safety Subsection
B-77	Life preserver	1unit	100,000-metric ton raw water reservoir EL 70m	Industrial Safety/ Worker Safety Subsection
B-78	Life preserver	1unit	First pumping station EL 21.9m	Industrial Safety/ Worker Safety Subsection
B-79	Life preserver	1unit	Second pumping station EL 100m	Industrial Safety/Worker Safety Subsection

Table 2-3 of procedure 113.5 -Additional procurement of CSNPP first aid required materials and facilities for response to the compound disaster accident (Category A)

Item No.	Equipment / facility name & its use	Specification / Quantity		Storage Place & its elevation(EL)	Responsible Section
⊙A-01	Diesel generator power truck for general use	4.16kV/1500kW		40ft ContainerG/T EL 21.9m	Electrical Section
⊙A-02~A5	Diesel generator for #1 spare	480V/500kW		#1 EL 28m Roof	Electrical Equipment Subsection
⊙A-06~A09	Diesel generator for #2 spare	480V/500kW		#2 EL 28m Roof	Electrical Equipment Subsection
⊙A-10	Diesel generator for TSC spare	480V/200kW		G/T Generator area, EL 21.9m	Electrical Equipment Subsection
⊙A-11	Diesel generator for TSC N2 SYS spare	480V/200kW		G/T Generator area, EL 21.9m	Electrical Equipment Subsection
⊙A-17	Diesel generator power truck for general use	110V 220V	/320A	Machine Shop, EL 9.15M	Repairs Section/ Machine shop Subsection
⊙A-18	Diesel generator power truck for general use	110V 220V	/320A	Machine Shop, EL 9.15m	Repairs Section/ Machine shop Subsection
⊙A-29	Gasoline generator for AOV operation	110V 220V	/3.5kW	#1 Instrument control work shop, EL 11.3m	I & C Section/ Calibration & Test Subsection
⊙A-30	Gasoline generator for AOV operation	110V 220V	/3.5kW	#2 Instrument control work shop, EL 11.3m	I & C Section/ Calibration & Test Subsection
⊙A-33	Diesel generator for unit 1 warehouse spare	480V/200kW		#1 Waste warehouse, EL 22.7m	Solid Radwaste Subsection
⊙A-34	Diesel generator for unit 2 warehouse spare	480V/200kW		#2Waste warehouse, EL 18.9m	Solid Radwaste Subsection
⊙A-42~A43	Gasoline engine pump for fire fighting	10kg/396Gal/min		Onsite Fire Station, EL 10.7m	Fire Protection Subsection
⊙A-44~A47	Gasoline engine pump for fire fighting	10kg/396Gal/min		G/T Generator area work shop, EL 21.9m	Fire Protection Subsection

Item No.	Equipment / facility name & its use	Specification / Quantity	Storage Place & its elevation(EL)	Responsible Section
⊙A-48	Gasoline engine pump for pumping building water	10kg/396Gal/min	#2warehouse, EL 18.9m	Liquid Radwaste Subsection
⊙A~A49	Gasoline engine pump for pumping building water	10kg/396Gal/min	#2warehouse, EL 18.9m	Liquid Radwaste Subsection
⊙A-50~A51	Diesel Engine air compressor for unit valve operation	$800ft^3$/min 104psi , 200HP	#2 warehouse, EL 18.9m	Machine & Tool Subsection
⊙A-52	Small size motor driven air compressor for AOV operation	144^L/min, 110V 104psi , 2HP	#1 Instrument control work shop, EL 11.3m	Calibration & Test Subsection
⊙A-53	Small size motor driven air compressor for AOV operation	144^L/min, 110V 104psi , 2HP	#2 Instrument control work shop, EL 11.3m	Calibration & Test Subsection
⊙A-54	Small size motor driven air compressor for AOV operation	144^L/min, 110V 104 psi , 2HP	#2 Instrument control work shop, EL 11.3m	Calibration & Test Subsection

Table 2-4 of procedure 113.5 -Additional procurement of CSNPP first aid required materials and facilities for response to the compound disaster accident (Category B)

Item No.	Equipment / facility name & its use	Specification / Quantity	Storage Place & its elevation(EL)	Responsible Section
⦿B-01	5KVPower cable	1core /3600M	#2 Warehouse, EL 18.9m	SWYD Subsection
⦿B-02	5KVPower cable	1 core /2000M	#2 Warehouse, EL 18.9m	Electrical Section
⦿B-03	600VPower cable	1 core /4000M	#2 Warehouse, EL 18.9m	Electrical Equipment Subsection
⦿B-04	600VPower cable	3 core #4 /1000M	#2 Warehouse, EL 18.9m	Electrical Equipment Subsection
⦿B-05	600VPower cable	3 core 6/1000M	#2 Warehouse, EL 18.9m	Electrical Equipment Subsection
⦿B-06	600VPower cable	3 core #8/3000M	#2 Warehouse, EL 18.9m	Electrical Equipment Subsection
⦿B-07	600VPower cable	3core #10 /1000M	#2Warehouse, EL 18.9m	Electrical Equipment Subsection
⦿B-14	Sump pump (A&B)	220V/3"/4HP x2sets	#1 SBGT EL 16.2m	Machine & Tool Subsection
⦿B-15	Sump pump (C&D)	220V/3"/4HP x2sets	#2 SBGT EL 16.2m	Machine & Tool Subsection
⦿B-16	Tool power wheel seat	110V/30M x15pcs	Tool room, EL 9.15m	Machine & Tool Subsection
⦿B-17	#12 Galvanized iron wires	50kg	Heavy Machine Shop, EL 8.5m	Machine & Tool Subsection
⦿B-18	#10 Galvanized iron wires	50kg	Heavy Machine Shop, EL 8.5m	Machine & Tool Subsection
⦿B-19	#8 Galvanized iron wires	50kg	Heavy Machine Shop, EL 8.5m	Machine & Tool Subsection
⦿B-20	High class diesel oil	200liters	Heavy Machine Shop, EL 8.5m	Machine & Tool Subsection
⦿B-23	Coiler (Flexible hose) & fixture	3" § /60m	850000galOil Tank south side material room, EL 21.9m	Gas Turbine Subsection

Item No.	Equipment / facility name & its use	Specification / Quantity	Storage Place & its elevation(EL)	Responsible Section
⊙B-24	Coiler (Flexible hose) & fixture	4" ∮ /100m	850000galOil Tank south side material room, EL 21.9m	Gas Turbine Subsection
⊙B-25	Coiler (Flexible hose) & fixture	6" ∮ /20m	850000galOil Tank south side material room, EL 21.9m	Gas Turbine Subsection
⊙B-26	Water hose & fixture	2.5" ∮ /1640m	100000 metric ton raw water reservoir raw water filtration room, EL 70m	Machine shop Section
⊙B-27	Natural Borax	29 metric ton	Maolin Warehouse, EL 100m	Radioactive Chemistry Subsection
⊙B-28	Natural Borax	29 metric ton	Maolin Warehouse, EL 100m	Radioactive Chemistry Subsection
⊙B-40	Plastic bag	30 liter capacity /600pc	Radwaste Section container, EL11.3m	Decontamination Subsection
⊙B-41	Plastic bag	120 liter capacity /600pc	Radwaste Section container, EL, 11.3m	Decontamination Subsection
⊙B-42	Plastic bag	150liter capacity/600pc	Radwaste Section container, EL 11.3m	Decontamination Subsection
⊙B-43	Water hose	3" ∮ /100m	#1 R-15Stair room EL 11.3m	Liquid Radwaste Subsection
⊙B-44	Water hose	3" ∮ /100m	#2 R-15stair room EL. 11.3m	Liquid Radwaste Subsection
⊙B-47	Oxygen gas	$6M^3$/pcx10pcs	Hsiokeng gas warehouse, EL 13.2m	Supply Section/Material Subsection
⊙B-48	Acetylene	3kg/pc x10pcs	Hsiokeng gas warehouse, EL 13.2m	Supply Section/Material Subsection
⊙B-49	Nitrogen gas	$6M^3$/pc x10pcs	Hsiokeng gas warehouse, EL 13.2m	Supply Section/ Material Subsection
⊙B-50	Argon gas	$6M^3$/pc x10pcs	Hsiokeng gas warehouse, EL 13.2m	Supply Section/ Material Subsection

Item No.	Equipment / facility name & its use	Specification / Quantity	Storage Place & its elevation(EL)	Responsible Section
⦿B-52	Premium motor gasoline #95	400 liters	Hsiokeng oil warehouse, EL 14.4m & gasoline engine oil used	Supply Section/ Material Subsection
⦿B-53	Waterproof Clothing	L&XL Size x20sets	Commodity warehouse, EL 7.4m	General affairs Subsection
⦿B-65	Combustible gas monitor	0~100%LELx30sets	Industrial safety Section Office, EL 24m / Control Room, EL 28m	Worker Safety Subsection
⦿B-80	Lead clothing (Reserve other than site allocated)	600pcs	Laundry Room, EL 18.9m	Radiation Protection Subsection
⦿B-81	Lead clothing (Reserve other than site allocated)	50pcs	Laundry Room, EL 18.9m	Radiation Protection Subsection

3. Flooding

3.1 Design basis

3.1.1 Flooding against which the plant was designed

3.1.1.1 Characteristics of the DBF (Design Basis Flooding)

The design basis flooding of Chin Shan NPP mainly considers the influence of tsunami and storms on the site.

1. Tsunami

   According to the Final Safety Analysis Report (FSAR), Section 2.6.1.1, the potential maximum tsunami run-up height at Chin Shan NPP is 9m. If considered the high tide wave of 1.73m, the total run-up height is 10.73m. The data is originated from the analysis report on the Prediction of Tsunami Run-up at the Coast of Chin Shan by the Tainan Hydraulics Laboratory.

2. Flooding

   Based on the past record of 10000 statistical years, Chin Shan NPP adopts the probable maximum precipitation (PMP) rate of 297mm/hr as the plant design basis flood. The data considered the lower PMP of 252.7mm/hr at Tanshui area and the upper PMP of 325.2mm/hr at Anpu area during the past 10000 statistical years and the data of historical storm measured both at Tanshui and Anpu weather stations during 1943 to 1972.

Additionally, the Hsiokeng Creek and the Chien-Hua Creek pass through Chin Shan NPP. Therefore, it’s necessary to consider whether the mudslides could possibly lead to onsite flooding and its damage influence. The Hsiokeng Creek, located on east of the plant, has never caused mudslides since the establishment of the plant. Also, as stated on the disaster prevention web site of Government Council of Agriculture, the Hsiokeng Creek is not a mudslide-prone stream. On the other hand, the Chien-Hua Creek (also known as Alibon Creek) is located on west of the plant. The potential of mudslide at 1.5 kilo-meters from its origin is medium, but the stream is 4.2 kilo-meters away from Chin Shan NPP. Through the inquiry with the Mudslide Disaster Prevention Center of Soil and Water Conservation Bureau, Council of Agriculture, it is learned that Chien-Hua Creek has not caused any mudslides in recent years. As claimed in Hsiokeng Creek and Chien-Hua Creek Mudslides Risk Assessment Report published on Aug. 14, 2002, by the Ebasco Engineering Corporation and Jin Ying Civil Engineering Consultant Company, the mudslide potential of Hsiokeng Creek and Chien-Hua Creek can be classified as the low potential, low risk levels. And even if mudslides occur at stream upstream, the mudslide deposition of Chien-Hua Creek and Hsiokeng Creek are still 4.2 km and 3.5 km away from Chin Shan NPP. In other words, Chin Shan NPP is located outside of the mudslide deposition areas of both streams, so the plant would not be affected by the possible mudslide challenges.

3.1.1.2 Methodology used to evaluate the design basis flood

1. Design basis of tsunami in FSAR

   As described in the Final Safety Analysis Report (FSAR) of Chin Shan NPP, the tsunami maximum potential run-up height near the plant is 9m. If considered the high tide wave of 1.73m, the total run-up height is 10.73m. So FSAR recommends that the ground elevation of the plant should be higher than 11m. Therefore, the elevation level of the main area in the plant was set to be 12 meters. The tsunami run-up level and the elevation of the main buildings in the plant, from the Final Safety Analysis Report (FSAR) of Chin Shan NPP are cited as following:

   As per the historical records, the biggest tsunami happened on 6/11/1867 with estimated run up height of 7.5m had resulted in a severe damage in nearby Keelung District. The tsunami was believed to be initiated by an eruption of submarine volcano, 134 km northern east to Keelung coast. It was calculated that the tsunami level from this event was 2.12 meters high in Chin Shan coast. If considering the coast slope of 1/5 and the simultaneous biggest wave, the total energy is the combination of wind wave and the tsunami effect. Therefore, the combined rising is calculated as the sum of 9 meters tsunami under the coast slope of 1/5 and the additional surge wave of 1.73 meters. Under this consideration, the tsunami run up height for Chin Shan NPP was designed to be 10.73 m and the elevation of the major buildings was set to be 12 m high in order to prevent it from tsunami attack.

2. Design basis of flooding in FSAR

   Chin Shan NPP can be divided into two parts: Chien-Hua area in the west of the plant and Hsiokeng area in the east of the plant. In between the two parts are mountain hills and Chien-Hua Tunnel connects the two areas. Hsiokeng area is in the valley of Hsiokeng Creek, which passes from south to north through Hsiokeng area and runs into the East China Sea. The main facilities in this area are spare part warehouses, the offices for the Engineering Improvement Section and the Radiation Laboratory etc. Chien-Hua area is in the downstream valley of Chien-Hua Creek. When the plant was originally designed, the Chien-Hua Creek was diverted to pass through the plant area by building the embankment and revetment. The plant also constructed man-made drain trenches to guide the water to flow from south to north through Chien-Hua area and run into East China Sea. The main facilities of the power plant are located within the Chien-Hua area. During the plant initial constructing stage, this area was reclaimed with soil to make the landscape descend from south to north. Furthermore, the ground level of the power blocks and the levees at the exit of Chien-Hua Creek were reclaimed to reach 12 meters high to prevent the power block main buildings from being flooded if natural disasters happened. (According to the Sinotech Engineering Consultant re-measurement, it was confirmed that they are still higher than 11 meters.)

   Since Chin Shan NPP was short of the historical rainfall data during its construction period of time, those historical rainfall data of Taipei, Tanshui, Keelung, Anpu and Chutzehu etc., were adopted as the basis to implement the analysis and to get the maximum recurrence rainfall of each district during past 10,000 years. Therein, Anpu (325.2 mm/hr) and Tanshui (252.7 mm/hr) where are closer to the site showed the biggest rainfall, so that the rainfall of Anpu was adopted as the upper limit and that of Tanshui was adopted as the lower limit to calculate and get the probable maximum precipitation (PMP) rainfall (297mm/hr) of Chin Shan NPP during the past 10,000 years, which was then be adopted as the design basis for Chin Shan NPP.

The drain system in the main area of the plant, Chien-Hua area of Chin Shan NPP, is comprised with two following parts:

(1) Power Block area: the drain on the ground level was done by gravity. There are five different pipes in diameter of 50cm, 60cm, 80cm, and 100cm (two pipes) respectively to drain the rainfall into Chien-Hua Stream. Besides, there is also a trench, with 70cm in width and 50~150cms in depth, to drain the water out of the power block. Hence, the total drain capability of this power block is 5.6cms (i.e., 5.6 cubic meters per second) and this drain system covers a drain area of 45,394m^2. According to the statement in FSAR 2.4.3.1 that the maximum design precipitation for the plant is 297mm/hr, which implied that the maximum precipitation in this power block area was 3.745cms that was still smaller than the total drain capability of 5.6cms. So the design basis in FSAR for the Power Block drain is enough.

(2) The rest of Chien-Hua area: the drain on the ground level was also done by gravity. There are two drain routes; one drains toward west into Chien-Hua Stream and the other drains toward north out of the plant into East China Sea. According to FSAR 2.4, the drain design of Chin Shan NPP is based on 10,000-year probable maximum flood (PMF) of 764m^3/ sec (27,000 CFS), and 10,000-year probable maximum precipitation (PMP) of 297mm/hr. The water in this area is gathered and drained by the man-made trenches at Chien-Hua Creek. It occupies 80m^2 out of the 87 m^2 designed cross-sectional area of Chien-Hua Creek, so there is still a margin of 7m^2 capabilities. Therefore, the man-made trenches at Chien-Hua Creek can drain not only the rainfall from the upstream in the mountain area, but also the water from related trench around the plant buildings at the downstream of the stream. These drain pipes are installed in parallel with the descending landscape of the plant, so all the rain is converged and eventually drained into the sea by these trenches. The drain capability in the rest of Chien-Hua area is bigger than the once every 10,000-year probable PMF and the once every 10,000-year PMP.

(3) Taipower Company has invited Sinotech Engineering Consultant Company to help finish the measuring and drawing the map of the plant elevation. According to the map, it was concluded that the inundation-prone area in the plant was in the region between the northern part of power block north wall and the container area (contractor offices). This region includes the main parking lot, the temporary electrical substation, the grassy area, etc. Since the

trenches have already been installed in this area with enough capabilities to drain cumulated water into Chien-Hua Creek and East China Sea, it would not be affected by possible flooding.

3.1.1.3 Conclusion on the adequacy of the design basis for flooding

1. The adequacy of design basis for tsunami

After the Fukushima Accident, Taipower Company has finished an investigation on the oceanic and terrestrial geographic landscapes near the power plant and to review both the design basis against tsunami and the safety of plant facilities stated in the Final Safety Analysis Report (FSAR). According to the result of both the investigation and review, it indicated that the elevation of Chin Shan NPP is 11.2m, so it would not be flooded by possible tsunami. According to related analysis, investigation performed on tsunami, including the report “Influence of Tsunami Induced by Potential Massive Scale of Earthquakes on the Nuclear Power Stations in Taiwan” published by the National Science Council (NSC) on Aug. 19, 2011, it indicated that Chin Shan plant current tsunami design basis is appropriate. Current elevations design for all the TPC power plants used the historical meteorological data as a basis. It also considered the run-up elevation of the tsunami in the past that might threat to Taipower nuclear power plants. After reviewing the distribution of the oceanic trench near Taiwan, some reasonable margins has been incorporated in the design basis of the plant elevation to minimize the threat from possible tsunami intrusion. The related design bases are listed in the Table below:

Table 3-1

Plant Name	Chin Shan	Kuosheng	Maanshan	Lungmen
FSAR Tsunami run-up height (Note 1)	10.8m	10.3m	12.6m	8.1m
Site Elevation	11.2m	12.0m	15.0m	12.0m

Note 1: The result of this analysis was based on the Central Weather Bureau and some Japanese documented records.

In addition to that, TPC will set up a program to assess the FSAR relevant items with regarding to the possibility of submarine volcano eruption and submarine mountain collapse.

2. The adequacy of design basis for flooding

(1) Chin Shan Unit 1 and unit 2 commenced their commercial operation from Dec. 10, 1978 and July 15, 1979 respectively and it has lasted for more than 30 years. Based on the data provided by the Central Weather Bureau on the maximum precipitation records in Anbu and Tanshui during Jan. 1, 1979 to Aug. 30, 2011, it was concluded that no precipitation at or nearby the power plant during the recorded period (Refer to Table 3-2) was higher than the

design basis maximum precipitation of the plant (297mm/hr).

Table 3-2

Maximum precipitation records from weather stations near Chin Shan NPP (Jan. 1, 1979 ~ Aug. 30, 2011)			
Name of weather stations	Maximum precipitation	Date of record	Note
Anpu	136.5mm/hr	Sept. 5, 2001	(Note 2)
Tanshui	96.0mm/hr	Aug. 16, 1993	
Cape Fugui	116.0mm/hr	Oct. 31, 2000	(Note 1, 2)

Note 1: Cape Fugui Weather Station is located at Jiuqionglin, Shimen Dist., New Taipei City, Taiwan (near the Shanxi Branch of Shimen Elementary School). Since the establishment of the weather station in Oct, 1994, the maximum precipitation is 116.0mm/hr, which happened on Oct. 31, 2000, when Xangsane Typhoon seized Taiwan.

Note 2: It showed from the table that the recorded maximum precipitation at Chin Shan NPP since the commercial operations was 116.0mm/hr (At Cape Fugui on Sept. 5, 2001). Although the maximum precipitation of 136.5mm/hr, measured at Anpu Weather Station, exceeded 116.0mm/hr, the maximum precipitation measured at Cape Fugui was only 38.5mm/hr at that time.

(2) The previous daily maximum precipitation records, measured from the commercial operations of Chin Shan NPP at the Tanshui and Anpu Weather Stations, have been provided to TPC by the Central Weather Bureau. With the data, the plant adopted the Log Pearson type III model to analyze and learned that the probable maximum precipitation in every 10,000-statistically-calculated reoccurrence interval year in Tanshui area was 231.54mm/hr and the PMP value for Anbu area was 358.61mm/hr. As described in FSAR, by using the Anpu PMP data showing above as the upper limit and the Danshui PMP as the lower limit, the probable maximum precipitation at Chin Shan NPP in every 10,000-statistically-calculated reoccurrence interval year was 295mm/hr (The average of 231.54 mm/hr and 358.61 mm/hr), which was still less than the design maximum precipitation of Chin Shan NPP (297mm/hr).

Based on the description above, the design basis of maximum precipitation for Chin Shan NPP (297mm/hr) should be appropriate.

3.1.2 Provisions to protecti against the DBF

3.1.2.1 Key SSC required to achieve safe shutdown after flooding

1. Main facilities of Chin Shan NPP can be divided into two categories: nuclear safety related facilities (Safety Related) and not nuclear safety related facilities (Non-Safety Related). All nuclear safety related facilities should comply with the seismic category 1 requirements, including

the combined structure building, condensate storage tank (CST), the 5th diesel generator building, the emergency seawater pump house, the 850,000-gallon oil tank and the offgas chimney. For non-safety related facilities, they need not comply with the seismic category 1 requirements. Those facilities include the gas turbine building, circulating water pump house, gaseous waste buildings, dikes, etc. All the nuclear safety related facilities must be operable under disasters challenge. Therefore, all the nuclear safety related facilities should be operable to ensure nuclear safety even under the design tsunami of FSAR seizes. In regard to non-safety related facilities, the nuclear safety would not be threatened if they were lost after tsunami attack.

The following descriptions summarized the review of safety-related SSC to cope with the design basis flooding and ensure the safe shutdown requirements for Chin Shan NPP:

(1) The geographic landscape of Chin Shan NPP descends from south to north. The ground elevation of important buildings / facilities at Chin Shan NPP, including both units turbine buildings, the combined structure building, emergency pump house, the 5th emergency diesel generator buildings, etc. are all located higher than 11meters, except the circulating water pump house (Normal Intake Pump House). Hence, when encountered the design basis tsunami, those except the circulating water pump house, can survive and meet the current design basis requirement. For the circulating water pump house, the related equipment is non-safety related. Therefore, their failure will not affect the safe shutdown of units.

    In addition, regarding the risk that the emergency pump house, underground intake trenches and tsunami protection gates at Chin Shan NPP might be influenced by tsunami intrusion, Taipower Company has invited the Sinotech Engineering Consultant Company to conduct an assessment and prepared “the comprehensive evaluation on the capability of the nuclear power plants in Taiwan to respond to tsunami”. The conclusion from this assessment indicated that these tsunami protection gates would not be damaged under tsunami intrusion and neither did the emergency pump house structure and underground intake trenches would be damaged by tsunami.

(2) The elevation of important water storage tanks and oil tanks at Chin Shan NPP are described in Table 3-3 and Table 3-4. Excluding DST, all the elevations of other storage tanks are higher than tsunami design run-up height. Even though the DST is located on the underground floor in the combined structure building (EL. - 0.25meters), the building is not prone to the intrusion of the design basis tsunami. Hence, DST could be survived under tsunami event. Meanwhile, the ground elevation of CST is 11.2m and CST is enclosed by high walls. The ground elevation of these walls is higher than 11meters with wall height more than 3.2m, so it can protect the CST and prevent it from being damaged by the design basis tsunami.

Table 3-3 Elevation of important water storage tanks at Chin Shan NPP

Item	Name of water storage tank	Capacity (tons)	Seismic category	Structure material	Elevation from sea water level

1	CST (unit #1)	1893	I	Stainless steel tank body	11.2meters above Seawater level
2	CST (unit #2)	1893	I	Stainless steel tank body	11.2meters above Seawater level
3	DST (unit #1)	189	II	Aluminum tank body	0.25meters beneath Seawater level (inside building)
4	DST (unit #2)	189	II	Aluminum tank body	0.25meters beneath Seawater level (inside building)
5	3,000-ton raw water reservoir (2 units, shared)	6,000	II	Reinforced concrete	78meters above Seawater level
6	100,000-ton raw water reservoir (2 units , totally 100,000 tons)	100,000	II	Reinforced concrete	62meters above Seawater level

Table 3-4 Elevation of important oil tanks at Chin Shan NPP

Item	Oil tank	Seismic category	Capacity	Elevation from sea level	Material	Overflow dikes for oil leakage
1	#1 EDG Daily Tank	I	1200gallons	Building 11.2m	Steel tank body	Inside Building
2	#2 EDG Daily Tank	I	1200gallons	Building 11.2m	Steel tank body	Inside Building
3	EDG Storage Tank	I	850,000gallons	Tank bottom 19.7m	Steel tank body	Yes
4	5th EDG Daily Tank	I	1300gallons	Building 20.2m	Steel tank body	Inside Building
5	5th EDG Storage Tank	I	61000gallons	onsite 11.2m	Steel tank body	Yes
6	GT Daily Tank (3 sets)	II	Totally 1800 kilolitres	Oil tank 25.9m	Steel tank body	Yes
7	35000-kilolitre Storage Tank	II	35000 kilolitres	Oil tank 110.8m	Steel tank body	Yes

(3) As described in previous paragraph, the design drain capability of the site is capable to drain the heavy rainfall without causing flooding. Equipment in the building will not be affected by heavy rainfall. The most serious heavy rainfall at the site happened during the period of October 30 to November 1, 2000 when Xangsane Typhoon invaded Northern area of Taiwan. The cumulated precipitation observed is shown in Table 3-5 and Table 3-6. The precipitation level has reached extremely heavy rainfall standard. During that period, the drain trench did

not cause overflow and site buildings were not flooded.

Table 3-5 Maximum hourly & daily precipitation during Xangsane Typhoon (observed at Cape Fugui Weather Station)

Max Hourly Precipitation 24:00 October 31, 2000	116 mm/hr
Max Daily Precipitation 16:00 October 31, 2000~ 15:00 November 1, 2000	757.5 mm/hr

Table 3-6 Maximum daily precipitation during Xangsane Typhoon (observed at Cape Fugui Weather Station)

	Daily Precipitation
October 30, 2000	45.0mm
October 31, 2000	540.5mm
November 1, 2000	290.5mm
Cumulated Precipitation	876mm

2. In response to Fukushima Accident, Chin Shan NPP immediately followed WANO SOER 2011-2 recommendation 3 to verify the capability to mitigate internal & external flooding events required by plant design and to review the flooding prevention measures and conduct walk down inspection of related equipment / facilities.

   (1) Onsite flooding prevention measures can be divided into two categories, area inside buildings and area outside buildings:

   - Flooding prevention measures for area outside buildings. (Refer to Appendix 1)

   - Flooding prevention measures for area inside buildings. (Refer to Appendix 2)

   (2) In compliance with a comprehensive evaluation on the capability of the nuclear power plants in Taiwan to respond to external and internal flooding, Chin Shan NPP has conducted the walkdown inspection for related equipment /facilities to verify whether they can meet the requirement of the design basis flood. The result of the walkdown inspection is described in detail shown in Appendix 3~6. (Completed by June 30, 2011)

3.1.2.2 Main measures taken to protect Chin Shan NPP against the possible flooding

1. The elevation of the coastal road around the plant is more than 11 meters above the sea level, which can act as a tsunami barrier to protect Chin Shan NPP against the possible flooding.

2. The man-made drain trenches at Chien-Hua Creek have tsunami gates to block tsunami and the elevation of all main buildings is higher than 11m, so there is no concern of flooding.

3. Before Chin Shan NPP was constructed, the site was prepared and filled with soil to follow the geographic landscape of the area (i. e., descending from south to north). According to the construction data, the elevation of reactor building was 12m higher than the exit of Chien-Hua Creek. The re-measurement result by the Sinotech Engineering Consultant Company showed that it is still more than 11m above the exit of stream. These efforts were to prevent the main buildings from flooding induced by natural disasters.

4. All the designs for the drain pipes / trenches in the main Chien-Hua area of Chin Shan NPP have incorporated the considerations to ensure the capability in responding to probable maximum precipitation, and further protected the site important buildings from being damaged by flooding.

5. Although Hsiokeng Creek is not a mudslide-prone stream, the 1.5-km upstream of Chien-Hua Creek (Alibon Stream) near its origin has a medium potential of mudslide, although there was no experience of occurrence of mudslides in the recent years. Chin Shan NPP has modified plant procedure 104.37 "Chien-Hua Creek mudslide monitoring procedure" to include Chien-Hua Creek and Hsiokeng Creek for mudslide monitoring. (Complete after June 30, 2011)

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

The design for building elevations at Chin Shan NPP has considered the safety margin and requirements from FSAR, which covered the maximum tsunami run-up height, maximum sea wave height and maximum flood height. Hence, the design elevations are enough to protect against the design basis tsunami and would not cause the safety-related SSC being flooded.

During normal operation, all emergency equipment areas use the equipped floor sump pumps and the control room continuously monitors the sump water level. The sump pumps will be automatically started to control the level, if necessary. However, in order to enhance the disaster prevention and mitigation mechanism, Chin Shan NPP has established the associated procedures, something like the opening /closing of tsunami protection gates, management in response to internal flooding, onsite emergency flooding operating procedure, etc. to cope with the unusual events. This disaster prevention and mitigation procedures contained the disaster prevention and mitigation arrangement and preparation items, which included the mobile flooding mitigation equipment, such as drain pumps, sump pumps, emergency power generators, etc. If loss of monitoring power supply, the "mechanical" contact type of flooding alarms in the emergency equipment areas could still help main control room monitor the flooding situation and arrange the diesel-driven drain pumps, if necessary, to pump out the water. The related plant procedures are summarized as follows:

1. Procedure # 104.22-- "Typhoon prevention and response procedure"

   Purpose: Protect against typhoons and flooding to minimize the property lost.

   Abstract:

(1) Preparation before typhoon season: All divisions conduct walkdown inspection with the typhoon/ disaster prevention and mitigation arrangement and preparation checklist by the end of March every year and finish improvement by the end of April.

(2) After typhoon warnings are issued: All related divisions review and check typhoon response preparation items before the typhoon response center is established.

(3) Disaster response and preparation: When both sea and land alerts of typhoons are issued after the initial sea alerts, the typhoon response center is established to respond. The superintendent assigns the typhoon shift manager and asks response manpower to be on call, and the shift manager leads the response manpower.

2. Procedure # 104.37-- "Chien-Hua Creek mudslide monitoring procedure"

Purpose: Monitor potential mud/rock slide in Chien-Hua and Hsiokeng Creek, minimize property damage

Abstract: During flooding season, monitor the upstream of Chien-Hua Creek and Hsiokeng Creek and initiate the necessary alert if there is a potential disaster.

3. Procedure # 513—"Procedure for operation during typhoon alert period"

Purpose: Protect the plant against typhoons and decrease loss. During typhoons, the plant faces more threat than it does in a normal weather condition. To prevent this situation from happening and affecting the safe shutdown of units, this procedure is created to sever as guideline for operation during typhoon warning period.

Abstract: This procedure sets up rules regarding actions operators should take, including:

(1) After Central Weather Bureau issues both sea and land warning of typhoons

(2) One hour prior to the typhoon zone arrives at site

(3) Operation rules to follow during typhoons

- Timing for the units to stop reducing power

- Timing for the units to increase power or restart

(4) When gust wind measured at the site reaches 60 m/sec and the typhoon is a threat to the operation safety of the plant protection area or can seriously hinder plant workers to perform safe unit operation, the plant announces the units enter unusual alert status.

(5) When Central Weather Bureau announces the speed of the sustained wind of a typhoon reaches 60 m/s and the typhoon is a threat to the operation safety of the plant restricted area or can seriously hinder the plant workers to perform safe operation, the plant announces the units enter the emergency alert event.

4. Procedure # 514-- "Procedure for operation during tsunami alerts"

Purpose: Set up operation rules for plant workers to follow after the plant receives the far-land tsunami alerts by Central Weather Bureau and expects tsunami would seize the power plant.

Abstract: If the plant receives the far-land tsunami alerts by Central Weather Bureau and expects tsunami would seize the plant, follow step A. If the plant receives off-coast tsunami alerts and expects tsunami would seize the plant, follow step B. If units have been shut down, follow step C.

(1) If the plant receives the far-land tsunami alerts and expects tsunami would seize the plant, enter Emergency Action Level ─ Unusual Event (HU1).

(2) If the plant receives off-coast tsunami alerts and expects tsunami would seize the plant, enter Emergency Action Level ─Unusual Event (HU1).

(3) If units have been shut down, start Torus Cooling and utilize the main condenser as much as possible to bring units to cold shutdown status.

(4) If Central Weather Bureau issues tsunami alerts and they may seize the plant and the anticipated wave height is 5m higher than sea water level, perform RPV emergency depressurizing to lower the reactor pressure to 35 kg/cm^2.

5. Procedure # 515— "External flooding emergency response procedure"

Purpose: When external flooding meets any of the following situations, immediately comply with this procedure.

(1)When a super typhoon or heavy rain with occurrence frequency more than once every 1000-year, or Chien-Hua Creek water level reaches the design basis flooding water level. 【Chien-Hua Creek water level 2.75m (EL. 4.6m)】

(2) A huge tsunami seizes the coast near the plant, which causes the sea to encroach on the plant.

(3) Fire-fighting pipes or fresh water pipes outside of buildings rupture.

(4) Flooding enters buildings and the flooding level has reached 17.25' in the turbine buildings, -0.83' in the reactors buildings, and -0.83' in the combined building.

Abstract: Based on the situations specified in this procedure, adopt the following response measures:

(1) Monitor water level increasing of Chien-Hua Creek.

(2) If Chien-Hua Creek water level reaches the warning height of design basis flood 【Chien-Hua Creek water level 2.75m (EL. 4.6m)】, continue monitoring water level and take the following actions.

- When flooding is expected to damage unit equipment safety, start reducing power and bring the units to cold shutdown status.

- Notify all control divisions to pile up green sandbags at entrances/exits of and around related buildings to at least 1meter high in order to prevent flooding from entering buildings.

(3) Onsite fire-fighting pipes or fresh water pipes outside of buildings rupture.

- Find out location, size, and system of the ruptured pipes. If fire-fighting system pipes rupture and leak, isolate the ruptured pipes after confirmation. If fresh water pipes leak or any pipes rupture, manage to isolate them.
- Pile sandbags around low spots at buildings to prevent flooding from entering buildings.

(4) If huge tsunami inundates the coast near the plant and cause sea to encroach on the plant, follow procedure 1451 for emergency response (Established after June 30, 100).

(5) If flooding enters buildings and the flooding has reached 17.25' in the turbine buildings, -0.83' in the reactors buildings, and 0.83' in the combined building, follow procedure 515.2 "Internal flooding response procedure" to respond.

(6) Operator secondary action

- Continue conducting walkdown inspection at buildings till flooding at the plant is dismissed.

(7) Flooding at the plant is dismissed.

- When Chien-Hua Creek water level is lower than 0.9m, continue monitoring the outlet water levels at Chien-Hua Creek till the end of the 3 shifts on next day. If all water levels are lower than 0.9m, flooding onsite is considered dismissed.
- After ruptured fire-fighting pipes or fresh water pipes have been isolated or completely repaired, and internal flooding is cleaned up (excluding equipment repair), flooding is dismissed.
- After a tsunami alert is dismissed and both internal and external flooding is cleaned up (excluding equipment repair), and technology managers meet and decide, or the superintendent or his authorized person considers the actual situation of the plant, flooding is announced to be dismissed.

(8)After flooding is dismissed, close tsunami gates and remove sandbags at and around buildings.

6. Procedure # 515.2— "Internal flooding response procedure"

Purpose: Provide measures for responding to internal flooding that result from flood water entering buildings through ground flood or from ruptured pipes in buildings and other damaged equipment that lead to a lot of leaking.

Abstract: Internal flooding can happen when flood water enters buildings through ground floor, or when pipes that deliver water, such as circulating water, sea water onsite, condensed water, feedwater, fire-fighting water , primary system water, CSCW cooling water , chiller water system , liquid waste, and etc. rupture and cause a lot of leaking. Meanwhile, if floor sump pumps can not drain water fast enough, this can worsen the situation and cause flooding events as well as dysfunction of equipment.

There are four areas where internal flooding happens and they are respectively (1) gas turbine buildings, (2) the combined building, (3) reactor buildings, and (4) waste buildings. Each area is explained with event signs, action guideline, emergency response steps, and etc. Other related procedure is listed below:

(1) Procedure 540.4 Section SC/L-2 and Section SC/L-5.

(2) Operation specification LCO 3.4.4 RCS Operational Leakage (leaking of the reactor cooling water system).

(3) Procedure 308.1-- "Equipment and ground drain sump system procedure"

(4) Procedure 308.14-- "Waste sea water drain system procedure"

(5) Procedure 912-- "Radioactive material release control procedure"

3.1.2.4 Other effects of the flooding taken into account

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

Power sources from outside of the power plant contain two power switchyard systems 345kV and 69kV, which are respectively at elevation of 16m and 22m. Both are higher than the potential tsunami run-up height, so basically none of which will be affected by tsunami.

(1) Each unit of Chin Shan NPP is equipped with 2 safety related emergency diesel generators, providing power to the emergency cooling system if power sources from offsite lose.

(2) Additionally, Chin Shan NPP also has a gas-cooling emergency diesel generator (5th EDG) shared by the two units during emergency, so it can replace any of the 2 emergency diesel generators (EDG) originally used by each unit. If both units simultaneously encountered the station blackout event, the plant current operating procedure for the 5th EDG shall be followed as follows:

a. The 5th EDG is aligned in advance to feed power to each unit essential bus.

b. Unnecessary load on this bus is to shed and unnecessary loads of the other unit which will be fed power are isolated and its automatic start shall be prevented.

c. Transfer power to the other unit essential bus from the original power receiving bus via the 5th EDG bus.

The above-mentioned operation steps and detailed bus load distribution had been listed in detail in the plant procedure 1452.1 section 1. The 5th EDG simultaneously feeds power to both SBO units without overload operation by ways of the above-mentioned operation can be ensured.

(3) All the safety related emergency diesel generators are designed in accordance with DBE (Design Base Earthquake), so they are strong enough to resist against DBE and would not fail. Besides, the ground elevation of the buildings where they are located is higher than the potential tsunami run-up water level, so they will not be affected by tsunami. With this consideration, in response to Fukushima Accident, Chin Shan NPP has issued MMR to install water-tight doors at entrances of 5th EDG buildings, and plans to install floodgates at entrances of Combination Structure Building to enhance water-proofing capability of buildings. In addition, Chin Shan NPP also plans to construct tsunami wall at north side of power block to protect plant from tsunami attack. (Completed after June 30, 2011)

(4) Besides, Chin Shan NPP has also installed two gas turbines, with building ground elevation of 22 m, so they are not affected by tsunami. Either of these two gas turbines is already capable of replacing the 69KV power source from offsite of Chin Shan NPP.

2. Flooding may hinder or delay offsite supporters and rescue equipment to arrive at the power plant, and accidents can occur during office hours or off-duty hours:

(1) If accidents happened during office hours:

a. If operation crews on call can not arrive at the plant due to flooding, workers from the training shift at the simulator center and standby support shift, approximately 10 people (mostly licensees), can be on duty and assist with operation and handling of the units.

b. All workers from the maintenance division and long-term contractors are onsite during duty shift. Therefore, maintenance manpower can reach around one hundred people, which is enough for meeting the demand of equipment maintenance during emergency.

c. There are 8 fire-fighting workers in every day-shift period. Emergency response team would organize 25 people into standby emergency fire-fighting manpower.

(2) If accidents happened during off-duty hours:

a. There are 23 workers (including the operation division staff) living in Maolin Standby Dormitory onsite. They can first be notified to help with unit operation. In addition, 102 shift workers live in the standby dormitory in Tanshui as well as in the neighboring areas of Tanshui, Chin Shan, Shimen, and etc., so they can get to the site to assist before other supporters arrive.

b. There are 45 maintenance workers (Mechanical, Electrical, I&C, Machine Shop Sections, Health Physics, and etc.) living in onsite standby dormitory. They can be also mobilized to help with equipment rush repair. Besides, 186 workers from the maintenance division live in the standby dormitory in Tanshui as well as in the neighboring areas of Tanshui, Chin Shan, Shimen, and etc. They can be notified to come in and cope with emergency response. Also, the maintenance supporting contractors have technicians living in Chin

Shan and Shimen areas. According to the maintenance contracts signed by both the power plant and the supporting contractors, emergency rescue and repairing work was required by the contract, so it is possible for power plant to ask help from those supporting manpower during emergency.

c. At the present, the fire-fighting manpower is acquired via outsourcing. There're six fire-fighting workers remaining onsite during plant off-duty hours. All the fire-fighting workers are local residents of Chin Shan and Shimen, so they can get to the plant quickly once there was an emergency. Furthermore, security guards working onsite can join to assist with emergency related work.

d. If accidents happened during off-duty hours and supporting manpower can not arrive at the plant immediately that might cause an impact to the plant. Under this situation, the plant needs to utilize the supporting from contractor's technicians who live in Chin Shan, Shimen, and Keelung areas.

(3)In case that the transportation route outside the plant was interrupted and resulted in an obstruction or delay of manpower and equipment arriving at site, the National Nuclear Emergency Response Centre can implement the following response measures under the plant's requests:

a. By using the heavy mechanical equipment to rule out the roadblock.

b. Helicopter that can use the vacant space in site vicinity for landing shall be used to carry the rescue manpower and equipment resources.

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

3.1.3.1 General Procedures

1. Each year, the plant conducts the routine or post-natural disaster walkdown inspection for all onsite drain trenches to complying with procedure 104.22 "Typhoons disaster prevention and response procedure" and 795.12 "Onsite structure monitoring and walkdown inspection operating procedure" to make sure that the trenches could function properly with their structure sturdy. Moreover, the related divisions have annual contracts to have these trenches cleaned. All these practices have been completed on March 15, 2011.
2. Following procedure 792.1-- "Test operating procedure for closing and opening tsunami gates" to ensure the reliability of tsunami gates during possible tsunami attack and to provide detailed operation steps to test closing and opening for the tsunami gates.
3. Inspection of penetrations by following two procedures. One is procedure 791.1-- "Penetration periodical inspection procedure" and the period of the inspection cycle is 18 months. The other is procedure 791.2-- "Inspection procedure for the seal completeness of the perforated pipes and reserved holes at outer walls of buildings" and the period of the inspection cycle is 18 months.

4. Following procedure 104.37 to monitor mudslides situation induced by Chien-Hua Creek and Hsiokeng Creek.

3.1.3.2 Compliance on mobile equipment and supplies

According to current licensing basis, when encountered the design basis tsunami, onsite flooding would not occur. The structures, systems and components (SSC, including reactors and spent fuel pools) required to shutdown reactor would not be damaged and are still strong enough to bring units to safe shutdown.

After the lesson learned, in addition to the existing spare general mitigation equipment, Chin Shan NPP has considered all category of equipment needed to respond to combined natural disasters and procured two large 4.16kV/1500kW mobile container power vehicles, twelve medium size of 480V/500kW, 480V/200kW and other diesel generators, several convenient gasoline/diesel generators, air compressors, internal combustion engine drain pumps (Some of them have not been delivered to the plant yet), and other mitigation equipment or spares (See Table 3-1～3-4, extracted from "A/B category list of disaster prevention and mitigation equipment for Chin Shan NPP" in the plant procedure 113.5, contents are subjected to change if deemed necessary).

The arrangement for the distributed locations of the equipment just described above considers the nature of the spare equipment or their distribution methods, and all the equipment is placed in safe elevation (For the elevation of these locations, please refer to the evaluation report for "the earthquakes and potential tsunami run-up height in the northern Taiwan area" by NSC published in August, 2011.) to ensure the equipment will not be affected by typhoons, floods or tsunami and is placed at locations convenient for retrieving and use. Chin Shan NPP also revised the procedure 113.5 and added a section of "Preparation and management for disaster prevention and mitigation equipment", which requires internal combustion engine, generators, air compressor and mobile equipment in the category A to be periodically inspected and tested in every season to comply with the preventive maintenance (PM) management procedures. Cables, pipes, oil pipes, oil material, borax and gaseous material in the category B are inspected once half a year. Those newly modified management policies have clear specification and planning for the storage and allocation of spare equipment, the inspection and testing requirements and the organizations to be in charge of these activities. This effort helps the disaster prevention and mitigation work to be well prepared and facilitate a quick communication and efficient maneuvering in response to natural disaster (Completed after June 30, 2011).

Under a similar design consideration, Kuosheng NPP and Lungmen NPP will support and supply mobile mitigating equipment to Chin Shan when needed.

3.1.3.3 Deviations from CLB and remedial actions in progress

Even though the re-measurement result of the building ground elevation at Chin Shan NPP is 80cm lower than the original designed elevation (12m), it does not influence the flooding prevention and drain capability of the plant based on the following reasons:

1. The maximum tsunami run-up elevation of FSAR is 10.73meters, which is still lower than the actual ground elevation of the plant, the coastal roads in north of the plant, and the elevation on the top of the tsunami gates.

2. When the plant was built, the site was prepared and filled with soil according to geographic landscape of area (descends from south to north). According to the record, the elevation of reactor building was 12m higher than the exit of Chien-Hua Creek. These efforts are to prevent the main buildings from being flooded if natural disasters happened.

3. The artificial trenches at Chien-Hua Creek can drain not only the rainfall from the upstream in the mountain area, but also the water from related trench around the plant buildings at the downstream. These drain pipes are installed parallel to the descending landscape of the plant, so all the rain is converged and eventually drained into the sea by those trenches. The drain capability in the rest of Chien-Hua area is bigger than the once every 10,000-year probable PMF and the once every 10,000-year probable PMP.

Considering the inconsistence between the elevation designed in FSAR and the actual elevation measured, the plant will add a note in FSAR 2.4.2.6 and 3.4 to notify that "The ground elevation described in FSAR and its design map is 12m, which is called the nominal elevation and is 80cm higher than the actual elevation."

3.1.3.4 Specific compliance check already initiated by the licensee

Based on the lesson learned, Chin Shan NPP conducted the related reviews and promised to make improvements as below: (Completed after June 30, 2011)

1. DCR-C0-3307-- "To respond to sudden seizure of tsunami, install speed functions of closing and opening tsunami gates."

2. DCR-C0-308-- The intake structure: The implement fixed bar at the opening of ESW intake structure to prevent large debris brought by tsunami to enter the trench.

3. DCR-C0-3283-- "Install floating valves at the opening for the ESW wash pumps on the second floor underground, which can help release accumulated water on the floor and protect against tsunami."

4. MMR-C0-0407-- "Install water tight doors at the entrances of 5th EDG building."

5. MMR-C0-0416-- "Install supporting baffles for the seal of perforated pipes at the valve pits of

ESW pump rooms on the first and second floors underground, as well as the holes on walls for pipes of ESW pump and wash pumps."

Despite MMR-C0-04047, Chin Shan NPP plans to install floodgates at entrances of Combination Structure Building to enhance water-proofing capability, and construct tsunami wall at north side of power block to protect plant from tsunami attack.

Furthermore, Taipower Company has finished an investigation on the oceanic and terrestrial geographic landscapes near the power plant and again reviewed the design basis against tsunami and safety of plant facilities in the Final Safety Analysis Report (FSAR) for the plant. Based on the investigation and inspection result, the plant updates the elevation information in the Final Safety Analysis Report and ensures that important buildings and equipment would not be inundated by tsunami. (Completed after June 30, 2011)

3.2 Evaluation of margins on CLB

3.2.1 Envisaged additional protection measures based on the warning lead time

1. In order to gain more lead time after tsunami warning issued, Taipower Company has established an earthquake and tsunami warning network system between Central Weather Bureau and each of the nuclear power plants in Taiwan, also the warning and maintenance mechanism has been set up. The network is continuously gathering and sending information for the seismological center of Central Weather Bureau to use as a related improvement reference. (Completed before June 30, 2011)

2. Normally tsunami gates should stay at the fully closed position to protect against tsunami, so there is no need to consider tsunami warning lead time.

3. However, when there is heavy rain or typhoons, there is time between the issue of warnings and the occurrence of flooding. During this time period, Chin Shan NPP should continue monitoring the outlet water levels at Chien-Hua Creek. When the water levels reach 1.0m, open the lower tsunami gates (closer to the ocean). When the water levels reach 2.0m, open the upper tsunami gates (closer to the plant) to prevent onsite flooding.

4. During tsunami lead time, comply with procedure -- "Onsite flooding emergency operating procedure" and increase manpower when necessary. Follow the plan to pile sandbags at ground floor entrances/ exits of all important building to prevent tsunami from affecting or entering all buildings. (Completed after June 30, 2011)

5. If heavy rain warnings issued by Central Weather Bureau forecast that the precipitation warning figure is 500mm/day, warnings for mudslide-prone streams are issued. Then, comply with the following procedure:

104.37-- "Chien-Hua Creek mudslide monitoring procedure" to conduct walkdown inspection. Watch for mudslides signs, such as abnormal murkiness in stream water, rumbling sounds of mountains, and etc. and pay attention to see whether there are situations that would hinder the delivery of water in rivers/streams, such as ground surface anomaly change and deposition in rivers/streams, abnormal changes at slope ground, abnormal collapse and sliding of slopes, and etc.

106.9.4-- "Risk management and response procedure" to control and prevent abnormal or sensitive events during plant operations. By establishing the "Risk management and response team" to respond and collect essential information and dispatch manpower to effectively manage the risks. Periodically review and evaluate possible adverse factors that might influence plant safe operation. Therefore, the plant can deal with unexpected situations in time, contact supporting resources (consisting of military and police force) to "solve crisis" in time or "solve disputes" effectively, therefore to reduce damage possibility to the plant and avoid unnecessary disturbance.

3.2.2 Weak points and cliff edge effects

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

Refer to the analysis methodology of nuclear plants in Japan, Taipower Company has adopted event tree to find the cliff edges and safety margin. In accordance with "Stress Test Evaluation and Event Tree Analysis for Chin Shan, Kuosheng, and Maanshan Power Plants," the conclusion of the tsunami case for Chin Shan NPP is briefly described as follows (For details, please see Appendix 7):

If the tsunami has occurred near Chin Shan NPP and the plant wants to maintain the reactor in safe shutdown condition, the plant must meet the following requirements: after reactor trip and stay at sub-critical condition, DC and Instrumentation function well, capability for HPCI/RCIC to inject water into RPV, AC power and low-pressure RHR are available and cumulated decay heat in containment could be released into the atmosphere.

The analysis result of the tsunami event for Chin Shan NPP indicated that there was only one successful path to keep reactor in cold shutdown, which was:
The reactor tripped successfully after tsunami caused LOUH (loss of ultimate heat sink), but long-term high-pressure water makeup for the reactor failed. The long-term alternative water makeup for the reactor (including containment ventilation) succeeded. High-pressure reactors water makeup for the reactors succeeded. Reactor depressurizing succeeded. Diesel generators succeeded. BCSS (Backup Containment Spray System) water injection succeeded.

Description of safety margin and its cliff edge is as follow:

Since there is only a success path, its cliff edge is the cliff edge of this tsunami event. Its safety margin needs to adopt the smallest safety margin of each heading, namely 0.64m (39.83feet –37.72feet =2.11feet); its cliff edge also needs to use the smallest figure of each heading, namely 12.14m (39.83feet).

3.2.3 Envisaged measures to increase robustness of the plant

After the Fukushima Accident, Taipower company immediately establishes a tsunami evaluation mission team for all the plants to conduct an investigation on the oceanic and terrestrial geographic landscape near the power plants, once again reviewed the design basis tsunami and the safety of plant facilities in the Final Safety Analysis Report (FSAR) for all the plants, and completed the following enhancement measures:

1. Completed an investigation on the oceanic and terrestrial geographic landscape near the power plants, once again reviewed the design basis against tsunami and the safety of plant facilities in the Final Safety Analysis Report (FSAR) for all the plants. Based on the results of the investigation and inspection, the elevation of Chin Shan NPP is 11.2m, so it is confirmed that important buildings and equipment would not be inundated by tsunami. (Complete after June 30, 2011)

2. Through walkdown and inspect tsunami gates, sea water trenches that might be a possible run-up routes, water-proof of penetrations, battery chambers/switchgear rooms as well as diesel generator buildings, onsite drain capability and routes to ensure that related facilities to resist against tsunami have enough capability to respond. (Complete before June 30, 2011)

3. Six tsunami gates are controlled by power motors and can be closed within 5 min in compliance with procedure. (Complete after June 30, 2011)

4. Enhance the capability of the emergency seawater system to resist against tsunami. Complete the evaluation of the capability of the emergency seawater system at Chin Shan NPP to fight against tsunami and make sure that tsunami run-up water level would not cause damage to structure and equipment in the plant and to ensure the cooling function of the emergency seawater system after tsunami attack. (Complete after June 30, 2011)

5. Immediately reviewed the protection designs to fight against typhoons, heavy rain, and onsite flooding. The plant also examined its drain capability to ensure Chin Shan NPP has enough capability to fight against flooding. (Complete before June 30, 2011)

6. To draw maps of area and building which are inundation-prone. The plant also established Tables and lists for drain routes and drain capability of the plant, so the plant can further enhance its drain capability. (Complete after June 30, 2011)

7. To procure 8 gasoline/diesel-driven drain pumps to respond to the seizure of beyond design basis flood and to enhance the maneuverable drain capability of buildings. (Complete after June 30, 2011)

8. To complete modifying procedure 104.37-- “Chien-Hua Creek mudslide monitoring procedure” which includes the Chien-Hua Creek and Hsiokeng Creek as targets of mudslide monitoring. (Complete after June 30, 2011)

9. Based on the analysis result of the tsunami event tree, Chin Shan NPP has planned the enhancement measures, to review the seal function of the entrance/exit connecting to outside environment at all important buildings (containing ESW pump rooms) and to work out the design improvement program about installing water tight doors for 5th EDG Building entrances (MMR-C0-0407, see Appendix 8), floodgates for Combination Structure Building entrances to enhance flood barrier capability, and construct tsunami wall at north side of power block to protect plant from tsunami attack.. (Complete after June 30, 2011)

References

a. Official Document

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2. 「The Report on the Prediction of Tsunami Run-up at the Coast of Chin Shan」(台南水工試驗所)

b. Industrial Document

1. WANO SOER 2011-2：「Fukushima Daiichi Nuclear Station Fuel Damage Caused by Earthquake and Tsunami Response Template」(WANO)

c. Taipower Internal Document

1. 「核一廠終期安全分析報告」(台灣電力公司)
2. 「台電核能設施海嘯侵襲影響總體檢－補充地形測量成果集冊(第一核能發電廠)」(中興工程顧問股份有限公司)
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4. 「核能一廠功率運轉活態安全度評估」(核研所)
5. 104.22 程序書：「颱風災害預防與處理」
6. 104.37 程序書：「乾華溪土石流監測」
7. 106.9.4 程序書：「危機管理及應變作業程序」
8. 113.5 程序書：「災害防救要點」
9. 513 程序書：「颱風警報期間運轉」
10. 514 程序書：「海嘯警報期間之運轉」
11. 515 程序書：「廠區水災緊急操作規程」
12. 515.2 程序書：「廠房內水災處理程序書」
13. 791.1 程序書：「穿越孔定期檢查程序」
14. 791.2 程序書：「廠房外牆穿越管件及預留孔密封完整性檢查檢查程序」
15. 792.1 程序書：「防海嘯閘門關閉及開啓操作測試」
16. 795.12 程序書：「廠區結構監測巡視作業程序」

Appendix 1: External Flooding-- Flooding prevention measures for areas outside of buildings

Equipment	Mitigation strategy required (Y/N)	Vulnerabilities noted
1.Equipment used to resists against flooding (Follow procedure 113.5 to conduct verification)	N	NA
2.Flooding sandbag	Y	Originally the quantity of flood barrier sandbags was evaluated to be not enough (300bags), so the plant decided to change the way sandbags were piled and store them at the 1F entrances/exits of all buildings.
3.Tsunami gates (Follow procedure 792.1 & 795.6 and conduct verification.)	Y	Addition of procedure 792 requires the plant to inspect tsunami gates, chains, and track annually by walkdown when performing gate closing and opening tests.
4.Install 6 tsunami gates and hoists for these gates	Y	The installation was completed by the end of Oct. 2011.

Appendix 2: Internal Flooding-- Flooding prevention measures for areas in buildings

Equipment	Mitigation strategy required (Y/N)	Vulnerabilities noted
Liquid waste accumulator (2 units, 15 accumulators/unit)	N	The design of these accumulators uses seismic class I structure. If design basis earthquakes happen, they can not be available for use.

1. If internal flooding happens due to the rupture and leaking of liquid waste accumulators after earthquakes happen, the plant has spare mobile sump pumps (as listed in Appendix 3) for use. Therefore, the plant can use emergency power to drain flooding to prevent safety equipment from being inundated and losing functions.
2. When waste tank was damaged to result in flooding，flooding water will be limited in each waste tank because each waste tank has the compartments so that it will not result in large amount of water leakage and building flooding .Moreover, waste tanks are all allocated in Radwaste Building where has not any safety related equipment so that it will not impact unit shutdown function.
3. The radwaste liquid will be pumped to each waste collection tank in Waste Building via temporary water pump. If large amount of radwaste liquid continuously produced and exceeds the collection capacity of collection tanks, the plant procedure 1414-9 「CSNPP Radwaste Liquid Storage Facilities and Disposal Timing after Severe Natural Disaster」had already programmed its response measures such that radwaste liquid can be pumped to Turbine Building Basement Floor for temporary storage and then recovered or released through the necessary process , sampling, and assessment as per the plant URG release control if each tank collection facilities and its disposal measures are still incapable for response.
4. The relevant manpower had been already programmed in the「Sump Pump Water Drain Operation Alignment Timing Table」in the plant URG 1451「CSNPP Ultimate Response Guidelines」. Its operation training had been carried out on 6/15 /2011in connection with pre-stress test and its retraining had been programmed and incorporated in yearly training course.

Appendix 3: External Flooding

Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
Emergency generators	Tool rooms	Y	Y	NA
	Fire hall	Y	Y	NA
	G/T workshop	Y	Y	NA
drain pumps	Tool rooms	Y	Y	NA
	Fire hall	Y	Y	NA
Mobile crane	Heavy machine rooms	Y	Y	NA
Forklift truck		Y	Y	NA
Hydraulic elevator	Heavy machine rooms	Y	Y	NA
Chemical fire truck	Garages	Y	Y	NA
Fire truck with a water tank		Y	Y	NA
Dry powder fire extinguisher	Fire hall	Y	Y	NA
Air breather		Y	Y	NA
Emergency light		Y	Y	NA
Smoke ventilator		Y	Y	NA
Vehicle equipped with lighting	Garages	Y	Y	NA
Ambulance		Y	Y	NA
Emergency medical equipment and medicine	Medical room	Y	Y	NA
Vehicle that delivers staff, workers, and materials	parking lot	Y	Y	NA
Fire-fighting water pool	Maolin area	Y	Y	NA
Water-shielding sandbag	In west of heavy machine rooms	Y	Y	NA
Computer and the Internet	computer room	Y	Y	NA

Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
Short-wave communication system	# 1/#2 control room & microwave comm. station	Y	Y	NA
Oil absorbent boom	Equipment storage room at south of the 850,000-gallon oil tank	Y	Y	NA
Manual oil pump		Y	Y	NA
Fuel leak absorber		Y	Y	NA
Oil dispersant		Y	Y	NA
Oil absorbent pad		Y	Y	NA
Debris handling	Inlet pump room	Y	Y	NA
Flashlight	Warehouses	Y	Y	NA
Telescope	Industrial Safety division office	Y	Y	NA
Oxygen detector		Y	Y	NA
Inflammable gas detector		Y	Y	NA
Anti-electrostatic shoes	Industrial Safety division container	Y	Y	NA
Triangle warning flag		Y	Y	NA
Anti-electrostatic suit	O/G hydrogen production room	Y	Y	NA
Drinking water, foods, and other life necessities	Maolin Restaurant	Y	Y	NA
Life-saving vest	Inlet pump room	Y	Y	NA
	100,000-ton water pool	Y	Y	NA
	First pumping station	Y	Y	NA
	Second pumping station	Y	Y	NA
Lifebuoy	Inlet pump room	Y	Y	NA
	100,000-ton water pool	Y	Y	NA
	First pumping station	Y	Y	NA

Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
	Second pumping station	Y	Y	NA
Life-saving rope	Inlet pump room	Y	Y	NA
	100,000-ton water pool	Y	Y	NA
	First pumping station	Y	Y	NA
	Second pumping station	Y	Y	NA
Drain trenches	Outside of buildings in the plant	Y	Y	NA
Tsunami gates	Tsunami gates	Y	Y	NA
Penetrations	All buildings	Y	Y	Unit 1 has completed by March 31, 2011, Unit 2 has completed by April 15, 2011.

Methods of verification/inspection:

1. Inspection of disaster prevention equipment follows procedure pallets "Onsite flooding emergency response procedure."
2. Inspection of drain trenches follows procedure 795.12 "Site Area Structure Monitoring and Walkdown Operation Procedure" and the timings of the inspection are:
   (1) When Central Weather Bureau issues typhoon warnings to northern Taiwan.
   (2) When Central Weather Bureau issues warnings for earthquakes with magnitude 4 and above
   (3) Consecutive heavy rain (Total precipitation reaches 130 mm and above in 24 hours.).
3. Measures about tsunami gates: procedure 792.1-- "Test operating procedure for closing and opening tsunami gates" and procedure 795.6-- "Walkdown inspection procedure for equipment of the maintenance division."
4. Inspection of related penetrations complies with procedure 791.1-- "Penetration periodical inspection procedure," and procedure 791.2-- "Inspection procedure for the seal completeness of the perforated pipes and reserved holes at outer walls of buildings." The inspection cycle for both procedures is 18 months.
5. The equipment listed in appendix 3 are the same as those listed in the plant procedure 113.5 「Disaster Prevention and Relief Points」. The inspections of the more important equipment such as fire trucks are according to the plant 700 serials procedures and the inspections of the other passive equipment are thru visual inspection.

Appendix 4: Barriers

System name	Inspection timing	Current maintenance mechanism /procedure	Maintenance measures planned for enhancement
Tsunami gates	Every year	Number : 792.1 Name: gate closing and opening test	The procedure addition requires the plant to inspect tsunami gates, chains, and track situations every year by walkdown when performing gate closing and opening tests, which is added in notes in procedure : 792.1—"Test operating procedure for closing and opening tsunami gates" and procedure 795.6-- "Walkdown inspection procedure for equipment of the maintenance division."
Penetrations in buildings	18 months	1. Number: 791.1, Name: Penetration periodical inspection procedure. 2. Number: 791.2, Name: Inspection procedure for the seal completeness of the perforated pipes and reserved holes at outer walls of buildings.	Verification was completed at unit 1 by March 31, 2011(aiming to areas that were accessible during operation.). As for unit 2, the verification was finished by April 15, 2011(in coordinating with the schedule for current unit outage).

Appendix 5

Onsite sandbag piling plan list				
Location	Potential flooding entrance	Total length of sandbag piling (meter)	Number of sandbags needed to form a 1-meter pile (bag)	Note
Unit 1	11	22.55	1353	
Unit 2	12	24.15	1449	
New chiller building	4	10.97	658	
5th diesel generator	2	2.83	170	
O/G buildings	5	9.29	557	
Total			4187	

Note:

1. Size of a sandbag is approximately 50cm (L) × 70cm (W) × 10cm (H).
2. If piled with the double layer section stacking method, 4187 bags are needed (60bags/meter).
3. The plant plans to arrange a sandbag piling area at the empty space near each entrance (marked with paint) and clearly note the quantity and designated areas.
4. The method of piling is to put pallets at the bottom as a support in order to arrange and prepare sandbags and prevent them from damage.

Appendix 6: Internal Flooding

Equipment/Material	Physical Location	Available and staged (Y/N)	Functional (Y/N)	Gaps noted or corrective actions taken
Sump Pump (28 sumps and 37 pumps for each of the two units)	waste /reactors /combined /gas turbine buildings	Y	Y	There are 3 mobile sump pumps for each unit and 5 spare mobile drain pumps in tool rooms.
Fire -proof doors (2 doors for each unit) (T-21, T-22)	Heater bay floor	N	N	The internal flooding event at Chin Shan NPP (caused by rupture of pipes, tank bodies, etc.) was analyzed in Dec. in 1988 by Nuclear Engineering Department, Taipower Company. The range of the analysis includes the combined structure building and gas turbine buildings. According to the analysis result, the event did not affect the safe shutdown function of units. During normal power supply, important equipment areas have floor sump drain pumps and the control room monitors sump water levels all the time. If abnormal water levels happen, the plant automatically starts sump drain pumps and has started tests on April 8, 2011. The test result shows everything about the related sump drain pumps is normal.
Fire -proof doors (3 doors for each unit) (R-1, R-8, R-13)	Waste buildings leading to the combined building EL-0.83/17.33feet	N	N	
Fire -proof doors (4 doors for each unit) (D-4, D-14, SW-3, R-23)	EL39.83feet leading to reactors /the combined building/gas turbine buildings	N	N	

1. Internal flooding is drained by sumps and delivered to waste system for treatment. Then, the water is recycled or released out of the plant. Presently all sump test results are normal.
2. If the amount of internal flooding is too much for sumps to respond and the sump motors are inundated by the flooding and lose function, the plant has spare mobile sump pumps as listed in the appendix above. They can start draining after being provided with power to prevent safety equipment from losing functions due to flooding.
3. The related sump pumps in the arrangement and preparation items of disaster prevention and mitigation procedure 113.5 are inspected once in every June. They will be completely inspected by March 30, 2012.
4. Related sump pumps in procedure 781.9-- "Sump drain pumps maintenance procedure" are disassembled for inspection, repair and maintenance in every outage.
5. The sump pumps listed in appendix 6 had already been incorporated in the plant PM for control. The process to check its functionality and management after repair request had been put in plant normal practice for years.

Appendix 7: Tsunami case for Chin Shan NPP

The tsunami case for Chin Shan NPP, including the initiating event, and the final shutdown consequence, contain a total of 11 headings, plus their related event sequence progression. There are two scenarios in this tsunami case; one is the basic situation of the tsunami case and the other one is the consequence of the tsunami-induced LOUH. The following only discusses the consequence of the tsunami-induced LOUH and detailed description is as below: (Please refer to Section 3.1 of this report for description of the consequence of earthquake-induced LOUH.)

1. Initiating event: This is the beginning of the event tree. After earthquakes result in the loss of outside power and induce the tsunami, LOUH happens. As shown in Fig. 1-2 of this Appendix, the earthquake-induced tsunami at Chin Shan Power Plant causes the value of LOUH to be 11.5meters or 37.72feet. As a result, the key element (vulnerability) is the height of ESW I & C equipment. (ESW pump room I & C circuit elevation is 37.72 feet or 11.5m.)
2. Reactors trip: The tsunami causes ATWS. Therefore, the key element is the height of CRDM. (HCU bottom elevation is 40.50 feet.)
3. DC power source and I&C: The tsunami causes the DC power source (125 VDC Bus 1, Bus 6) or the control panels of both RCIC and HPCI pumps to fail, so the key element, the height of DC SWBD/ control panel, 57.16feet, (DC SWBD elevation is 57.16 feet (or 17.42m) and the control panel equipment elevation is 57.16 feet.)
4. RCIC/HPCI core makeup: The same as the 3rd sequence, the tsunami causes RCIC, HPCI pumps or their control panels to fail. Hence, the key element, the height of RCIC /HPCI pumps/control panels, needs to be higher than 12.14m (39.83 feet). (The elevations of the top of the RCIC pump base and the HPCI pump base are 1.17 feet and 3.33feet respectively. Control panels are in the control room. Because tsunami needs to be higher than building ground to be able to flow into buildings and cause flooding, use the elevation of the first floor of buildings, 39.83 feet (12.14m), to be the vulnerability.).
5. Reactors depressurized: The tsunami causes the SRV control panel to fail, so the key element is the height of SRV control panel. (Control panels are in the control room and the floor elevation is 73.83 feet.).
6. Onsite AC power (diesel generators) and CSCW/ECW: the tsunami causes LOUH, so water-cooling DG-1Aand DG-1B definitely fail and only DG-5 can operate. The same as Section 3.1, this sub-subject contains two situations:
   a. Success of high-pressure water injection: this still needs SPCM to cool Torus, but SPCM definitely fails owning to LOUH.
   b. Failure of high-pressure water injection/water makeup: when high-pressure water injection/water makeup fails, DG-5 needs to supply power to 4 LPCI pumps and 2 CS pumps

in the two units to inject water in the low-pressure reactors. However, because low-pressure water injection/water makeup also requires AC power and SPCM, low-pressure water injection/water makeup definitely fails when failure of high-pressure water injection/water makeup occurs. Therefore, directly jump to the 9th sequence to address the alternative water makeup for the reactors.

As shown in Fig. 1-2, the key element for onsite AC power in Chin Shan NPP failure is the lowest height of AC Switchgear / DG-5/ DG-5control panel. (AC Switchgear equipment elevation is 40.16 feet. DG-5 base top elevation is 40.66 feet. The elevation of DG-5 control panel is 40.66 feet, so using 40.16 feet as the key element.)

7. LPCI / LPCS core makeup: follow the previous (6th) sequence, LPCI / LPCS water makeup for the reactors definitely fails, so directly jump to the 9th sequence to address the alternative water makeup for the reactors.
8. Containment cooling / RHR: follow the previous (7.) sequence, containment cooling / RHR definitely fails, so directly jump to the 9th sequence to address the alternative water makeup for the reactors.
9. Alternative water makeup/ fire-fighting water/ sea water for the reactors: follow the previous (8^{th}) sequence, the tsunami results in LOUH and then the loss of RHRSW. Therefore, as shown in Fig. 1-2, the alternative water makeup for the reactors at Chin Shan NPP fails, so the key element will be the height of BCSS pump. (BCSS pump base top elevation is 40.5feet.)
10. Containment ventilation: the tsunami causes LOUH to have very little influence on containment ventilation.
11. Reactor cold Shutdown: this is the end of the event tree and contains two scenarios. The first scenario is that the reactors would not melt down if the reactors shutdown cooling succeeds. The second is that the reactors shutdown cooling fails and the reactors melt down.

    As previously described in Section 3.1 in this report and the conclusion of the tsunami case for Chin Shan NPP, there is only one successful situation of reactor cold shutdown, which is:

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

    Because there is only a success path, its cliff edge is the cliff edge of this tsunami case. Its safety margin needs to adopt the smallest safety margin of each heading, namely 0.64 M (39.83feet –37.72feet =2.11 feet); its cliff edge also needs to use the smallest figure of each heading, namely 12.14m (or 39.83 feet).

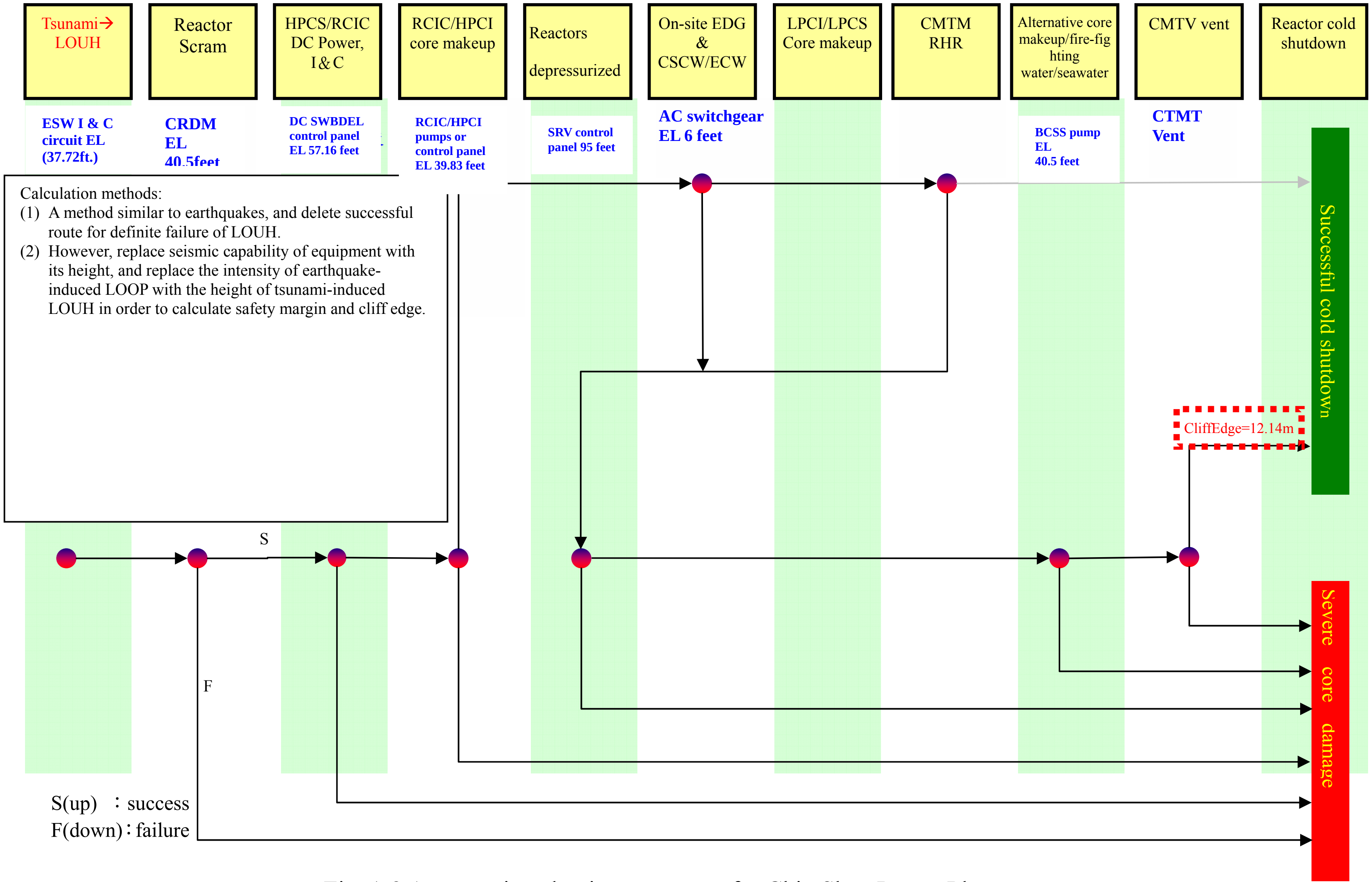

Fig. 1-2 A tsunami evaluation event tree for Chin Shan Power Plant

Appendix 8: MMR-C0-0407 Installation of water tight doors for 5th EDG Building

Number	Name of building	Door No.	Location	width (mm)	Structure opening width
1	5th EDG	DG1	Door at the east of 5th diesel generator building	1950	2100
2	5th EDG	DG8	Door at the south of 5th diesel generator building	900	1000

Table 3-1 of procedure 113.5 -Current disaster prevention and mitigation equipment at Chin Shan NPP (category A)

Item number	Equipment name/ purpose	Specification/ Specification		Location and elevation (EL)	Management division / division or section
A-12	Diesel generators /OSC spare	480V/400kW		#5 D/G west side OSC spare power EL 11.3 m	Electric/Electric equipment section
A-13	Gasoline generators /general spare	110V 220V	/3kVA	G/T electric warehouse EL 21.9m	Electric/Electric transmission section
A-14	Gasoline generators /general spare	110V 220V	/3.5kVA	G/T electric warehouse EL 21.9m	Electric/Electric transmission section
A-15	Gasoline generators /general spare	110V 220V	/4.1kVA	Tool room EL 9.15m	Mechanic /Mechanic equipment section
A-16	Gasoline generators /general spare	110V 220V	/4.1kVA	Tool room EL 9.15m	Mechanic /Mechanic equipment section
A-19	Gasoline generators /supply power	110V/180A		Machine Workshop EL 9.15m	Machine Shop section
A-20	Gasoline generators /supply power	110V/180A		Machine Workshop EL 9.15m	Machine Shop section
A-21	Gasoline generators /supply power	110V/180A		Machine Workshop EL 9.15m	Machine Shop section
A-22	Diesel generators /supply power	110V/180A		Machine Workshop EL 9.15m	Machine Shop section
A-23	Diesel generators /supply power	110V/180A		Machine Workshop EL 9.15m	Machine Shop section
A-24	Diesel generators /supply power	110V/180A		Machine Workshop EL 9.15m	Machine Shop section
A-25	Diesel generators /supply power	110V/250A		Machine Workshop EL 9.15m	Machine Shop section
A-26	Diesel generators /supply power	110V/300A		Machine Workshop EL 9.15m	Machine Shop section
A-27	Diesel generators /supply power	110V/300A		Machine Workshop EL 9.15m	Machine Shop section
A-28	Diesel generators /supply power	110V 220V	/320A	Machine Workshop EL 9.15m	Machine Shop section
A-31	Gasoline generators /fire-fighting	110V 220V	/3.0kVA	Fire hall EL 10.7m	Industrial Safety/Fire-fighting section
A-32	Gasoline generators /fire-fighting	110V 220V	/3.0kVA	Fire hall EL 10.7m	Industrial Safety/Fire-fighting section
A-35	Gasoline engine drain pumps /general	3" ∮ discharge head 31m		Tool room EL 9.15m	Mechanic /Mechanic equipment section
A-36	Gasoline engine drain pumps /general	3" ∮ discharge head 31m		Tool room EL 9.15m	Mechanic /Mechanic equipment section
A-37	Gasoline engine drain	2" ∮ discharge		Tool room EL 9.15m	Mechanic /Mechanic

	pumps /general	head 30m		equipment section
A-38	Gasoline engine drain pumps /general	2" § discharge head 30m	Tool room EL 9.15m	Mechanic /Mechanic equipment section
A-39	Gasoline engine drain pumps /general	2" § discharge head 30m	Tool room EL 9.15m	Mechanic /Mechanic equipment section
A-40	Gasoline engine drain pumps /fire-fighting	10kg/396gal/min	Vehicle with fire-fighting equipment EL 10.7m	Industrial Safety/Fire-fighting section
A-41	Gasoline engine drain pumps /fire-fighting	10kg/396gal/min	Fire hall EL 10.7m	Industrial Safety/Fire-fighting section
A-55	Mobile crane (diesel)	25 metric tons	Heavy machine rooms EL 8.5m	Mechanic /Mechanic equipment section
A-56	Mobile crane (diesel)	14 metric tons	Heavy machine rooms EL 8.5m	Mechanic /Mechanic equipment section
A-57	Forklift truck (diesel)	14 metric tons	Heavy machine rooms EL 8.5m	Mechanic /Mechanic equipment section
A-58	Forklift truck (diesel)	7 metric tons	Heavy machine rooms EL 8.5m	Mechanic /Mechanic equipment section
A-59	Forklift truck (diesel)	5 metric tons	Heavy machine rooms EL 8.5m	Mechanic /Mechanic equipment section
A-60	Forklift truck (diesel)	3.5 metric tons	Heavy machine rooms EL 8.5m	Mechanic /Mechanic equipment section
A-61	Hydraulic elevator (diesel)/working at high places	Loading capacity 100kg/10m	Heavy machine rooms EL 8.5m	Electric/Electric protection section
A-62	Fire truck with a water tank /fire-fighting	10M3 fire-fighting water	Fire hall EL 10.7m	Industrial Safety/Fire-fighting section
A-63	Chemical fire truck /fire-fighting	Equipped with fire-fighting foam, dry powder, and etc.	Fire hall EL 10.7m	Industrial Safety/Fire-fighting section
A-64	Vehicle with fire-fighting equipment /fire-fighting	Equipped with strong light, and pumps, generators , demolishing device, and etc.	Fire hall EL 10.7m	Industrial Safety/Fire-fighting section
A-65	Ambulance (gasoline)/deliver patients	Equipped with emergency stretchers/beds and emergency rescue device required by law	Fire hall EL 10.7m	Industrial Safety/Fire-fighting section

Table 3-2 of procedure 113.5 -Current disaster prevention and mitigation equipment at Chin Shan NPP (category B)

Item number	Equipment name	Specification/ Specification	Location and elevation (EL)	Management division / division or section
B-08	ESW pumps spare motor	4.16kV/400HP	#2 warehouse EL 18.9m	Electric/Electronic engineering section
B-09	RHR pumps spare motor	4.16kV/1000HP	#2 warehouse EL 18.9m	Electric/Electronic engineering section
B-10	CRD pumps spare motor	460V/250HP	#2 warehouse EL 18.9m	Electric/Electric equipment section
B-11	CSCW pumps spare motor	460V/250HP	#2 warehouse EL 18.9m	Electric/Electric equipment section
B-12	Satellite phone	A whole set	#1/#2 unit control room EL 28m	Electric/Electric equipment section
B-13	Microwave communicative system	A whole set	#1 microwave communication station EL 85.7m	Electric/Electric equipment section
B-21	flood barrier sandbag	20kg/bag x4300 units	Distribute in #1/#2 units and at totally 37 entrances/exits of related buildings. EL 11.3m	Engineering Improvement section
B-22	Debris handling device	Wood hammers, brooms, trash bags, and etc.	Work room for pump room workers EL 8m	Machine Shop /Turbine section
B-29	Oil absorbent boom x10 units	Non-woven cloth 10'x8" ∮	Equipment room at south of 850,000-gallon oil tank EL 21.9m	Environmental and chemical/Environmental protection section
B-30	Manual oil pump x5units	55cmx1.5cm ∮	Equipment room at south of 850,000-gallon oil tank EL 21.9m	Environmental and chemical/Environmental protection section
B-31	Fuel leak absorberx10kg	Powder mineral ore	Equipment room at south of 850,000-gallon oil tank EL 21.9m	Environmental and chemical/Environmental protection section
B-32	Oil dispersant x20liters	Non-ionic surfactant	Equipment room at south of 850,000-gallon oil tank EL 21.9m	Environmental and chemical/Environmental protection section
B-33	Oil absorbent pad x200 units	Oil absorbent PP fiber	Equipment room at south of 850,000-gallon oil tank EL 21.9m	Environmental and chemical/Environmental protection section
B-34	Floating material 2Lx10, pallet x2 units	PVC floating material /pallet	Equipment room at south of 850,000-gallon oil	Environmental and chemical/Environmental protection section

Item number	Equipment name	Specification/ Specification	Location and elevation (EL)	Management division / division or section
			tank EL 21.9m	
B-35	Empty iron container x10 units	55gallons	Equipment room at south of 850,000-gallon oil tank EL 21.9m	Environmental and chemical/Environmental protection section
B-36	Cleaning sump pump x 2 units	1/6 horse power	#1/#2 unit control room EL 28m	Waste/ Liquid waste section
B-37	Cleaning sump pump x 2 units	1/6 horse power	#1/#2 unit, tool box in waste control rooms EL 11.3m	Waste/ Liquid waste section
B-38	Extension cord x 2units	30m/unit	#1/#2 unit, tool box in waste control rooms EL 11.3m	Waste/ Liquid waste section
B-39	1" § plastic pipe x2 units	25meters/pipe	#1/#2 unit, tool box in waste control rooms EL 11.3m	Waste/ Liquid waste section
B-45	Anti-electrostatic suit x5 units	Sx1, Mx2, Lx1, XLx1	O/G 1Fhydrogen production room EL 11.3m	Operation/Shifts
B-46	Computer and information on the Internet/equipment	Exchanger, Ethernet	Computer room EL 28m	Computer section
B-51	Premium diesel	100liters	Small pit in #1warehouses EL 13m	Supply/Material section
B-54	Flashlight x10units	general flashlight /headlight	Supply division warehouses EL 7.4m	Supply/General administration section
B-55	Drinking water, foods, and other life necessities	Based on 104.22 A list (Typhoon arrangement and preparation)	Supply division & Maolin Rest. EL 110m	Supply/General administration section
B-56	Vehicle that delivers staff & workers	40 seats	Parking lot EL 7.5m	Supply/General administration section
B-57	Big truck	15 metric tons	Parking lot EL 7.5m	Supply/General administration section
B-58	Dry powder fire extinguisher x 20units	15-pound type	Fire hall EL 10.7m	Industrial Safety/Fire-fighting section
B-59	Air breather x10units	Capacity 6.5liters, air pressure 300BAR	Fire hall EL 10.7m	Industrial Safety/Fire-fighting section
B-60	Emergency headlight W type x10units	12V/50W, 150000 candle light	Fire hall EL 10.7m	Industrial Safety/Fire-fighting section
B-61	Smoke ventilator	110V/1HP	Fire hall EL	Industrial

Item number	Equipment name	Specification/ Specification	Location and elevation (EL)	Management division / division or section
	x2units		10.7m	Safety/Fire-fighting section
B-62	Maolin fire-fighting water pool	A pool	Maolin warehouse EL 105m	Industrial Safety/ Fire-fighting section
B-63	Telescope x1unit	10 times magnification	Industrial Safety division office EL 24m	Industrial Safety/ Fire-fighting section
B-64	Oxygen detector x 5units	0~25%	Industrial Safety div. Office. EL 24M /Ctrl. Room EL 28m	Industrial Safety /Industrial Safety section
B-66	Anti-electrostatic shoe x 5pairs	Mx2, Lx3	Industrial Safety division container EL 11.3m	Industrial Safety/Industrial Safety section
B-67	Triangle warning flag x10 units	20m/ unit	Industrial Safety division container EL 11.3m	Industrial Safety/Industrial Safety section
B-68	Life-saving vest	2 pieces	Inlet pump room EL 5.6m	Industrial Safety/Industrial Safety section
B-69	Life-saving vest	2 pieces	100,000-ton raw water reservoir EL 70m	Industrial Safety/Industrial Safety section
B-70	Life-saving vest	2 pieces	First pumping station EL 21.9m	Industrial Safety/Industrial Safety section
B-71	Life-saving vest	2 pieces	Second pumping station EL 100m	Industrial Safety/Industrial Safety section
B-72	Lifebuoy	3 units	Inlet pump room EL 5.6m	Industrial Safety/Industrial Safety section
B-73	Lifebuoy	2 units	100,000-metric ton raw water reservoir EL 70m	Industrial Safety/Industrial Safety section
B-74	Lifebuoy	2 units	First pumping station EL 21.9m	Industrial Safety/Industrial Safety section
B-75	Lifebuoy	2 units	Second pumping station EL 100m	Industrial Safety/Industrial Safety section
B-76	Life-saving rope	2 units	Inlet pump room EL 5.6m	Industrial Safety/Industrial Safety section
B-77	Life-saving rope	1unit	100,000-metric ton raw water reservoir EL 70m	Industrial Safety/Industrial Safety section

Item number	Equipment name	Specification/ Specification	Location and elevation (EL)	Management division / division or section
B-78	Life-saving rope	1unit	First pumping station EL 21.9m	Industrial Safety/Industrial Safety section
B-79	Life-saving rope	1unit	Second pumping station EL 100m	Industrial Safety/Industrial Safety section

Table 3-3 of procedure 113.5 -Chin Shan NPP procured disaster prevention and mitigation equipment (Category A) after the lesson learned,

Item number	Equipment name/ purpose	Specification/ Specification		Location and elevation (EL)	Division/ division & section in charge
A-01	Diesel generators power vehicle /general use	4.16kV/1500kW		40-feet container area in G/T EL 21.9m	Electric/Electronic engineering section
A-02	Diesel generators /#1 unit spare	480V/500kW		#1 unit roof EL 28m	Electric/Electric equipment section
A-03	Diesel generators /#1 unit spare	480V/500kW		#1 unit roof EL 28m	Electric/Electric equipment section
A-04	Diesel generators /#1 unit spare	480V/500kW		#1 unit roof EL 28m	Electric/Electric equipment section
A-05	Diesel generators /#1 unit spare	480V/500kW		#1 unit roof EL 28m	Electric/Electric equipment section
A-06	Diesel generators /#2 unit spare	480V/500kW		#2 unit roof EL 28m	Electric/Electric equipment section
A-07	Diesel generators /#2 unit spare	480V/500kW		#2 unit roof EL 28m	Electric/Electric equipment section
A-08	Diesel generators /#2 unit spare	480V/500kW		#2 unit roof EL 28m	Electric/Electric equipment section
A-09	Diesel generators /#2 unit spare	480V/500kW		#2 unit roof EL 28m	Electric/Electric equipment section
A-10	Diesel generators /TSC spare	480V/200kW		G/T generator EL 21.9m	Electric/Electric equipment section
A-11	Diesel generators /N2 SYS spare	480V/200kW		G/T generator EL 21.9m	Electric/Electric equipment section
A-17	Diesel generators /general spare	110V 220V	/320A	Machine Workshop EL 9.15m	Machine Shop section
A-18	Diesel generators /general spare	110V 220V	/320A	Machine Workshop EL 9.15m	Machine Shop section
A-29	Gasoline generators /AOV operation	110V 220V	/3.5kW	#1 unit I & C room EL 11.3m	I & C /Instrument calibration section
A-30	Gasoline generators / AOV operation	110V 220V	/3.5kW	#2 unit I & C room EL 11.3m	I & C /Instrument calibration section
A-33	Diesel generators /#1warehouse spare	480V/200kW		#1 waste warehouse EL 22.7m	Waste /Solid waste section
A-34	Diesel generators /#2warehouse spare	480V/200kW		#2 waste warehouse EL 18.9m	Waste /Solid waste section
A-42	Gasoline engine drain pumps /fire-fighting	10kg/396gal/min		Fire hall EL 10.7m	Industrial Safety/Fire-fighting section
A-43	Gasoline engine drain pumps /fire-fighting	10kg/396 gal/min		Fire hall EL 10.7m	Industrial Safety/Fire-fighting section
A-44	Gasoline engine drain pumps /fire-fighting	10kg/396 gal/min		G/T generator maintenance room EL	Industrial Safety/Fire-fighting

Item number	Equipment name/ purpose	Specification/ Specification	Location and elevation (EL)	Division/ division & section in charge
			21.9m	section
A-45	Gasoline engine drain pumps /fire-fighting	10kg/396 gal/min	G/T generator maintenance room EL 21.9m	Industrial Safety/Fire-fighting section
A-46	Gasoline engine drain pumps /fire-fighting	10kg/396 gal/min	G/T generator maintenance room EL 21.9m	Industrial Safety/Fire-fighting section
A-47	Gasoline engine drain pumps /fire-fighting	10kg/396 gal/min	G/T generator maintenance room EL 21.9m	Industrial Safety/Fire-fighting section
A-48	Gasoline engine drain pumps /to drain accumulated water out of buildings	10kg/396 gal/min	#2 warehouse EL 18.9m	Waste/ Liquid waste section
A-49	Gasoline engine drain pumps /to drain accumulated water out of buildings	10kg/396 gal/min	#2 warehouse EL 18.9m	Waste/ Liquid waste section
A-50	Diesel engine air compressor /unit valve operation	800ft3/ min 104psi , 200HP	#2 warehouse EL 18.9m	Mechanic /Mechanic equipment section
A-51	Diesel engine air compressor /unit valve operation	800ft3/ min 104psi , 200HP	#2 warehouse EL 18.9m	Mechanic /Mechanic equipment section
A-52	Small electric air compressor /AOV operation	144L/ min , 110V 104psi , 2HP	#1 unit I & C room EL 11.3m	I & C /Instrument calibration section
A-53	Small electric air compressor /AOV operation	144L/ min , 110V 104psi , 2HP	#2 unit I & C room EL 11.3m	I & C /Instrument calibration section
A-54	Small electric air compressor /AOV operation	144L/ min , 110V 104 psi , 2HP	#2 unit I & C room EL 11.3m	I & C /Instrument calibration section

Table 3-4 of procedure 113.5 -Chin Shan NPP procured disaster prevention and mitigation equipment (B category) after the lesson learned

Item number	Equipment name/ purpose	Specification/ Specification	Location and elevation (EL)	Management division / division or section
B-01	5KV power cable	1core/3600m	#2warehouse EL 18.9m	Electric/Electric transmission section
B-02	5KV power cable	1core/2000m	#2 warehouse EL 18.9m	Electric/Electronic engineering section
B-03	600V power cable	1core/4000m	#2 warehouse EL 18.9m	Electric/Electric equipment section
B-04	600V power cable	3cores, #4 /1000m	#2 warehouse EL 18.9m	Electric/Electric equipment section
B-05	600V power cable	3cores, #6/1000m	#2 warehouse EL 18.9m	Electric/Electric equipment section
B-06	600V power cable	3cores, #8/3,000m	#2 warehouse EL 18.9m	Electric/Electric equipment section
B-07	600V power cable	3cores, #10/1000m	#2 warehouse EL 18.9m	Electric/Electric equipment section
B-14	sump pumps x2units(A&B)	220V/3"/4HP	#1 unit SBGT EL 16.2m	Mechanic/Mechanic equipment section
B-15	sump pumps x2units(C&D)	220V/3"/4HP	#2 unit SBGT EL 16.2m	Mechanic/Mechanic equipment section
B-16	Cable wheel stand x15units	110V/30M in length	Tool room EL 9.15m	Mechanic/Mechanic equipment section
B-17	#12 galvanized wire	50kg	Heavy machine rooms EL 8.5m	Mechanic/Mechanic equipment section
B-18	#10 galvanized wire	50kg	Heavy machine rooms EL 8.5m	Mechanic/Mechanic equipment section
B-19	#8 galvanized wire	50kg	Heavy machine rooms EL 8.5m	Mechanic/Mechanic equipment section
B-20	Premium diesel	200liters	Heavy machine rooms EL 8.5m	Mechanic/Mechanic equipment section
B-23	Soft hose and pipe clamp	3" ∮/60 shakus (1 shaku = 1.094 ft)	Equipment room at south of 850,000-gallon oil tank EL 21.9m	Machine Shop/Turbine section
B-24	Soft hose and pipe clamp	4" ∮/100 shakus	Equipment room at south of 850,000-gallon oil tank EL 21.9m	Machine Shop /Turbine section
B-25	Soft hose and pipe clamp	6" ∮/20 shakus	Equipment room at south of 850,000-gallon oil tank EL 21.9m	Machine Shop /Turbine section
B-26	Feedwater hose and pipe clamp	2.5" ∮/1640 shakus	100,000-ton raw water reservoir in fresh water filter	Machine Shop section

Item number	Equipment name/ purpose	Specification/ Specification	Location and elevation (EL)	Management division / division or section
			room EL 70m	
B-27	Borax	29 metric tons	Maolin warehouses EL 100m	Environmental and chemical/Radiochemistry section
B-28	Boric acid	29 metric tons	Maolin warehouses EL 100m	Environmental and chemical/Radiochemistry section
B-40	Plastic bag	30 liters/ 600 bags	Waste division container EL 11.3m	Waste/ Decontamination section
B-41	Plastic bag	120 liters/ 600 bags	Waste division container EL 11.3m	Waste/ Decontamination section
B-42	Plastic bag	150 liters/ 600 bags	Waste division container EL 11.3m	Waste/ Decontamination section
B-43	Feedwater soft hose	3" ∮ /100m in length	stairway at #1 unit R-15 door EL 11.3m	Waste/ Liquid waste section
B-44	Feedwater soft hose	3" ∮ /100m in length	Stairway at #2 unit R-15 door EL 11.3m	Waste/ Liquid waste section
B-47	Oxygen	6M3/unit x10units	Xiaoken gas warehouse EL 13.2m	Supply/Material section
B-48	Acetylene	3kg/unit x10units	Xiaoken gas warehouse EL 13.2m	Supply/Material section
B-49	Nitrogen	6M3/unit x10units	Xiaoken gas warehouse EL 13.2m	Supply/Material section
B-50	Argon	6M3/unit x10units	Xiaoken gas warehouse EL 13.2m	Supply/Material section
B-52	95 gasoline	400liters	Xiaoken gasoline warehouses EL 14.4m and gasoline divisions	Supply/Material section
B-53	Frogman suit x20units	L&XL Size	Supply division Warehouses EL 7.4m	Supply/General administration section
B-65	Inflammable gas detector x30units	0~100%LEL	Industrial Safety division office EL 24M / control room EL 28m	Industrial Safety/Industrial Safety section
B-80	Lead blanket (spare)	600 pieces	Laundry room EL 18.9m	Health physic division/ Radiation protection section
B-81	Lead suit (spare)	50 pieces	Laundry room EL 18.9m	Health physic division/ Radiation protection section

4. Extreme natural events

4.1 Very bad weather conditions (storms, heavy rainfalls)

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

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

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

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

Severe weather conditions that may seize Chin Shan Power Plant include natural events such as typhoons, heavy rainfalls, lightnings, external fires, mudslides, etc. The most severe natural event is the combination of typhoons, heavy rainfalls and mudslides. Chin Shan Power Plant has made great efforts to assess the protection capabilities against the natural events. The design of protection capability for Chin Shan Power Plant is as follows:

1. Elevation of the plant

   Chin Shan Power Plant is one of the power plants in Taiwan that belong to Taipower Company. Located in Shimen District in New Taipei City in northern Taiwan, the plant faces East Sea to the north, with coordinates of 121°35'E, 25°18'N. The width and length of the plant are approximately 200meters and 1.2kms respectively and the site covers approximately 233 hectares. Chin Shan Power Station can be divided into two parts: Chien-Hua area, west side of the plant, and Hsiokeng area, east side of the plant. Mountain hills stretching from north to south lie in between, and Chien-Hua Tunnel connects these two parts of the plant. There is Hsiokeng Creek to the east of Hsiokeng area which flows from south to north and flows into East China Sea. As for Chien-Hua area, it has Chien-Hua Stream near its west side.

Chin Shan Power Plant has two reactors. Important equipment and buildings, such as reactor building, combination structure building, turbine building, the 5th diesel generator building, gas turbine building, power switchyard, essential service water building, and etc., are all located in Chien-Hua area. The plant elevation is 11.2m and above. Power Block is 500meters from the coast. Chien-Hua area is in the valley of the downstream of Chien-Hua Creek. Chien-Hua Creek is 8km in length and drainage area is around 9.5 km^2. During plant construction, downstream of Chien-Hua Creek that flew through the plant has been modified to become artificial drainage trenches (hereinafter referred to as Chien-Hua Creek artificial trenches) to serve as main drainage trenches of the plant and of Chien-Hua Creek basin.

2. Drainage capacity of plant area

(1) Drainage system

a. The drainage system of Chin Shan Power Plant is mainly used for draining precipitation-induced surface flow, done by gravity, with trenches and pipes around buildings as well as RC drainage pipes, which are all designed to install in descending l. The drainage system can accommodate not only the heavy rain from the upstream of the mountain area, but also the converged precipitation from related trench around the plant buildings. Eventually, all the precipitation from the drainage system is transported to Chien-Hua Creek artificial trenches and discharged into the sea.

b. There are 5 drainage pipes in the west of the plant, Power Block area, with total drainage capability of 4.4CMS and connecting with Chien-Hua Creek man-made trenches; there is also one drainage pipe in the north of the plant, with drainage capability of 1.2CMS and flowing into East China Sea . The total drainage capability of Power Block area is 5.6CMS and covers a drainage area of 45,394m^2. According to the design basis stated in FSAR 2.4.3.1, the maximum precipitation intensity for the plant is 297mm/hr, and the maximum precipitation intensity in this area is calculated to be 3.745CMS, which is still within the total drainage capability of this Power Block area.

(2) Drainage capability

a. According to FSAR 2.4.3.1 (Probable Maximum Precipitation, PMP), during the plant design stage, there was limited historic record for precipitation data near the plant area. Thus, historic precipitation records of Taipei, Tanshui, Keelung, Anpu, and Chutzehu were also taken into consideration when analyzing precipitation data. The once every 10,000-year probable maximum precipitation figures of these 5 areas are included in

Table 4-1. Among these figures, Anpu and Tanshui had the biggest PMP figures and these two areas are also closer to the plant. As a result, the data of these two areas were used as basis for evaluation and analysis. It is concluded that the once every 10,000-year probable maximum precipitation of these areas is 297mm/hr, which is used as the design basis for PMP of Chin Shan Power Plant.

Table4-1 The analyzed probable maximum precipitation at different Recurrence intervals at design stage of Chin Shan Power Plant

Recurrence intervals (year)	Maximum precipitation measured at all weather station (mm/hr)				
	Taipei	Tanshui	Keelung	Anpu	Chutzehu
5	66.2	50.3	59.8	62.1	64.0
10	78.0	62.5	71.0	76.0	67.0
20	86.0	75.2	82.2	90.6	70.0
50	100.0	92.0	100.0	112.0	72.0
100	107.6	109.7	112.1	132.8	74.0
200	118.0	124.0	129.0	152.0	
500	130.0	146.0	149.0	182.0	
1,000	136.0	171.9	165.4	214.8	
10,000	172.1	**252.7**	233.2	**325.2**	

b. Unit 1 and Unit 2 of Chin Shan Power Plant started commercial operation on Dec. 10, 1978 and July 15, 1979 respectively. Central Weather Bureau provided the maximum precipitation data measured at Anpu and Tanshui Weather Station (Table 4-2) from Jan. 1, 1978 to Aug. 30, 2011. None of the provided data exceeds the maximum precipitation, 297mm/hr, which is adopted as plant design basis. This demonstrated the appropriateness of plant design basis and the sufficient drainage capacity with extra margin.

Table 4-2 Maximum precipitation records from weather stations near Chin Shan Power Plant from Jan. 1, 1979 to Aug. 30, 2011

Weather station	Maximum precipitation	Date of occurrence	Note
Tanshui	96.0mm/hr	Aug. 16, 1993	
Fugui Cape	116.0mm/hr	Oct. 31, 2000	(Note 1)
Anpu	136.5mm/hr	Sept. 5, 2001	(Note 2)

Note 1: Fugui Cape Weather Station of Central Weather Bureau is located near No.13, 10th Neighborhood, Jiuqionglin, Shimen Dist., and New Taipei City, Taiwan (near the Shanxi branch of Shimen Elementary School). Since the

establishment of the weather station in Oct, 1994, the maximum precipitation is 116.0mm/hr, which happened on Oct. 31, 2000, when Xangsane Typhoon seized Taiwan.

2. Even though the maximum precipitation, 136.5mm/hr, measured at Anpu Weather Station on Sept. 5, 2001, exceeded 116.0mm/hr, the maximum precipitation measured at Fugui Cape Weather Station is only 38.5mm/hr.

c. According to FSAR 2.4.2.2 (Flood Design Considerations) and FSAR 2.4.3.3 (Design Flood for Various Site of Structure), the drainage design of Chin Shan Power Plant is based on the once every 10,000-year probable maximum flood (PMF), 764 CMS (27,000 CFS). The drainage system of the plant occupies 80 square meters of the designed cross-sectional area of Chien-Hua Creek, which is 87 square meters, so there is still a margin of 7 square meters. Hence, even if probable maximum flood (PMF) occurs, there is still about 0.91 meter between the flooding level and top of Chien-Hua Creek drainage trenches.

Thus, as long as Chien-Hua Creek artificial drainage trenches and the trenches around plant buildings, and RC drainage pipes stay unclogged, there is no concern of external flooding even if the plant is suffered from the seizure of a storm with probable maximum precipitation reaching 297mm/hr (Note: The 8% design margin of Chien-Hua Creek artificial trenches is still available for extra margin.)

d. Storms or mountain floods in Taiwan often come along with typhoons. The most serious storm that has seized Chin Shan Power Plant since its establishment is the one that happened when Typhoon Xangsane slammed Taiwan between Oct. 30 and Nov. 1 in 2000. The maximum precipitation intensity at that time was 116.0mm/hr (official record of Central Weather Bureau), much lower than the design basis PMP of the plant, 297mm/hr. Thus, the storm did not cause external flooding at the plant. The accumulated precipitation is shown in Table 4-3 and Table 4-4, which is qualified as very heavy rainfall, but at that time Chien-Hua Creek drainage trenches were not full or overflew and there was no internal or external flooding at Chien-Hua area of the plant. Consequently, it proves that there is no problem with the drainage and protection capabilities of Chin Shan Power Plant.

Table 4-3 Maximum hourly & daily precipitation during Xangsane Typhoon (observed by Fugui Cape Weather Station)

Max Hourly Precipitation 24:00 October 31, 2000	116 mm/hr
Max Daily Precipitation 16:00 October 31, 2000~ 15:00 November 1, 2000	757.5 mm/hr

Table 4-4 Maximum daily precipitation during Xangsane Typhoon
(observed by Fugui Cape Weather Station)

Occurred Date	Daily Precipitation
October 30, 2000	45.0mm
October 31, 2000	540.5mm
November 1, 2000	290.5mm
Accumulated Precipitation	876mm

3 Drainage design for inside of buildings

Drainage design for inside of buildings covers turbine building, combination structure building, reactor building, radwaste building, and so on. FSAR Para.2.4 and 3.4 and procedure 515.2 – "Internal flooding response procedure" provide more detail of flooding event analysis and related protection measures.

(1) Design basis for equipment protection is as follows:

a. Safety related components have redundancy. They are appropriately separated and have drainage design feature.

b. Water-proof rooms are designed to protect safety related equipment. Switches and circuits provide alarms to notify the control room when the doors are inappropriately opened.

c. Watertight design feature for rooms that contain safety related equipment (such as corner room), worker passways, piping, and other penetration through walls.

d. Flooding level alarm is designed for building floor system, and the alarm signal is connected to the control room.

e. The drainage system for inside of buildings does not directly connect with the precipitation drainage system for outside of buildings. This prevents external flooding from overflowing and entering inside of buildings.

f. Penetrations between turbine building and combination structure building are sealed and leak-proof.

g. 6- inch curbs are installed for the doors of the rooms with less likelihood of flooding.

h. The sumps in the corner room on the bottom floor of reactor buildings are exclusively for this region and are not connected with other areas. This prevents external flooding from entering the building and ensures the reliability of important ECCS equipment.

(2) Based on the protection design stated above, protection 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 (Refer to FSAR Para.3.4 for more detail.).

Design for protection of important safety related equipment in buildings (outside of containment vessels) against flooding is as follows:

a. Design of water-proof doors

   Rooms containing cold shutdown safety related equipment:

   RHR PUMP–A CORNER ROOM

   HPCI/CORE SPRAY PUMP-A ROOM

   RHR PUMP–B CORNER ROOM

   RCIC/ CORE SPRAY PUMP-B CORNER ROOM

   Doors at these 4 rooms to outside of TORUS area are water-proof.

b. Design of water-seal penetration:

   This design is to ensure complete seal at wall penetrations for existing pipes, ventilation pipes, cable trays, and cable tubes, at floor penetration, and at penetrations and reserved holes on exterior walls of buildings. This effort is to maintain the water/air seal function and further to increase the safety of workers and equipment.

c. Design of floor drains:

   Floor drains in the above-mentioned 4 rooms containing cold shutdown safety related equipment do not drain water to outside of the rooms directly, while the floor drains in other buildings and on passways drain directly to outside of buildings.

(3) The areas outside of the building area of the plant have their own independent drainage systems. The drainage system on east side of the plant is separated from the building area by safety fences and roads, and so is the drainage system on west side of the plant. The drainage system for 345kV power switchyard on south side of the plant is separated from the building area by safety fences. The drainage system on north side of the plant is separated from the building area by safety fences. The safety fences on north side of the plant have entrances/exits for vehicles, but precipitation on ground does not enter the plant from north because the ground descends from south to north. Therefore, precipitation from outside of the building area will not flow into the building.

(4) Consideration for the design of the areas outside of the building area of the plant:

a. All openings on doors of exterior walls or on the ground are at least 6 inches above the ground to prevent accumulated precipitation from entering buildings. Elevation of the ground outside of buildings is 11.2 meters above sea water level.

b. Expansion joints and structure joints at the foundation under the ground and at walls are installed with synthetic rubber water-proof tapes. All the foundation bottom of buildings and exterior walls under the ground are enhanced with waterproofing.

c. Design of ground drainage system for the site surrounding area which can accommodate probable maximum precipitation (PMP), and the surface has enough slope ratios to release the rain from roof drainage when maximum rainfall intensity is reached.

4. Capability to protect from mudslides

(1) The length of Chien-Hua Creek is 8kms. According to information from Water and Soil Conservation Bureau, MOEA, the upstream of Chien-Hua Creek (Alibon Creek) is 1.5kms in length and its mudslide potential is medium. (Fig.4-1)

The full length of Hsiokeng Creek is 4kms. Because the information about mudslide-prone rivers/ streams in Taiwan by Water and Soil Conservation Bureau, MOEA, does not include this creek, it means Hsiokeng Creek is not mudslide-prone. Also, there is no land excavation activity in this area, plantation is prosperous and lands at slopes or hills are well preserved.

(2) Buildings in the plant nearest to Chien-Hua Creek are 50 meters away. Chien-Hua Creek does not have any historic mudslide records. Except for the construction of Interim Storage Plan for Spent Fuel at Chin Shan Power Plant, there has been no large scale of land excavation activity near the creek. Required by the environmental impact assessment, the power plant conducts periodical environment monitoring program surrounding the upstream of Chien-Hua Creek, This environmental monitoring program requires satellite images to be taken every 6 months to observe if any abnormal changes in the area of the creek, but no noticeable collapse has been observed in the basin of the upstream of Chien-Hua Creek.

(3) The most serious typhoons the Great Taipei area in recent years has suffered from are Typhoon Xangsane, on Oct. 31, 2000, and Typhoon Nari on Sept. 16, 2001. Therefore, after Typhoon Nari, Chin Shan Power Plant hired E & C Engineering Consultant Company to conduct evaluation and analysis of mudslides. E & C Engineering Consultant Company partnered with Jinyin Civil Engineering Consultant Company to accomplish the project "Hsiokeng Creek and Chien-Hua Creek mudslides Risk Assessment." As stated in Hsiokeng Creek and Chien-Hua Creek Mudslides Risk Assessment Report published on Aug. 14, 2002, the mudslide potential of Hsiokeng Creek and Chien-Hua Creek can be classified into low potential, low risk catagory. And even if mudslides occur at their upstream, the mudslide deposition starting points of Chien-Hua Creek and Hsiokeng Creek are still 4.2kms and 3.5kms from Chin Shan Power Plant. In other words, Chin Shan Power Plant is located outside of the mudslide deposition areas of both streams, so the plant should not be affected by mudslide disasters.

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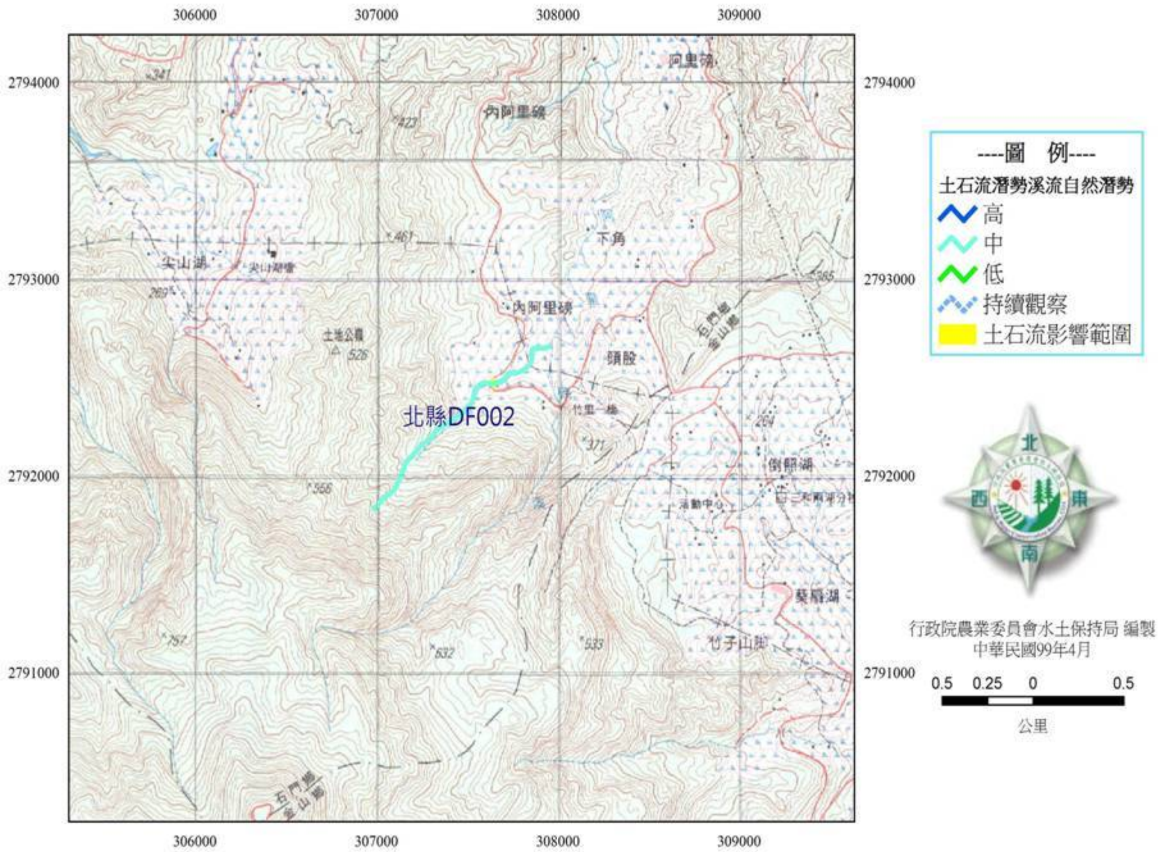


Fig. 4-1 Mudslide potential of Chien-Hua Creek

5. Capability to protect from land sliding

According to the geologic maps (Fig. 4-2, 4-3) from "Geological Database and Map Book for Metropolitan Areas and Surrounding Hill and Land Environment -Fugui Cape Geologic Map" published by Central Geological Survey, MOEA in 2008, the strata at the plant base are alluvion and volcanic breccias, whose lithologic structures are volcanic rocks as well as plutonic rocks and their lithologic nature does not contain clear layers. Even though there were lithologic chip slip (rock falling) incidents in a small area in north of the base, overall there are no concern of land sliding conditions.

It is learned from site survey that on the hills on both sides (comprised of Chien-Hua area and Hsiokeng area) of the plant base, vegetation and plantation is prosperous and mostly a primitive forest scene; land excavation is very rare. Large drainage trenches exist at toe of slopes, so surface flow drained quickly and no water will be accumulated.

Summarizing the description above, the strata at the plant base are alluvion and volcanic breccia, which do not have the characteristics that form a dip-slope. Hills in some areas of the plant had incidents of regional land waste sliding and collapse, but the reason was consecutive heavy rain washing these areas and these incidents had no direct influence on plant buildings. Thus, it is concluded that there should be no concern of land sliding issues within the plant base.

Fig. 4-2 (Lithologic structure type of Chin Shan Power Plant base)

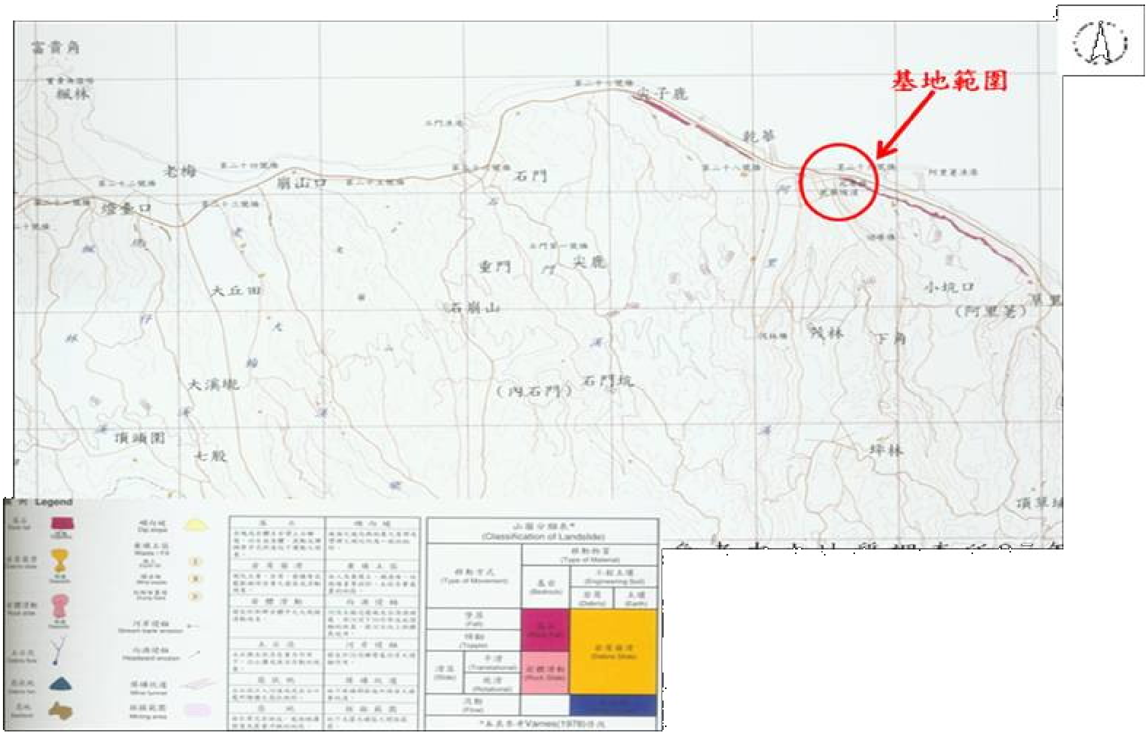


Fig. 4-3

6. Sustainability of exposed equipment toward strong winds

(1) Building structure

According to FSAR 3.3 of Chin Shan Power Plant, the design wind speed as well as maximum instantaneous wind speed of both seismic category 1 and 2 structures 30 feet above the ground are 134 mph (60 m/sec) and 148 mph (66 m/sec) respectively. (Note: According to the typhoon intensity classification system of Central Weather Bureau in Taiwan, severe typhoons have winds that reach Beaufort scale 16 and wind speed is higher than 51 m/sec.)

Because there is height difference between structures and ground surface, pressure difference between top of a structure and ground surface is formed. Wind pressure is directly proportional to the square of wind speed, and wind speed increases with the increase of pressure gradient. Hence, when there is a rapid change in air pressure and wind speed at top of structure escalates quickly, wind pressure will increase significantly. Design wind speed and design wind pressure at Chin Shan Power Plant are shown in Table 4-5:

Table 4-5 Design wind speed and design wind pressure at Chin Shan Power Plant

Height (feet)	Design wind speed (mph)	Design wind pressure (psf)
0~50	148	75
50~150	168	95

Major building structures of the plant are all designed as seismic category I. They are capable of withstanding strong wind, as well as projectile and hail strike. Typhoon-Generated Missiles addressed in FSAR 3.5.2. 4 origin mainly from branches and crush materials resulting from damaged house. It is concluded from FSAR analysis that major building structure of the plant can withstand projectile strike which is generated from strong wind.

(2) Power switchyard structure

The early design wind speed of the structure of the transmission route towers of Taipower Company was that 50 m/sec for eastern Taiwan (Force Level 15) and 40m/sec for western Taiwan(Force Level 12). Besides, there was still thirty percent of margin to resist gust wind at 52m/sec, which is Force Level 16.

On July 25, 1977, Taiwan suffered from the seizure of Typhoon Thelma, which landed in southern Taiwan and resulted in severe damage and disaster. Kaohsiung Harbor Transmission Substation, which is near Dalin Fossil Power Station and the only one ultra high pressure transmission substation in southern Taiwan, was seriously damaged. Power from the south could not be transported to the north. This led to power outage in many areas of Taiwan. A report stated this typhoon was the most destructive natural event in Taiwan since WWII. After Typhoon Thelma, Taipower Company reviewed and enhanced the capability of the structure of the transmission grid against winds.

The design guideline for the structure of the power transmission grid, provided by the power supply division, states that the transmission route of this plant is an important route in western Taiwan. The sustainability of the structure against winds is shown in the table below. Design is based on wind speed at 44.9m/sec (Force Level 14) and gust speed 61.9 m/sec (Force Level 17). However, even if the plant loses offsite power sources, the plant still has diesel generators, gas turbine generators, and the 5th diesel generator. All of these can provide the power needed for safe shutdown.

Table 4-6 The standard for supporting structure and cable design speed resistance

表 5 支持物及電線基準速度壓標準表

<table>
<tr><th colspan="2" rowspan="2">荷重條件</th><th rowspan="2">基準速度壓 qo (Kg/m²)</th><th colspan="3">對應風速(m/Sec)</th></tr>
<tr><th>基準風速 (10分鐘平均)</th><th>陣風率</th><th>陣風</th></tr>
<tr><td colspan="2">平常時(全島一致)</td><td>20</td><td></td><td></td><td>17.5</td></tr>
<tr><td rowspan="4">颱風時</td><td>西部一般線路</td><td>200</td><td>39.8</td><td>1.45</td><td>57.7</td></tr>
<tr><td>西部重要線路</td><td>230</td><td>44.9</td><td>1.38</td><td>61.9</td></tr>
<tr><td>東部一般線路</td><td>260</td><td>50.6</td><td>1.3</td><td>65.8</td></tr>
<tr><td>東部重要線路</td><td>300</td><td>54.4</td><td>1.3</td><td>70.7</td></tr>
<tr><td colspan="2">作業時(全島一致)</td><td>20</td><td></td><td></td><td>17.5</td></tr>
</table>

According to Design Guideline for Power Switchyard of Nuclear Power Station (First edition, 1987), the design wind speed for Class A equipment as well as structures was 70 m/sec and wind-resistance strength should attain 100 m/sec. For the plant equipment installed in later period of time, such as GCB and GCS, this design guideline was followed.

(3) Off gas stack design wind speed:

The design wind pressure at elevation of 98.5 m is listed in the table below:

Height (m)	Design wind pressure (psf)
99~164	95
>164	105

(Note: According to the typhoon intensity classification system of Central Weather Bureau in Taiwan, severe typhoon is defined as winds that reach Beaufort scale 16 and wind speed higher than 51 m/sec.)

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

4.1.2 Weak points and cliff edge effects

Through the evaluation of Stress Tests of Combined Natural Events of Typhoons and Heavy Rainfalls/Mudslides for Chin Shan Power Station" in Appendix 4-1, weak points and cliff edge effects of the plant in extreme situations are estimated and described as follows, along with responding enhancement measures:

Scenario A: The elevation of the plant is 11.2meters and it is 500 meters from the coast. The base on east and west side of the plant is hills. The landscape of the base descends from south to north and is a natural valley, which is easy for drainage. The main area of the plant is in Chien-Hua area. In a heavy rainfall scenario, the rainfall should be able to be drained into the sea through Chien-Hua Creek quickly, so the plant would not be flooded and further mudslides would not occur. However, if unexpected mudslides happen and cause flooding to reroute and to enter Chien-Hua area of the plant as well as Power Block area, units would be in danger.

Scenario B: The drainage capability of the plant is based on the assumption that probable maximum precipitation of a storm, 297mm/hr, falls in the plant. Now, in order to create a very extreme scenario of extreme weather, if a beyond design basis storm seizes the plant, without occurrence of any mudslides, the beyond design basis precipitation can not be drained by the drainage trenches and therefore generates surface flow entering Chien-Hua area of the plant and Power Block area. Then, units of the plant may be affected.

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

1. Vulnerabilities associated with extreme weather

   For the enhancement measures responding to the assumed scenarios A and B described above, related procedure to respond to typhoons, heavy rainfalls, and mudslides are reviewed and subsequent enhance measures established are as follows:

   (1) Procedure 104.22 “Typhoon disaster prevention and response procedure”:

      a. Preparation before the typhoon season: All divisions conduct walkdown inspection before the end of March every year following checklists for typhoon and disaster prevention and mitigation items and complete improvement by the end of April.

      b. After typhoon alerts are issued: All related divisions inspect, verify, and prepare items to respond to typhoons before the typhoon emergency response center is established.

      c. Disaster response: When the latest status of typhoons changes from “sea alerts to “sea and land alerts”, the plant holds typhoon meetings and establishes the typhoon emergency response center. The superintendent assigns the typhoon shift manager to gather response manpower and have them stay on call. The shift manager leads and dispatches emergency response manpower.

   (2) Procedure 513 “Procedure for operation during typhoon alert period”

      Important equipment at the power station has a class 1 structure and a class 1 system, so they are designed to sustain high wind speed carried by typhoons when they seize. These pieces of important equipment need to ensure that units can stay intact and they have enough capability to conduct safe shutdown of reactors.

      Once turbines, generators, main transformers or unit auxiliary transformers(UT-X/Y) are out of order or inoperable, power needed for reactor safe shutdown will be provided by offsite power sources (startup transformers ST-A/AS and ST-B/BS) or onsite emergency diesel generators. The chance for power plant to lose offsite power sources during typhoons is bigger than that of normal weather. To prevent happening and avoid influencing plant safe shutdown, this procedure provides guidance for safe operation of units when typhoon alert is issued.

   (3) Procedure 515 “External flooding emergency response procedure”

      a. When external flooding occurs in any of the following situations, this procedure should be executed immediately.

         i. When a super typhoon or extremely heavy rain whose occurrence frequency is more than once every 1000-year happens, and Chien-Hua Creek water level reaches the design basis flooding water level. 【Chien-Hua Creek water level 2.75meters (EL.4.6meters)】

ii. A huge tsunami seizes the coast near the plant, which causes the sea to encroach on the plant.

iii. Onsite fire protection pipes or raw water pipes rupture.

iv. Flooding enters buildings and the flooding level has reached 17.25' in the turbine buildings, 0.83' in the reactor buildings, and 0.83' in the combination structure building.

b. Emergency response measures of the plant include:

i. Monitor the rising outlet water level situations at the Chien-Hua Creek.

ii. If Chien-Hua Creek water level reaches the warning height of design basis flood 【Chien-Hua Creek water level 2.75m (EL.4.6m) 】, continue to monitor the rising water level. When flooding is expected to affect equipment safety, start reducing power and bring the units to cold shutdown status.

iii. Notify all control divisions to pile sandbags (green color) at entrances/exits around related buildings to at least 1 meter to prevent flooding from flowing into buildings. (The plant will procure and prepare 4000 sandbags (green color))

iv. When Chien-Hua Creek water level rises or is expected to rise, or when the plant receives "sea and land alerts for typhoons" from Central Weather Bureau and judges that typhoons may hit the power station, or when the outlet water level (the lowest point of waves) at Chien-Hua Creek monitored reaches 1.0 meters, quickly activate all flood gates at the downstream of Chien-Hua Creek. When the outlet water level at Chien-Hua Creek reaches 2.0 meters, quickly activate all flood gates at the upstream of Chien-Hua Creek.

v. Find out location, size, and system of the ruptured pipes. If fire protection system pipes rupture and leak, isolate the ruptured pipes after confirmation. If raw water pipes leak or any pipes rupture, manage to isolate them. Moreover, pile sandbags around low spots at buildings to prevent flooding from entering buildings. (There are 300 sandbags (beige color) on west side of heavy machine building available for use any time.).

(4) Procedure 515.2 "Internal flooding response procedure"

Internal flooding can happen when flood enters buildings through ground floor, or when pipes that deliver water, such as circulating water, service water, condensed water, feedwater, fire protection system water , primary system water, CSCW cooling water , chiller water, liquid waste, and etc. rupture and cause a lot of leaking. Meanwhile, if floor sump pumps can not drain water fast enough, this can worsen the situation and cause flooding events leading to malfunction of equipment.

There are four areas where internal flooding may happen and they are (1) turbine building, (2) combination structure building, (3) reactor building, and (4) waste treatment building. Each area is provided with event signs, action guideline, emergency response steps. Other related procedure is listed below:

i. Procedure 540.4 Section SC/L-2 and Section SC/L-5.
ii. Operation specification LCO 3.4.4 RCS Operational Leakage (leakage of the reactor coolant system).
iii. Procedure 308.1 “Equipment and floor drain sump system”
iv. Procedure 308.14 “Waste sea water drainage system”
v. Procedure 912 “Radioactive material release control procedure”

(5) Procedure 795.12 “Onsite structure monitoring and walkdown inspection procedure”

Perform routine walkdown inspection once every year or after natural disaster to confirm the plant drainage system is unclogged and the structure is sturdy. The time frame for the walkdown and inspection are:

i. When Central Weather Bureau issues typhoon alerts to northern Taiwan.
ii. When Central Weather Bureau issues alerts for earthquakes with magnitude 4 and above.
iii. Uninteruppted extremely heavy rainfall (total precipitation 130 mm and above in 24 hours).

(6) There have been no mudslide records for Hsiokeng Creek and Chien-Hua creek in recent years. However, if extremely heavy rainfall alert is issued and Central Weather Bureau forecast that the precipitation warning limit 500mm/day is reached; alerts for mudslide-prone creek will be issued. The plant then needs to comply with procedure 104.37 “Chien-Hua Creek mudslides monitoring procedure,” procedure 106.9.4 “Risk management and response procedure,” and rules related to “Temporary measures for outlet water level monitoring at Chien-Hua Creek.”

(7) With regard to the vulnerabilities of extreme natural event for CSNPP, lots of flooding water may intrude into buildings from the Combination Structure Building Gates D-4/R-15 and then drain to the Combination Structure Building Basement Floor along stairway, and result in flooding in Chiller Equipment Room. The preventive measures are as follows:

a. The floodgates will be installed in the entrance and exit including gate D-4 to mitigate water intrusion.
b. The steel plate fence is installed surrounding the original Essential Chiller Pumps to prevent flooding from directly affecting the safety related equipment.
c. Multiple floor drain holes have been installed in that area. Each hole is connected to sump through 3-inch drain pipes, and then drains to collector tank via 100 GPM sump pump.
d. Seeped tank is equipped with 2 transfer pumps with total capacity 170GPM. The transfer

pumps can be used as ground floor water pump in case of flooding and direct to Circulating Water Discharge Canal.

e. The plant has already procured each kind of mobile generator, sump pump, and water pump for backup support in addition to the existing equipment and tools listed in plant procedure 113.5.

2. Cliff edge effects

If the flooding in underground second Floor level of Combination /Reactor Building reached 56cm or above (i.e., the flooding from outside the building drained to four ECCS Rooms in Reactor Building via the seams of ground floor equipment hatch), all low pressure and high pressure safety injection pumps shall be inoperable and water makeup shall be interrupted so that reactor core safety will become very marginal.

If the flooding level is continuously rising to 30 cm above the underground first floor (EL.17.33 ft), CRD pump, CSCW pump and CST pump will lose their functions and Emergency Diesel Generators A & B will also lose their functions (Because MCC 3A-2, 4A-2, & CSCW pump lose their functions due to flooding so that Emergency Diesel Generators also lose their functions) so as to result in the emergency condition that on-site power is lost and there is only the 5th Diesel generator available for both units use. If the flooding level in Combination / Reactor Building reached 12.7 m or above (That is, the flooding level has reached 60 cm above ground floor), all ECCS injection pumps and alternative water makeup pumps such as CST Pump, BCSS Pump, RHR Booster Pump, and Condensate Pump will be inoperable unless flooding was eliminated or alternative injection path has been established to prevent from core fuel damage.

If the intake water quality is severely deteriorated due to heavy rainfall or tsunami, CWS& ESW will be lost (loss of ultimate heat sink) so that reactor core residual heat is unable to be removed and finally result in core fuel damage.

(1) As described in FSAR 3.4.3 of Chin Shan Power Plant, the maximum flood height at Chien-Hua Creek, which is close to units 1 and unit 2 of Chin Shan Power Station, is still 3 feet (0.91meter) lower than the ground surface of the power plant. The building drainage system does not directly connect with the storm drainage system of the plant. This can prevent flooding from reverse overflowing into buildings through the storm drainage system. Penetrations between turbine building and the combination structure building are sealed and leak-proof. The sumps in the corner rooms on the bottom floor of reactor building are exclusively for this region and not connected with other areas. This prevents external flooding from entering the building and ensures the reliability of important ECCS equipment. Storm drainage system and influence of tsunami has been taken into consideration during plant design stage. Consequently, no building would be flooded. However, if precipitation induced by natural disaster which is beyond design basis and causes internal flooding, then the floor levels in the combination structure building and reactor building below 39.83 feet elevation

would be the flooding vulnerabilities. .

(2) The major flooding vulnerability and cliff edge effect is at the bottom floor of reactor building with -0.83 feet elevation. This is because all corner rooms on this floor level contain RCIC and safety related emergency coolant injection systems, including high pressure coolant injection system (HPCI), low pressure coolant injection system (LPCI), core spray system (CS). If all of these systems are flooded, this would cause all high and low pressure emergency injection systems (containing electric water pumps and steam driven water pumps) inoperable. Then the plant would completely lose the reactor makeup function of emergency safety systems serve and only backup containment spray systems are available for use.

(3) BCSS is not a safety related system. It connects fire protection water systems and containment spray pipes and becomes a cooling water source for reactors and containments. When the back pressure of this spare water pump is smaller than 110 PSIG, it can deliver more than 250 GPM of water into reactors. Nevertheless, before using this system for emergency injection, reactors need to be depressurized first. Depressurizing process may temporarily make reactor water level drop to lower than top of fuel (TAF). According to the simulation analysis conducted by the Nuclear Safety Department of Taipower Company, there would be no zirconium-water reactions and therefore there is no safety concern. Ensure BCSS pump capacity is greater than 153 GPM to protect the fuel from serious event.

(4) The second vulnerability and cliff edge effect is at the ground floor of the combination structure building because there is a safety related electricity switch gear room, containing 4.16kV essential buses #3 and #4, exists in the building. If the room is flooded, it would cause A/B trains of safety related AC power equipment inoperable and this would lead to station blackout and loss of ultimate heat sink. Consequently, only DC battery system is available and it can sustain for 8 hours only. Since BCSS Pump and MOVs are located on the ground floor of EL. 39.83 feet, flooding inside plant building may cause damage to their power source. However, MOVs still can be manually operated, and water can be pumped into reactor and containment for cooling by using fire engine or other pumping device through BCSS URG injection point located outside of containment east wall (Refer to Procedure 1452.2 Para. 8 for detail.). In addition, CSNPP is planning to purchase special valve bonnet which can be connected to the fire protection water hose after the existing valve bonnet and disc are removed, for RHR system valves E11-FF003 and CS system valve E21-F044A/B. Fire water can be from either the fire water hydrant or the fire engine (Please refer to Procedure 1452.2 Para. 3 for details).

(5) Moreover, if essential service water system (ESW) inlets are clogged by a great deal of debris, this would also cause fine grid clogged and affect intake of the pumps, which will lead to loss of ultimate heat sink.

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

1. In respond to extreme weather condition

(1) When Central Weather Bureau issues sea and land alerts for typhoons and the plant judges that the typhoon may threaten the power station, Procedure 104.22 “Typhoon prevention and response procedure” needs to be executed.

(2) Follow procedure 104.37 “Chien-Hua Creek mudslide monitoring procedure” to conduct walkdown and inspection. Watch for mudslides signs, such as abnormal murkiness in stream water, rumbling sounds of mountains, and etc. and pay attention to see whether there are situations that would hinder the delivery of water in rivers/streams, such as clogged status and deposition in rivers/streams, abnormal changes at slope ground, abnormal collapse and sliding of slopes, and etc.

(3) When Central Weather Bureau forecasts the typhoon zone may seize Taiwan, Chinmen, and Mazu and issues “sea and land alerts for typhoons” and the plant is in one of the warned areas in the typhoon alert, comply with procedure 513 “Procedure for operation during typhoon alert period.”

(4) When there is internal or external flooding, follow procedure 515.2 “Internal flooding response procedure” or procedure 515 “External flooding emergency response procedure.”

(5) When situations of beyond design basis happen and onsite and offsite AC power or reactor water makeup capability are lost, the plant must take decisive actions and be prepared to abort reactors and then follow procedure 1451 “Unit ultimate response guideline.”

2. Enhancement measures:

(1) In response to the tsunami event, all openings on the underground trenches of ESW intake pumps are installed with grids to resist against tsunamis and first openings on the top are installed with fixed screens to prevent large trash from entering underground trenches, so the intake function of ESW drainage pumps would not be affected. (After June 30, 2011)

(2) Perform routine walkdown inspection once every year in accordance with procedure 104.22 “Typhoons disaster prevention and response procedure” and 795.12 “Onsite structure monitoring and walkdown inspection operating procedure” to confirm the trenches can drain properly and their structure is sturdy. Moreover, related divisions setup annual contract to maintain these trenches cleaned.

(3) As per procedure 113.5, in addition to the existing spare rescue equipment, CSNPP has considered all category of equipment needed to respond to combined natural disasters, and has purchased two 4.16kV/1500kW mobile container diesel generators, eight 480V/500kW and four 480V/200kW diesel generators, plus various portable equipment including smaller diesel/gas generators, air compressors, internal combustion engine drainage pumps(Some of

them have not been delivered to the plant yet.), and other mitigation equipment. All those equipment are maintained to be available at all time for emergency use. The eight 480V/500kW diesel generators has been installed on the roof of the Combination Structure Building(EL. 100 feet), free of flooding, to provide power for emergency water supply pumps, HVAC, monitoring instrumentation, emergency light/communication, etc. Planned installation will be scheduled at EOC-26 outage for both Unit 1 and Unit 2. Manual power supply connection can be used prior to said installation. Two of the four mobile 480V/200kW diesel generators can provide emergency power to Unit 1 and 2 Radwaste Storage Building, the third one can provide emergency power to N2 inerting System, and the fourth is for spare. All four diesel generators installed or stored in the higher area of the Gas Turbine Building or Unit 1 Radwaste Building.(After June 30, 2011)

(4) The bottom floor of the combination structure building has higher possibility of flooding. If sump pumps do not have sufficient drain capacity, two pumps in the seeped tank can be used as drainage pumps and discharge the water through circulating seawater trenches. Additionally, Chin Shan Power Plant has procured 8 large gasoline engine drainage pumps to enhance drainage capability of plant buildings. (After June 30, 2011)

(5) The plant plans to install water-tight doors at entrances/exits of 5th EDG buildings, and floodgates at entrances/exits of Combination Structure Building to enhance water-proofing capability of buildings. (After June 30, 2011)

(6) The plant has procured two 4.16KV mobile diesel generators, which will be used to provide spare power sources to long term cooling related equipment. (After June 30, 2011)

(7) Through the power loading management listed in Procedure 1452.1, and the mechanism of 125VDC SWBD #6 distribution to DC SWBD #2, DC power source can sustain for at least 24 hours to supply the power required by the operation of RCIC. Power distribution from 125V DC Battery #6 to Battery #1 and Battery #2 can be accomplished via three 3 power supply panels - Ⅰ/Ⅱ/Ⅲ of the existing 125V DC system.

References

a. Official Document

1. 「都會區及周遭坡地環境地質資料庫圖集-富貴角圖幅」(經濟部中央地質調查所)

b. Industrial Document

N/A

c. Taipower Internal Document

1. 「核一廠終期安全分析報告」(台灣電力公司)
2. 「小坑溪及乾華溪土石流危險度評估報告」(益鼎公司、精英大地工程顧問有限公司)
3. 架空輸電線路設計準則(台灣電力公司)
4. 核能電廠開關場設計準則(台灣電力公司)
5. 104.22 程序書：「颱風災害預防與處理」
6. 104.37 程序書：「乾華溪土石流監測」
7. 106.9.4 程序書：「危機管理及應變作業程序」
8. 113.5 程序書：「災害防救要點」
9. 513 程序書：「颱風警報期間運轉」
10. 515 程序書：「廠區水災緊急操作規程」
11. 515.2 程序書：「廠房內水災處理程序書」
12. 535 程序書：「廠區全黑」
13. 795.12 程序書：「廠區結構監測巡視作業程序」
14. 1451 程序書：「核一廠斷然處置程序指引」
15. 1452.1 程序書：「斷然處置程序輔助程序書電源的建立」
16. 1452.2 程序書：「斷然處置程序輔助程序書水源的建立」
17. 1452.3 程序書：「斷然處置程序輔助程序書反應爐緊急降壓與圍阻體排氣」
18. 1452.4 程序書：「斷然處置程序輔助程序書熱沉的建立」
19. 1452.5 程序書：「斷然處置程序輔助程序書支援應變措施」
20. 1452.6 程序書：「斷然處置程序輔助程序書聚集所可居住性控制」

Attachment 4-1 Typhoon + Heavy Rain/Mud Flow(Mudslide) : Plant Internal Pressure Test

1.Illustration of Typhoon + Heavy Rain/Mud Flow : Plant Internal Pressure Test

Purpose: To test the capability of CSNPP to cope with compound extreme weather condition, and to find the safety margin for defense in depth, and to figure out the cliff edge.

(1) ：Initiation of test conditions.

1.Strong storm with heavy rain was being forecasted(alerted) to impact the plant directly within short time.

2.Typhoon response had been organized. (includes standby manpower and 6 (six) fire fighters)

3.One shift operators had been called to stay in the plant to act as backup manpower.

4.Both units operates at full power.

5.Typhoon bring heavy wind and rain which caused the plant lost off site power and backup power. Creek beside the plant was blocked by mud flow induced by heavy rain. Water overflow from the creek and flow into power block area, reactor building bottom floor (under ground) was being flooded. The plant lost its ECCS injection system and ESW (ultimate heat sink).

Note. The assumptions mentioned above is far away beyand the plant true situations, because

1. The Control Weather Bureau keeps its high reputation for a long time, the forecast will give the plant plenty time to prepare for a typhoon, if in need the reactor power will be decrease or bring to shutdown in advance.
2. The history shows that there is no strong typhoon and heavy rain hit the plant simultaneously, this stress test assumed that the rain fall was estimated based on 10,000 years recurrence and caused flood to the plant.
3. According the official announcement given by government, CSNPP is not located at mud flow precaution area, but this stress test assumed that the creek was blocked by mud flow to cause the water flow into the plant building.
4. Penetrations of the plant had been verified to be intact via procedure No.796 during each refueling outage. In the future, water tight doors/floodgates for major building

will be setup, in this stress test it was assumed that the water tight doors/floodgates were failed.

5. ESW pump house is located at 11.2 meter height and near the sea shore, the flood water will flow in to the sea instead of flow into the ESW pump house, in real case the ESW pump house will not be damaged by flooding.

(2) Control measures for standby manpower：

1. After typhoon alert announced, the operation chief shall follow the least numbers of typhoon response manpower to use support team or training team to assist in the unit operation. And also, it is assessed that the road condition may be interrupted due to strong wind and rain or roadblock, and it is anticipated that the takeover time will be delayed during typhoon period of time, the takeover manpower shall be called in advance or off-shift manpower shall be reserved to stay at site for standby in order to take over on time or assist in operation so as to avoid that on-shift operators work too long that their mental state and physical state are impacted to danger unit safe operation. 。
2. Moreover, the station General Affair Management Manual 3.4 「The Company Shuttle Bus Driving Points after the Government Announced Stop Work for New Taipei City , Taipei City , and Keelung City」 also had programmed its relevant executive details and processes. 。

(3) Operator protection under strong wind and heavy rainfall condition：

1. If operator still can go out to operate under the strong wind and heavy rain condition, the station had provided safety shoes, safety helmet, and safety belt that can provide the sufficient protections. And also light raincoat is provided for rain work. If operator is unable to go out to operate, operator shall be escorted by heavy vehicle (crane truck or forklift truck) to complete its necessary missions.
2. Most of the station power supply interfaces are remote operation and the switchboxes are equipped in indoors so that there is no need to operate them under the strong wind and heavy rain condition. Even if there is need to manually operate them at site, high voltage insurance gloves, cloths, and shoes can also be used to prevent from electrical shock. If there is any doubts of insulation degradation, its load side shall be measured to confirm if it is normal and then power distribution in order to avoid equipment damage.

(4) Proper isolation of power supply interface while its malfunction：

The power supply interface in the station existing design has the automatic isolation function. If it appears the condition that it should be isolated but not isolated, it shall be operated after the operator careful confirmation and judgment that this operation mode is a regular operation requirements for the on-shift operators. Therefore, the isolation operation of the power supply interface malfunction, the station shall judge and assess as per each kind of power supply interface malfunction condition and then take the necessary isolation operation in the adaptable isolation range.

- Stress test Time History (figure 1 of this chapter)
- Stress Flow Chart (figure 2 of this chapter)

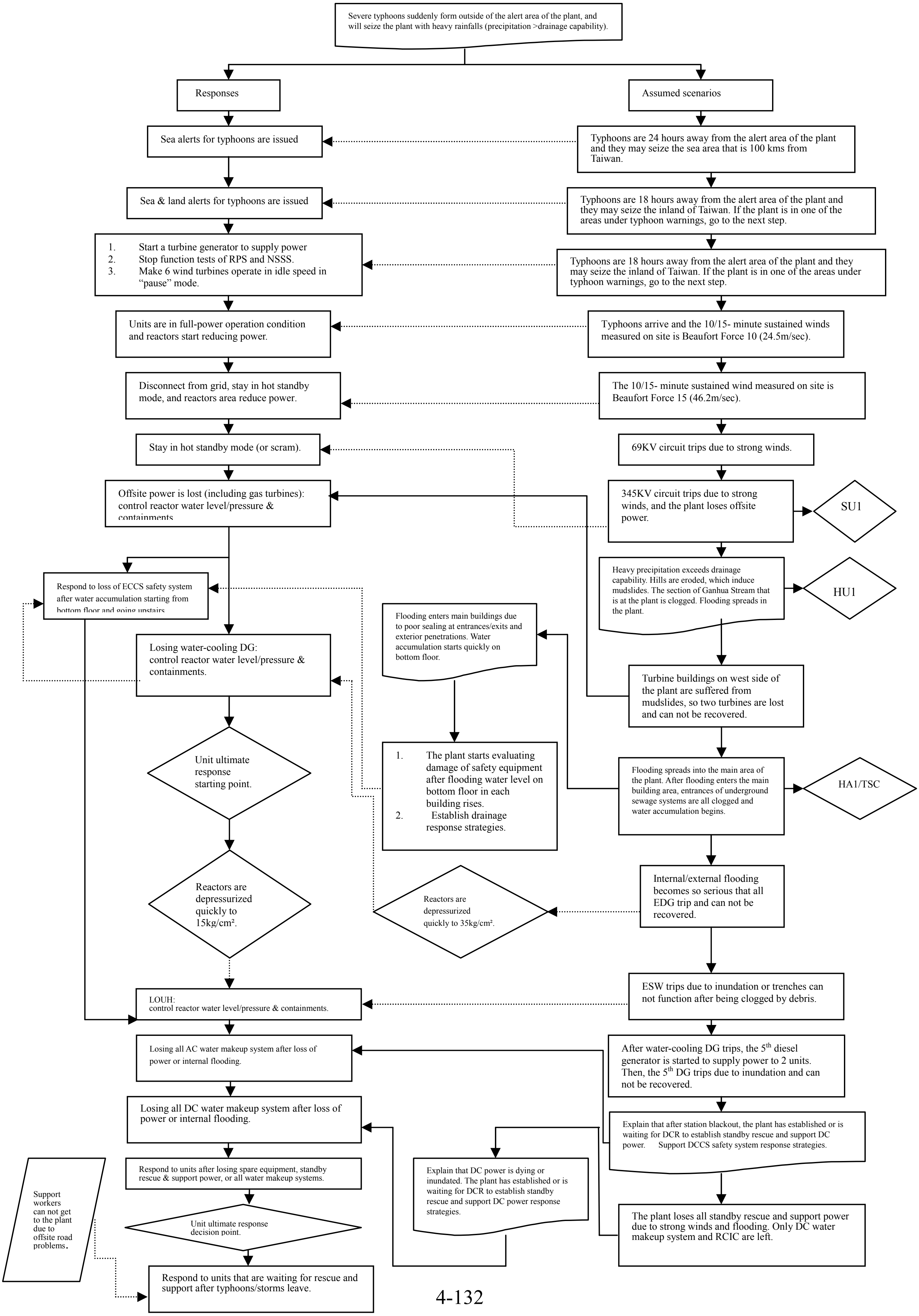

Severe typhoons suddenly form outside of the alert area of the plant, and will seize the plant with heavy rainfalls (precipitation >drainage capability).
Responses
Assumed scenarios
Sea alerts for typhoons are issued
Typhoons are 24 hours away from the alert area of the plant and they may seize the sea area that is 100 kms from Taiwan.
Sea & land alerts for typhoons are issued
Typhoons are 18 hours away from the alert area of the plant and they may seize the inland of Taiwan. If the plant is in one of the areas under typhoon warnings, go to the next step.
1. Start a turbine generator to supply power
2. Stop function tests of RPS and NSSS.
3. Make 6 wind turbines operate in idle speed in “pause” mode.
Typhoons are 18 hours away from the alert area of the plant and they may seize the inland of Taiwan. If the plant is in one of the areas under typhoon warnings, go to the next step.
Units are in full-power operation condition and reactors start reducing power.
Typhoons arrive and the 10/15- minute sustained winds measured on site is Beaufort Force 10 (24.5m/sec).
Disconnect from grid, stay in hot standby mode, and reactors area reduce power.
The 10/15- minute sustained wind measured on site is Beaufort Force 15 (46.2m/sec).
Stay in hot standby mode (or scram).
69KV circuit trips due to strong winds.
Offsite power is lost (including gas turbines): control reactor water level/pressure & containments.
345KV circuit trips due to strong winds, and the plant loses offsite power.
SU1
Heavy precipitation exceeds drainage capability. Hills are eroded, which induce mudslides. The section of Ganhua Stream that is at the plant is clogged. Flooding spreads in the plant.
HU1
Respond to loss of ECCS safety system after water accumulation starting from bottom floor and going upstairs
Flooding enters main buildings due to poor sealing at entrances/exits and exterior penetrations. Water accumulation starts quickly on bottom floor.
Losing water-cooling DG: control reactor water level/pressure & containments.
Turbine buildings on west side of the plant are suffered from mudslides, so two turbines are lost and can not be recovered.
Unit ultimate response starting point.
1. The plant starts evaluating damage of safety equipment after flooding water level on bottom floor in each building rises.
2. Establish drainage response strategies.
Flooding spreads into the main area of the plant. After flooding enters the main building area, entrances of underground sewage systems are all clogged and water accumulation begins.
HA1/TSC
Reactors are depressurized quickly to 15kg/cm².
Reactors are depressurized quickly to 35kg/cm².
Internal/external flooding becomes so serious that all EDG trip and can not be recovered.
LOUH: control reactor water level/pressure & containments.
ESW trips due to inundation or trenches can not function after being clogged by debris.
Losing all AC water makeup system after loss of power or internal flooding.
After water-cooling DG trips, the 5th diesel generator is started to supply power to 2 units. Then, the 5th DG trips due to inundation and can not be recovered.
Losing all DC water makeup system after loss of power or internal flooding.
Explain that after station blackout, the plant has established or is waiting for DCR to establish standby rescue and support DC power. Support DCCS safety system response strategies.
Respond to units after losing spare equipment, standby rescue & support power, or all water makeup systems.
Explain that DC power is dying or inundated. The plant has established or is waiting for DCR to establish standby rescue and support DC power response strategies.
Support workers can not get to the plant due to offsite road problems.
Unit ultimate response decision point.
The plant loses all standby rescue and support power due to strong winds and flooding. Only DC water makeup system and RCIC are left.
Respond to units that are waiting for rescue and support after typhoons/storms leave.

Fig. 1

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

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

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

Assumed scenario →	Design basis & various scenario base line →	Protection intensity	Procedure Response	Man power and work duration
Central Weather Bureau issues sea and land alerts for typhoons, and the plant is in an areas under the typhoon warning. Typhoons of Beaufort Force 7 is 18 hours away from the alert area of the plant The plant is in “typhoon watching period” mode.	Power switchyard/ transmission route gust design 57.7m/sec, namely Force 17 Main buildings 60m/sec, namely Force17 and above	Power sources 1. 345kV 4 loops 2.69kV 2 loops 3. Gas turbine generators (A/B) 4. Water-cooling diesel generators (A/B) 5. Air-cooling diesel generator (5th) 6. Gas turbine generators fail, so start diesel generators (DCR in progress) 7.Two 1500kw mobile diesel generator (DCR) 8. Twelve 480V mobile diesel generators (Eight 500kw non-mobile diesel generators are located on or above 2F, supplying power to CSCW, SBGT, and DC charger.) 9. DC replaces. Feedwater system 1. CP/FW 2. CRD 3.RCIC 4.HPCI 5.CS 6. LPCI 7.SBLC receives water via TEST TK 8.CST via.RHR & CCS. feedwater pipes 9.Fire-fighting water via BCSS 10. Fire truck with a water tank (acquire water from stream and seawater) via BCSS 11.ESW acquires water via RHR 12.Increase the use of mobile equipment. As for CP, use remaining water in hot well (DCR in progress)	1.Abide by procedure 513 to watch the latest status of typhoons. If the plant judges typhoons may hit the site, comply with procedure 515 – “External flooding emergency response procedure’ to open flood gates. 2. Test to verify if all communicative system and NDS can function normally. 3. Confirm in 8 hours that DIV I. Ⅱ . Ⅲ emergency diesel generators can operate. 4. Confirm in 8 hours that the gas turbine can operate. All divisions conduct inspection based on “typhoon checklists” and make improvement following procedure 104.22—“ Typhoon checklist procedure.” Heat sink 1.CWP/SWP 2.ECW/BOOSTER PP 3.Water-cooling diesel generator change operating mode (Before item 4 DCR is finished, this is the alternative mode to use) 4.100,000-Ton raw water reservoir connected to ESW pump discharge. 5. SGBT (can be supplied with power by 480v mobile diesel generator) Control air source 1. Distribute soft hoses and quick connectors to be connected onto HCU nitrogen cylinders. Increase the gas source for dry wells to make it last for over 43.2 hours. 2. Liquid nitrogen tanks supply nitrogen.	On shift/ 8hrs (1-3) All divisions/ 10 hours before typhoons of Beaufort Force 7 arrive at the alert area of the plant (4)
Central Weather Bureau issues sea and alerts for typhoons, and the plant is in an area under the typhoon warning. Typhoons of Beaufort Force 7 is 10 hours away from t the alert area of the plant. The plant is in “typhoon alert period” mode.	Power switchyard/ transmission route gust design 57.7m/sec, namely Force 17 Main buildings 60m/sec, namely Force17 and above	Same as above.	When the typhoon emergency response team is established: 1.When the plant expects typhoons and heavy rainfall to hit the site, the superintendent (or his authorized person) reports to nuclear development division that the plant will be in the alert mode or hold typhoon meetings. 2.Typhoon coordinator informs the shift manager about the establishment of the team and the shift manager should stay in contact with the typhoon coordinator at all time. 3.The shift manager should assign workers to start NDS and confirm it is connected. 4. If abnormal situations or accidents regarding power generating at the plant occur due to typhoons, the plant should report obeying procedure for natural events or emergency events.	On shift/ 4 hours

Fig. 2"Typhoons +heavy rainfalls /mudslides" Stress Tests"

Assumed scenario	Design basis & various scenario base line	Response: Protection intensity	Response: Procedure	Man power and work duration
One hour before the radius of typhoons with wind of Beaufort Force 7 arrives at the site, or the site is expected to be within the radius of typhoons with wind of Beaufort Force 7 and the actual 10/15-minute sustain wind measured at the plant reaches Force 10.	Power switchyard/ transmission route gust design 57.7m/sec, namely Force 17 Main buildings 60m/sec, namely Force17 and above	<u>Power sources</u> 1. 345kV 4 loops 2. 69kV 2 loops 3. Gas turbine generators (A/B) 4. Water-cooling diesel generators (A/B) 5. Air-cooling diesel generator (5th) 6. Gas turbine generators fail, so start diesel generators 7.Two 1500kw mobile diesel generator (DCR) 8. Twelve 480V mobile diesel generators (Eight 500kw non-mobile diesel generators are located on or above 2F, supplying power to CSCW, SBGT, and DC charger.) 9. DC replaces. <u>Feedwater system</u> 1. CP/FW 2. CRD 3.RCIC 4.HPCI 5.CS 6. LPCI 7.SBLC receives water via TEST TK 8.CST via.RHR & CCS. feedwater pipes 9.Fire-fighting water via BCSS 10. Fire truck with a water tank (acquire water from stream and seawater) via BCSS 11.ESW acquires water via RHR 12.Increase the use of mobile equipment. As for CP, use remaining water in hot well (DCR in progress)	1. Follow procedure310.5 to start a gas turbine, connect it to 69 KV, and isolate outside power; the other is on standby. 2. Stop related function tests on RPS and NSSS system.	On shift/ 0.5hr
			<u>Heat sink</u> 1.CWP/SWP 2.ECW/BOOSTER PP 3.Water-cooling diesel generator change operating mode (Before item 4 DCR is finished, this is the alternative mode to use) 4.100,000-Ton raw water reservoir connected to ESW pump discharge. 5. SGBT (can be supplied with power by 480v mobile diesel generator) <u>Control air source</u> 1. Distribute soft hoses and quick connectors to be connected onto HCU nitrogen cylinders. Increase the gas source for dry wells to make it last for over 43.2 hours. 2. Liquid nitrogen tanks supply nitrogen.	
Sea and land alerts for typhoons are issued. The alert area of the site is within the area under typhoon alerts. The actual 10/15-minute sustain wind measured at the site reaches Force 10 (24.5m/sec).	Power switchyard/ transmission route gust design 57.7m/sec, namely Force 17 Main buildings 60m/sec, namely Force17 and above	Same as above.	Reduce power to turbine trip bypass set point of RPS in 3 hours.	On shift/ 3 hours
The actual 10/15-minute sustain wind measured at the site reaches Force 15 (46.2m/sec).	Power switchyard/ transmission route gust design 57.7m/sec, namely Force 17 Main buildings 60m/sec, namely Force17 and above	Same as above.	Disconnect from grid and stay in hot standby mode in 4 hours.	On shift/ 4 hours

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

Assumed scenario	Design basis & various scenario base line	Protection intensity / Procedure / Response	Man power and work duration
69kV transmission cable trips >57.7m/sec.	Power switchyard/ transmission route gust design 57.7m/sec, namely Force 17	<u>Power sources</u> 1. 345kV 4 loops 2. 69kV 2 loops LOSS 3. Gas turbine generators (A/B) 4. Water-cooling diesel generators (A/B) 5. Air-cooling diesel generator (5^{th}) 6. Gas turbine generators fail, so start diesel generators 7.Two 1500kw mobile diesel generator (DCR) 8. Twelve 480V mobile diesel generators (Eight 500kw non-mobile diesel generators are located on or above 2F, supplying power to CSCW, SBGT, and DC charger.) 9. DC replaces. <u>Feedwater system</u> 1. CP/FW 2. CRD 3.RCIC 4.HPCI 5.CS 6. LPCI 7.SBLC receives water via TEST TK 8.CST via.RHR & CCS. feedwater pipes 9.Fire-fighting water via BCSS 10. Fire truck with a water tank (acquire water from stream and seawater) via BCSS 11.ESW acquires water via RHR 12.Increase the use of mobile equipment. As for CP, use remaining water in hot well (DCR in progress) When the meteorological tower measured the speed of the gust at the plant is 60m/sec (Beaufort Force 17) and it poises a threat to the safety of the operation in the protection area or it seriously hinders workers from conducting safe operation, the plant immediately announces units go to HU1 using procedure 1401 as guidance. When the speed of sustain wind of typhoons reaches 60m/sec and it poises a threat to the safety of the operation in the protection area or it seriously hinders workers from conducting <u>Heat sink</u> 1.CWP/SWP 2.ECW/BOOSTER PP 3.Water-cooling diesel generator change operating mode (Before item 4 DCR is finished, this is the alternative mode to use) 4.100,000-Ton raw water reservoir connected to ESW pump discharge. 5. SGBT (can be supplied with power by 480v mobile diesel generator) <u>Control air source</u> 1. Distribute soft hoses and quick connectors to be connected onto HCU nitrogen cylinders. Increase the gas source for dry wells to make it last for over 43.2 hours. 2. Liquid nitrogen tanks supply nitrogen.	On shift/ Continue
345kV transmission cable trips >57.7m/sec.	Power switchyard/ transmission route gust design 57.7m/sec, namely Force 17	<u>Power sources</u> 1. 345kV 4 loops LOSS 3. Gas turbine generators (A/B) 4. Water-cooling diesel generators (A/B) 5. Air-cooling diesel generator (5^{th}) 6. Gas turbine generators fail, so start diesel generators 7.Two 1500kw mobile diesel generator (DCR) 8. Twelve 480V mobile diesel generators (Eight 500kw non-mobile diesel generators are located on or above 2F, supplying power to CSCW, SBGT, and DC charger.) 9. DC replaces. <u>Feedwater system</u> 1. CP/FW //LOSS 2. CRD 3.RCIC 4.HPCI 5.CS 6. LPCI 7.SBLC receives water via TEST TK //LOSS 8.CST via.RHR & CCS. feedwater pipes //LOSS 9.Fire-fighting water via BCSS 10. Fire truck with a water tank (acquire water from stream and seawater) via BCSS 11.ESW acquires water via RHR 12.Increase the use of mobile equipment. As for CP, use remaining water in hot well (DCR in progress) 1. Immediately shutdown reactor and achieve cold shutdown mode as soon as possible. 2. Confirm if gas turbine generators supply power to 345kV bus, or emergency bus should be supplied with power from water-cooling DG. (5076/207/501.6/204) <u>Heat sink</u> 1.CWP/SWP //LOSS 2.ECW/BOOSTER PP 3.Water-cooling diesel generator change operating mode (Before item 4 DCR is finished, this is the alternative mode to use) 4.100,000-Ton raw water reservoir connected to ESW pump discharge. 5.SGBT (can be supplied with power by 480v mobile diesel generator) <u>Control air source</u> 1. Distribute soft hoses and quick connectors to be connected onto HCU nitrogen cylinders. Increase the gas source for dry wells to make it last for over 43.2 hours. 2. Liquid nitrogen tanks supply nitrogen.	On shift/ 12 hours till reactors reach cold shutdown.

Fig. 2"Typhoons +heavy rainfalls /mudslides" Stress Tests"

Assumed scenario	Design basis & various scenario base line	Protection intensity	Procedure / Response	Man power & work duration
Mt. hills are seriously eroded by heavy rainfall and this leads to mudslides, which clog Chien-Hua Creek artificial trenches and consequently flooding spreads in the plant. (precipitation >500mm/day) Gas turbine bldgs suffers from mudslides, so the plant loses 2 gas turbines and can not recover.	Chien-Hua Creek drainage capability 297mm/hr Drainage systems of the plant mainly utilize Chien-Hua Creek artificial trenches. Not only do they drain rainfalls and mountain floods from the upstream of Chien-Hua Creek, they also drain rainfalls converged from the plant and around the plant. Information from Water and Soil Conservation, Council of Agriculture shows no mudslides of these two creeks. Gas turbine generators EL.22m	Power sources 3. Gas turbine generators (A/B) //LOSS 4. Water-cooling diesel generators (A/B) 5. Air-cooling diesel generator (5th) 6. Gas turbine generators fail, so start diesel generators 7.Two 1500kw mobile diesel generator (DCR) 8. Twelve 480V mobile diesel generators (Eight 500kw non-mobile diesel generators are located on or above 2F, supplying power to CSCW, SBGT, and DC charger.) 9. DC replaces. Feedwater system 1. CP/FW 2. CRD 3.RCIC 4.HPCI 5.CS 6. LPCI 7.SBLC receives water via TEST TK 8.CST via.RHR & CCS. feedwater pipes 9.Fire-fighting water via BCSS 10. Fire truck with a water tank (acquire water from stream and seawater) via BCSS 11.ESW acquires water via RHR 12.Increase the use of mobile equipment. As for CP, use remaining water in hot well (DCR in progress)	1. Follow procedure 104.37 to monitor Ganhua Stream water level and hold typhoon response meetings as well as establish the typhoon emergency response team. 2. Inspect if all emergency buses are supplied with power from water-cooling DG. 3. Follow EOP 540.1 to maintain reactor water level and EOP 540.3 to conduct containment pressure control/Start cooling suppression pools to lower their temperature as much as possible. 4.When there is a flooding event that is close to the DBF of the plant, the plant enters HU1 (natural events and accidents—emergency alert). 5. When there is a flooding event that is close to the DBF of the plant, notify all related divisions to pile sandbags (green) to 1 meter in height around and at entrances/exits of related buildings.(EOP 540.1/540.3/520/515/104) Heat sink 1.CWP/SWP 2.ECW/BOOSTER PP 3.Water-cooling diesel generator change operating mode (Before item 4 DCR is finished, this is the alternative mode to use) 4.100,000-Ton raw water reservoir connected to ESW pump discharge. 5.SGBT (can be supplied with power by 480v mobile diesel generator) Control air source 1. Distribute soft hoses and quick connectors to be connected onto HCU nitrogen cylinders. Increase the gas source for dry wells to make it last for over 43.2 hours. 2. Liquid nitrogen tanks supply nitrogen.	On shift / 1 hour
After flooding spreads into the main area of the plant, entrances/exits of the sewage system are clogged and accumulation starts quickly. (precipitation >297mm/hr) Place sandbags at entrances/exits of ground floor of reactor buildings	Chien-Hua Creek drainage capability 297mm/hr Elevation of the main area of the plant is 12m. Capability of the ground drainage system is 2.48cms. Drainage systems of the plant mainly utilize Chien-Hua Creek artificial trenches. Not only do they drain rainfalls and mountain floods from the upstream of Chien-Hua Creek, they also drain rainfalls converged from the plant and around the plant. Install water-shielding plates at exterior doors of ground floor of reactor buildings, air-cooling diesel generator (5th), and emergency seawater pump rooms. (MMR in progress)	Power sources 4. Water-cooling diesel generators (A/B) 5. Air-cooling diesel generator (5th) 6. Gas turbine generators fail, so start diesel generators 7.Two 1500kw mobile diesel generator (DCR) 8. Twelve 480V mobile diesel generators (Eight 500kw non-mobile diesel generators are located on or above 2F, supplying power to CSCW, SBGT, and DC charger.) 9. DC replaces. Feedwater system 2. CRD 3.RCIC 4.HPCI 5.CS 6. LPCI 9.Fire-fighting water via BCSS 10. Fire truck with a water tank (acquire water from stream and seawater) via BCSS 12.Increase the use of mobile equipment. As for CP, use remaining water in hot well (DCR in progress)	1. If water accumulation starts in the main area of the plant, follow procedure, confirm units are shut down and announce HA1, & establish TSC. 2. If TSC can not enter the plant, follow procedure 1408 "OSC mobilization and response procedure" to start emergency mobilization. 3. Monitor alarms for sumps outside of buildings/ Sump pumps are operating normally. 4. Pile sandbags at emergency equipment in main area of the plant or install water-shielding plates at entrances/exits of main buildings to prevent flooding from entering. (515/515.2/204/1408) Heat sink 2.ECW/BOOSTER PP 3.Water-cooling diesel generator change operating mode (Before item 4 DCR is finished, this is the alternative mode to use) 4.100,000-Ton raw water reservoir connected to ESW pump discharge. 5.SGBT (can be supplied with power by 480v mobile diesel generator) Control air source 1. Distribute soft hoses and quick connectors to be connected onto HCU nitrogen cylinders. Increase the gas source for dry wells to make it last for over 43.2 hours. 2. Liquid nitrogen tanks supply nitrogen.	Continue

Fig. 2"Typhoons +heavy rainfalls /mudslides" Stress Tests"

Assumed scenario	Design basis & various scenario base line	Protection intensity	Procedure / Response	Manpower and work duration

Flooding enters main buildings because of poor sealing of entrances/exits or penetrations. Water starts accumulating quickly on the bottom floor. The plant evaluates the damage rising accumulation water level on bottom floor of all buildings causes to safety systems.
 	
The plant evaluates the damage accumulation going upstairs can cause to safety systems.
 	
Drainage response strategies.
 	
Describe the situation of flooding on bottom floor of all buildings going up to ground floor complying procedure.
	Place sandbags at entrances/exits of ground floor of reactor buildings
	
	Install water-shielding plates at exterior doors of ground floor of reactor buildings, air-cooling diesel generator (5^{th}), and emergency seawater pump rooms. (MMR in progress)
	
	Conduct inspection of sealing of penetrations and reserved holes on exterior walls of buildings. (Procedure 791.2)
	
	Inside of the ECCS area is divided into 4 rooms and each room is isolated/not connected with another. Each room has water-seal doors, so leaking at the suppression pool area in containments would not enter each room. There are one 50gpm drainage pump and indoor flood alarms.
	Flooding at gas turbine buildings is drained into the sumps the buildings are equipped with. (Drainage capability 50gpm/unit, 5 units)
	Flooding at the waste treatment building is drained into the sumps the building is equipped with. (Drainage capability 50gpm/unit, 1 units)
	Flooding at the combination structure building is drained into the sumps the building is equipped with. Mechanic equipment group under the mechanic division is responsible for supplying drainage equipment during flooding. (2 mobile generators, 5 electric drainage pumps (procedure 113.5))
		Power sources
		4. Water-cooling diesel generators (A/B)//LOSS
		5. Air-cooling diesel generator (5^{th})
		6. Gas turbine generators fail, so start diesel generators
		7.Two 1500kw mobile diesel generator (DCR)
		8. Twelve 480V mobile diesel generators (Eight 500kw non-mobile diesel generators are located on or above 2F, supplying power to CSCW, SBGT, and DC charger.)
		9. DC replaces.
		Feedwater system
		2. CRD//LOSS 3.RCIC//LOSS 4.HPCI//LOSS 5.CS//LOSS 6. LPCI//LOSS
		9.Fire-fighting water via BCSS
		10. Fire truck with a water tank (acquire water from stream and seawater) via BCSS
		12.Increase the use of mobile equipment. As for CP, use remaining water in hot well (DCR in progress)
		Heat sink
		2.ECW/BOOSTER PP
		3.Water-cooling diesel generator change operating mode (Before item 4 DCR is finished, this is the alternative mode to use) //LOSS
		4.100,000-Ton raw water reservoir connected to ESW pump discharge.
		5.SGBT (can be supplied with power by 480v mobile diesel generator)
		Control air source
		1. Distribute soft hoses and quick connectors to be connected onto HCU nitrogen cylinders. Increase the gas source for dry wells to make it last for over 43.2 hours.
		2. Liquid nitrogen tanks supply nitrogen.
			1.Monitor water level of building sumps and if the sump pumps are operating normally. If water level is abnormal, follow procedure 566.4 to trace origins of excessive water and isolate them.
			2. 2. Install drainage pumps or electric drainage pumps and drain water from D-4/R-15 to outside of buildings. (1451)
			3. There is spare emergency rescue and support equipment, including drainage pumps in various sizes, 13 drainage machines, and 13 emergency generators, to provide supporting equipment to related damaged buildings and floors during flooding.
			4. Accumulation on 1F of the combined bldgs rises, so the plant will lose normal/emergency cooling system and control bldg HVAC. When the water rises to above 17.33 feet, the plant will lose CSCW. If the water level exceeds 39.83 feet, the plant will lose the function of DIV-1/2 switch room.
			*When expecting the bottom floor of the combined building will be flooded and cause the loss of normal/emergency chiller water system:
			(1) Order shutdown and stop using equipment in this area.
			*When expecting the motors in the CSCW pump area will be flooded:
			(1) If reactors are not shut down, manually shut down the reactors.
			(2) Stop using equipment in the CSCW pump area and water-cooling DG (A/B). Use air-cooling DG (5^{th}) to supply power.
			(3)Also, start distributing and placing reactor alternative feedwater (fire-fighting) till 1 valve left.
			*When expecting DIV-1/2 switch room will be flooded,
			(1) Start unit ultimate response. First distributing and placing feedwater pipes and then depressurize reactors to $15kg/cm^2$
				3workers/ 1.5hours set up a drainage station (typhoon emergency response team)
				
				Continue

Fig. 2"Typhoons +heavy rainfalls /mudslides" Stress Tests"

Assumed scenario	Design basis & various scenario base line	Protection intensity	Procedure / Response	Manpower and work duration
Flooding enters main buildings because of poor sealing of entrances/exits or penetrations. Water starts accumulating quickly on the bottom floor. The plant evaluates the damage rising accumulation water level on bottom floor of all buildings. causes to safety systems. The plant evaluates the damage accumulation going upstairs. can cause to safety systems. Drainage response strategies. Describe the situation of flooding on bottom floor of all buildings going up to ground floor complying procedure. (Continuing to next page)	Same as above.	Same as above.	5. When accumulation on 1F of the combined bldgs rises, water may start permeating via ECCS water-shielding doors due to reversed water pressure. * Water in the reactor buildings, EL. -0.83', starts accumulating. (1) Inform the typhoon emergency response team to enhance drainage to outside of buildings. (2) Immediately start distributing reactor alternative feedwater systems (fire-fighting water) till one valve left. *When any of the ECCS room area> highest normal operation water level during (1) Shutdown reactors and Controlled depressurize reactors to 35kg/cm². *When any of the ECCS room area> highest safe operation water level during (1) If reactors are not shut down, manually shut down the reactors. (2)Controlled depressurize reactors to 15kg/cm² *If none of the feedwater systems can operate, start unit ultimate response. 6. If accumulation on the ground of diesel generator Bldg>30cm, the plant will lose AVR panel and then DG. 7. Flooding on bottom floor of turbine bldgs will cause loss of feedwater system. 8. Flooding on bottom floor of the waste treatment bldg does not affect safety of reactors.	NA

Fig. 2"Typhoons +heavy rainfalls /mudslides" Stress Tests"

Assumed scenario	Design basis & various scenario base line	Protection intensity	Procedure / Response	Man power and work duration
Respond to flooding going upstairs from bottom floor of all buildings and subsequent loss of ECCS safety system.	Inside of the ECCS area is divided into 4 rooms and each room is isolated/not connected with another. Each room has water-seal doors, so leaking at the suppression pool area in containments would not enter each room. 1. Each room has one 50gpm drainage pump. 2. Each drainage system can deal with any size of ruptured pipes. 3. Any of the low pressure feedwater systems has at least 2 series of independent systems. 4.High pressure feedwater system/ isolated reactor core cooling system are steam-driven, so they can still operate during blackout. 5. Low pressure residual heat removing system has two separated two series. Only one of them can supply enough power for safe shutdown. Place sandbags at entrances/exits of ground floor of reactor buildings Install floodgates at exterior doors of ground floor of combination structure buildings, water tight doors at air-cooling diesel generator (5th), and tsunami wall at emergency seawater pump rooms. (MMR in progress) Conduct inspection of sealing of penetrations and reserved holes on exterior walls of buildings. (Procedure 791.2) Flooding at gas turbine buildings is drained into the sumps the buildings are equipped with. (Drainage capability 50gpm/unit, 5 units) Flooding at the waste treatment building is drained into the sumps the building is equipped with. (Drainage capability 50gpm/unit, 1 unit) Flooding at the combination structure building is drained into the sumps the building is equipped with. Mechanic equipment group under the mechanic division is responsible for supplying drainage equipment during flooding. (2 mobile generators, 5 electric drainage pumps (procedure 113.5))	Power sources 5. Air-cooling diesel generator (5th) 6. Gas turbine generators fail, so start diesel generators 7.Two 1500kw mobile diesel generator (DCR) 8. Twelve 480V mobile diesel generators (Eight 500kw non-mobile diesel generators are located on or above 2F, supplying power to CSCW, SBGT, and DC charger.) 9. DC replaces. Feedwater system 9.Fire-fighting water via BCSS 10. Fire truck with a water tank (acquire water from stream and seawater) via BCSS 12.Increase the use of mobile equipment. As for CP, use remaining water in hot well (DCR in progress) Heat sink 2.ECW/BOOSTER PP 4.100,000-Ton raw water reservoir connected to ESW pump discharge. 5.SGBT (can be supplied with power by 480v mobile diesel generator) Control air source 1. Distribute soft hoses and quick connectors to be connected onto HCU nitrogen cylinders. Increase the gas source for dry wells to make it last for over 43.2 hours. 2. Liquid nitrogen tanks supply nitrogen.	Based on the safety evaluation above, it is learned that only situations In reactor bldg and the combined buildings can affect ECCS; (Note: the following may have been performed, so the plant only needs to verify the completion.) 1. If accumulation at ECCS pumps on the bottom floor of reactor bldgs> highest normal operation water level. * When any of the ECCS room area> highest normal operation water level during, (1) Cut off power and isolate the equipment in this area. *When any of the ECCS room area> highest safe operation water level during (1)Shut down reactors and controlled depressurize to 35kg/cm². *When more than one ECCS room areas> highest safe operation water level (1) If reactors are not shut down, manually shut down the reactors. (2)Controlled depressurize reactors to under 15kg/cm² *If none of the feedwater systems can operate, start unit ultimate response. 2. When accumulation in ECCS bus power source area occurs, * When expecting the bottom floor of the combined building will be flooded and cause the loss of normal/emergency chiller water system: (1) Order shutdown and stop using equipment in this area. * When expecting the motors in the CSCW pump area will be flooded: (1) If reactors are not shut down, manually shut down the reactors. (2) Stop using equipment in the CSCW pump area and water-cooling DG (A/B). Use air-cooling DG (5th) to supply power. (3) Also, start distributing and placing reactor alternative feedwater (fire-fighting) till 1 valve left. * When expecting DIV-1/2 switch room will be flooded, (1) Start unit ultimate response. First distributing and placing feedwater pipes and then depressurize reactors to 15kg/cm². 3. If the plant loses all ECCS, first start distributing and placing feedwater pipes and then depressurize to under 15kg/cm². (1451)	

Fig. 2"Typhoons +heavy rainfalls /mudslides" Stress Tests"

Assumed scenario	Design basis & various scenario base line	Protection intensity (Response)	Procedure (Response)	Man power and work duration
Internal/external flooding is serious so all diesel generators trip and can not recover. (DG loss: reactor water level/ pressure & containment control)	Diesel generators are of redundancy and independence. Three of the areas in the buildings are at an elevation of 12m. Only one of them can supply enough power for safe shutdown. Install water-shielding plates at exterior doors of ground floor of reactor buildings, air-cooling diesel generator (5th), and emergency seawater pump rooms. (MMR in progress)	Power sources 5. Air-cooling diesel generator (5th) 6. Gas turbine generators fail, so start diesel generators 7.Two 1500kw mobile diesel generator (DCR) 8. Twelve 480V mobile diesel generators (Eight 500kw non-mobile diesel generators are located on or above 2F, supplying power to CSCW, SBGT, and DC charger.) 9. DC replaces. Feedwater system 9.Fire-fighting water via BCSS 10. Fire truck with a water tank (acquire water from stream and seawater) via BCSS 11.ESW acquires water via RHR//1 series LOSS 12.Increase the use of mobile equipment. As for CP, use remaining water in hot well (DCR in progress) Heat sink 2.ECW/BOOSTER PP//LOSS 4.100,000-Ton raw water reservoir connected to ESW pump discharge. 5.SGBT (can be supplied with power by 480v mobile diesel generator) Control air source 1. Distribute soft hoses and quick connectors to be connected onto HCU nitrogen cylinders. Increase the gas source for dry wells to make it last for over 43.2 hours. 2. Liquid nitrogen tanks supply nitrogen.	1. Follow procedure 535 to operate 5th emergency DG to make it supply emergency power to two units at the same time. 2. Comply with related EOP. 3. Obey procedure 1451 to conduct unit ultimate response and do standby feedwater preparation. 4. Use procedure 1451 as a guideline to conduct unit ultimate response and depressurize to under 15kg/cm². Meanwhile, open the double doors of the secondary containment ventilation trucks and the pressure release plates on top of secondary containment.	On shift/ 0.6hour Maintenance div./0.5 hour
Emergency pump room trips due to flooding or trenches can no function due to debris (Heat loss: reactor water level/pressure & containment control)	Emergency seawater pump room elevation is 12m and the pump motor is even higher, so the motor will not be inundated easily. Constructure tsunami wall at the emergency seawater intake system building to prevent flooding from entering and permeating. Grids have been installed at emergency intake forebays, so the trenches would not be clogged by debris.	Power sources 5. Air-cooling diesel generator (5th) 6. Gas turbine generators fail, so start diesel generators 7.Two 1500kw mobile diesel generator (DCR) 8. Twelve 480V mobile diesel generators (Eight 500kw non-mobile diesel generators are located on or above 2F, supplying power to CSCW, SBGT, and DC charger.) 9. DC replaces. Feedwater system 9.Fire-fighting water via BCSS 10. Fire truck with a water tank (acquire water from stream and seawater) via BCSS 11.ESW acquires water via RHR//LOSS 12.Increase the use of mobile equipment. As for CP, use remaining water in hot well (DCR in progress) Heat sink 2.ECW/BOOSTER PP//LOSS 4. 100,000-Ton raw water reservoir connected to ESW pump discharge. 5. SGBT (can be supplied with power by 480v mobile diesel generator) Control air source 1. Distribute soft hoses and quick connectors to be connected onto HCU nitrogen cylinders. Increase the gas source for dry wells to make it last for over 43.2 hours. 2. Liquid nitrogen tanks supply nitrogen.	Continue to follow EOP to maintain water level and containment pressure (1451/ EOP)	On shift/ 1 hour

Fig. 2"Typhoons +heavy rainfalls /mudslides" Stress Tests"

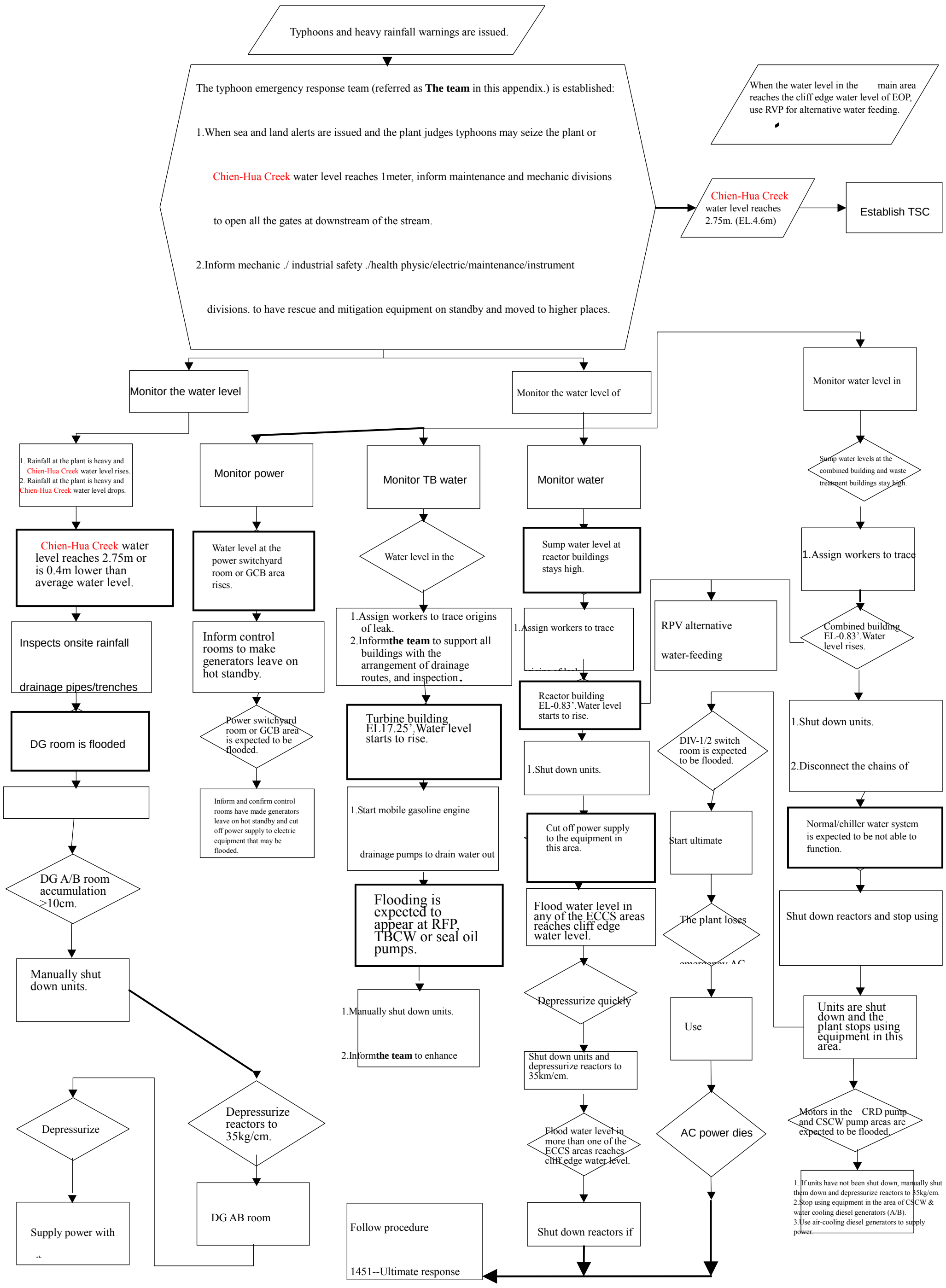
Assumed scenario	Design basis & various scenario base line	Protection intensity	Procedure / Response	Man power and work duration
After the 5th diesel generator supplies power to 2 units, it is inundated and can not recover. After explaining station blackout, the plant established or will wait for DCR to be set up and then establishes response strategies for standby rescue and support AC power to support ECCS safety system.	5th air-cooling diesel generator is at an elevation of 12m. Twelve 480V mobile diesel generators were procured after the lesson learned in order to complete DCR. 8 500kw mobile DGs are installed on floors higher than the 2nd floor. The rest are stored at appropriate elevations to avoid flooding. 480V mobile diesel generators (Originally, there was one unit, but the plant has procured 12 units.)	Power sources 5. Air-cooling diesel generator (5th) //LOSS 6. Gas turbine generators fail, so start diesel generators 7.Two 1500kw mobile diesel generator (DCR) 8. Twelve 480V mobile diesel generators (Eight 500kw non-mobile diesel generators are located on or above 2F, supplying power to CSCW, SBGT, and DC charger.) 9. DC replaces. Note: item 7 is still being procured, so it is not available for use. Even in in the worst situation, item 8 can still operate. Feedwater system 9.Fire-fighting water via BCSS 10. Fire truck with a water tank (acquire water from stream and seawater) via BCSS 12.Increase the use of mobile equipment. As for CP, use remaining water in hot well (DCR in progress) Heat sink 4.100,000-Ton raw water reservoir connected to ESW pump discharge. 5. SGBT (can be supplied with power by 480v mobile diesel generator)	By far the plant has lost all AC power sources and only has DC power to support reactors. Supply power to AC power sources based on priorities. 1. Connect two 480V and 100kw mobile DGs to SBGT and DC chargers of units. 2. Shift workers will start DG via changing D.S. to supply power till emergency response about SWGR 7/7s, after gas turbine generators fail. 3.After onsite flooding recedes, connect 480V mobile DG (1451). Control air source 1. Distribute soft hoses and quick connectors to be connected onto HCU nitrogen cylinders. Increase the gas source for dry wells to make it last for over 43.2 hours. 2. Liquid nitrogen tanks supply nitrogen. 3. Connect outage air systems ~~for~~ to both service and instruments air. Supply air for instruments to use (The systems for unit 1 can function, and the gas for unit 2 are being procured.)	Electric div/ 1 hour/ 1 unit Electric div/ 3 hours On shift/ 1 hour Electric div/3 hours
Due to loss of power or internal flooding, the plant loses all AC power. Eight 480V 500kw mobile diesel generators are procured and prepared, and they can be connected by workers. If added with Feedwater System item #12 and Heat Sink item #4 in the column of Protection intensity, after DCR is completed, the plant should not lose LOUH or feedwater system function	Inside of the ECCS area for AC power source is divided into 4 rooms and each room is isolated/ not connected with another. Each room has water-seal doors, so leaking at the suppression pool area in containments would not enter each room. 1. Each room has one 50gpm drainage pump. 2. Each drainage system can deal with any size of ruptured pipes. 3. Any of the low pressure feedwater systems has at least 2 series of independent systems. 4. Low pressure residual heat removing system has two separated two series. Only one of them can supply enough power for safe shutdown.	Power sources 8. Twelve 480V mobile diesel generators (Eight 500kw non-mobile diesel generators are located on or above 2F, supplying power to CSCW, SBGT, and DC charger.) 9. DC replaces. Note: item 7 is still being procured, so it is not available for use. Even in in the worst situation, item 8 can still operate. Feedwater system 9.Fire-fighting water via BCSS 10. Fire truck with a water tank (acquire water from stream and seawater) via BCSS 12.Increase the use of mobile equipment. As for CP, use remaining water in hot well (DCR in progress) Heat sink 4.100,000-Ton raw water reservoir connected to ESW pump discharge. 5. SGBT (can be supplied with power by 480v mobile diesel generator) 6. Suppression pools	Obey procedure 1451 to conduct unit ultimate response *Confirm if water source is available and plan about priorities. Meanwhile, Feedwater route has established and completed. *Primary containment ventilation operation route has been established. (When operating primary containment ventilation, must consider if the air would flow to the other unit and take protection measures (304.17)) Note: two 480V and 100kw mobile DGs can be connected to SBGT and DC chargers of units. Control air source 1. Distribute soft hoses and quick connectors to be connected onto HCU nitrogen cylinders. Increase the gas source for dry wells to make it last for over 43.2 hours. 2. Liquid nitrogen tanks supply nitrogen. 3. Connect outage air systems to both service and instruments air. Supply air for instruments to use (The systems for unit 1 can function, and the gas for unit 2 are being procured.)	Continue

Fig. 2"Typhoons +heavy rainfalls /mudslides" Stress Tests"

Assumed scenario	Design basis & various scenario base line	Protection intensity	Procedure / Response	Man power and work duration
The plant loses standby rescue and support AC power due to strong winds and flooding. Only DC water makeup system and RCIC system are left. Explain DC power will die or be inundated. The plant has established or is waiting for DCR to be set up and then establishes response strategies for standby rescue and support DC power.	The RCIC room has water-seal doors, so leaking at the suppression pool area in containments would not enter each room. There is one 50gpm drainage pump in the room. DC batteries can last for 8 hours and are located on 2F. When they are in the unnecessary load mode and their essential buses are connected, they can last for 24 hours. 480 V mobile diesel generators. (Originally there was 1 unit, but the plant has procured 12 units.)	Power sources 8. Twelve 480V mobile diesel generators (Eight 500kw non-mobile diesel generators are located on or above 2F, supplying power to CSCW, SBGT, and DC charger.) 9. DC replaces. Feedwater system 9.Fire-fighting water via BCSS 10. Fire truck with a water tank (acquire water from stream and seawater) via BCSS 12.Increase the use of mobile equipment. As for CP, use remaining water in hot well (DCR in progress) 13. RCIC//LOSS 14.HPCI//LOSS Heat sink 4.100,000-Ton raw water reservoir connected to ESW pump discharge. 5. SGBT (can be supplied with power by 480v mobile diesel generator) 6. Suppression pools Control air source 1. Distribute soft hoses and quick connectors to be connected onto HCU nitrogen cylinders. Increase the gas source for dry wells to make it last for over 43.2 hours. 2. Liquid nitrogen tanks supply nitrogen. 3. Connect outage air systems to both service and instruments air. Supply air for instruments to use (The systems for unit 1 can function, and the gas for unit 2 are being procured.)	Continue using RCIC to keep reactors covered in water (Watch primary containment pressure and conduct containment ventilation once (When operating primary containment ventilation, must consider if the air would flow to the other unit and take protection measures (304.17)) to ensure RCIC would not trip due to high ventilation pressure.). Monitor changes of reactor water level. When necessary, remove low pressure of RCIC, & isolate CSP/ change the interlock of the intake of suppression pools. (500.13 EOP) *Extend DC power. *Unnecessary load is turned off. * Twelve 480V mobile diesel generators (eight 480V 500kw mobile diesel generators, which can supply power to CSCW, SBGT, and DC chargers) (1451/540.7/535)	On shift / 0.5 hour On shift / 0.5 hour Electric div/ 1 hour
The plant loses all DC water makeup system due to loss of power or internal flooding.	Same as above	Power sources—Same as above. Feedwater system— 9.Fire-fighting water via BCSS 10. Fire truck with a water tank (acquire water from stream and seawater) via BCSS 12.Increase the use of mobile equipment. As for CP, use remaining water in hot well (DCR in progress) Heat Loss & Control air sources—Same as above.	*Confirm if water source is available and plan about priorities. Meanwhile, feedwater route has been completed. (500.EOP/1451) *Primary containment ventilation operation route is completed. (When operating primary containment ventilation, must consider if the air would flow to the other unit and take protection measures (304.17))	On shift/ 0.5 hour Continue
Ultimate response for the situation in which The plant loses all standby rescue and support power or all water makeup system.	Eight 480V 500kw mobile diesel generators are procured and prepared, and they can be connected by workers. If added with Feedwater System item #12 and Heat Sink item #4 in the column of Protection intensity, after DCR is completed, the plant should not lose LOUH or feedwater system function	Power sources 8. Twelve 480V mobile diesel generators (Eight 500kw non-mobile diesel generators are located on or above 2F, supplying power to CSCW, SBGT, and DC charger.) 9. DC replaces. Feedwater system 9.Fire-fighting water via BCSS 10. Fire truck with a water tank (acquire water from stream and seawater) via BCSS 12.Increase the use of mobile equipment. As for CP, use remaining water in hot well (DCR in progress) Heat sink 4.100,000-Ton raw water reservoir connected to ESW pump discharge. 5. SGBT (can be supplied with power by 480v mobile diesel generator) 6. Suppression pools Control air source 1. Distribute soft hoses and quick connectors to be connected onto HCU nitrogen cylinders. Increase the gas source for dry wells to make it last for over 43.2 hours. 2. Liquid nitrogen tanks supply nitrogen. 3. Connect outage air systems to both service and instruments air. Supply air for instruments to use (The systems for unit 1 can function, and the gas for unit 2 are being procured.)	After confirming the plant loses all water makeup function for reactors, obey ultimate response procedure. 1.Depressurize to below the pressure for alternative feedwater. 2.Conduct containment ventilation (When operating primary containment ventilation, must consider if the air would flow to the other unit and take protection measures (304.17))	On shift/ 0.5 hour

Fig. 2"Typhoons +heavy rainfalls /mudslides" Stress Tests"

Assumed scenario	Design basis & various scenario base line	Protection intensity	Procedure Response	Man power and work duration
Response during the time when the plant waits for rescue and support after typhoons and heavy rainfall. (Support workers on the way are hindered by poor offsite road conditions.) Twelve 480V mobile diesel generators were procured after the lesson learned in order to complete DCR. 8 500kw mobile DGs are installed on floors higher than the 2nd floor. The rest are stored at appropriate elevations to avoid flooding. Eight 480V 500kw mobile diesel generators are procured and prepared, and they can be connected by workers. If added with Feedwater System item #12 and Heat Sink item #4 in the column of Protection intensity, after DCR is completed, the plant should not lose LOUH or feedwater system function	Reactor cores must be covered in water at all time and containments need to maintain intact. Roads that connect the plant and offsite places: Danjin Highway. Communicative systems: microwave/fax machines/ satellite/the Internet/ phone lines directly connecting to Taipower Company, and etc. The minimum stored volume in 850,000-gallon oil tank is 450,000 gallons, which can supply oil to 4 DG at the same time for them to operate for 17 days (416hrs). The minimum stored volume in 35,000-metri kiloliter and 600-metri kilometer oil tanks is 12,000 metric kiloliters, which can supply oil to 1 DG for it to operate for 30 days. Based on the plant management specifications, control rooms must store the amount of food for 10 people for 5 days. DC batteries can last for 8 hours and are located on 2F. When they are in the unnecessary load mode and their essential buses are connected, they can last for 24 hours.	<u>Power sources</u> 8. Twelve 480V mobile diesel generators (Eight 500kw non-mobile diesel generators are located on or above 2F, supplying power to CSCW, SBGT, and DC charger.) 9. DC replaces. <u>Feedwater system</u> 9.Fire-fighting water via BCSS 10. Fire truck with a water tank (acquire water from stream and seawater) via BCSS 12.Increase the use of mobile equipment. As for CP, use remaining water in hot well (DCR in progress) <u>Heat sink</u> 4.100,000-Ton raw water reservoir connected to ESW pump discharge. 5. SGBT (can be supplied with power by 480v mobile diesel generator) 6. Suppression pools <u>Control air source</u> 1. Distribute soft hoses and quick connectors to be connected onto HCU nitrogen cylinders. Increase the gas source for dry wells to make it last for over 43.2 hours. 2. Liquid nitrogen tanks supply nitrogen. 3. Conduct big maintenance on onsite air systems for both workers and instruments. Supply gas for instruments to use (The systems for unit 1 can function, and the gas for unit 2 are being procured.)	Reactors: *If possible, continue using RCIC to maintain RPV water level. * If any of bus 3/4 is available for use, first obey feedwater systems (including alternative) listed in procedure 540.7 to maintain reactors covered in water. * If the plant loses power sources, extend DC power. (535): Unnecessary load is turned off. * If losing all feedwater systems, adopt alternative feedwater system to maintain water level. If the water level can not be maintained higher than TAF, use freshwater or seawater to be injected into reactors and then start ultimate response strategy making abiding by ultimate response procedure (1451). *Establish SRV alternative gas sources 1.Connect to CRD HCU nitrogen cylinders (DCR in progress) 2. Open the manual valves once on side of nitrogen pipes used by instrument connecting to the containment liquid nitrogen filling tanks (521) 3. Connect mobile air compressors. When SRV is opened and no SBGT is operating, conduct once primary containment ventilation, so confirm SB-108-209 has closed (304.17). Containment: *Pay attention to primary containment pressure and conduct containment ventilation once to ensure RCIC would not trip due to high ventilation pressure.). *When operating primary containment ventilation, must consider if the air would flow to the other unit and take protection measures (304.17) *If any of the bus 3/4 is available for use, set up ESW. *Inspect ESW motors to see if there are damages. If so, then fix them by replacing. Fuel pool: Continue monitoring water temperature and confirm reactors are covered in water all the time.. (1451)	Continue



Typhoons and heavy rainfall warnings are issued.
The typhoon emergency response team (referred as The team in this appendix.) is established:
1.When sea and land alerts are issued and the plant judges typhoons may seize the plant or
Chien-Hua Creek water level reaches 1meter, inform maintenance and mechanic divisions
to open all the gates at downstream of the stream.
2.Inform mechanic ./ industrial safety ./health physic/electric/maintenance/instrument
divisions. to have rescue and mitigation equipment on standby and moved to higher places.
When the water level in the main area reaches the cliff edge water level of EOP, use RVP for alternative water feeding.
Chien-Hua Creek water level reaches 2.75m. (EL.4.6m)
Establish TSC
Monitor the water level
Monitor the water level of
Monitor water level in
1. Rainfall at the plant is heavy and Chien-Hua Creek water level rises.
2. Rainfall at the plant is heavy and Chien-Hua Creek water level drops.
Monitor power
Monitor TB water
Monitor water
Sump water levels at the combined building and waste treatment buildings stay high.
Chien-Hua Creek water level reaches 2.75m or is 0.4m lower than average water level.
Water level at the power switchyard room or GCB area rises.
Water level in the
Sump water level at reactor buildings stays high.
1.Assign workers to trace
Inspects onsite rainfall
drainage pipes/trenches
Inform control rooms to make generators leave on hot standby.
1.Assign workers to trace origins of leak.
2.Inform the team to support all buildings with the arrangement of drainage routes, and inspection.
1.Assign workers to trace
RPV alternative
water-feeding
Combined building EL-0.83'.Water level rises.
DG room is flooded
Power switchyard room or GCB area is expected to be flooded.
Turbine building EL17.25'.Water level starts to rise.
Reactor building EL-0.83'.Water level starts to rise.
DIV-1/2 switch room is expected to be flooded.
1.Shut down units.
2.Disconnect the chains of
1.Shut down units.
Inform and confirm control rooms have made generators leave on hot standby and cut off power supply to electric equipment that may be flooded.
1.Start mobile gasoline engine
drainage pumps to drain water out
Cut off power supply to the equipment in this area.
Start ultimate
Normal/chiller water system is expected to be not able to function.
DG A/B room accumulation >10cm.
Flooding is expected to appear at RFP, TBCW or seal oil pumps.
Flood water level in any of the ECCS areas reaches cliff edge water level.
The plant loses
Shut down reactors and stop using
Manually shut down units.
1.Manually shut down units.
2.Inform the team to enhance
Depressurize quickly
Use
Units are shut down and the plant stops using equipment in this area.
Shut down units and depressurize reactors to 35km/cm.
Depressurize
Depressurize reactors to 35kg/cm.
Flood water level in more than one of the ECCS areas reaches cliff edge water level.
AC power dies
Motors in the CRD pump and CSCW pump areas are expected to be flooded.
1. If units have not been shut down, manually shut them down and depressurize reactors to 35kg/cm.
2.Stop using equipment in the area of CSCW & water cooling diesel generators (A/B).
3.Use air-cooling diesel generators to supply power.
DG AB room
Supply power with
Follow procedure
1451--Ultimate response
Shut down reactors if

Preparedness before the typhoon season (104.22):
All divisions conduct related inspections by the end of March every year and complete improvement by the end of April if any abnormal situations are noticed.

When any of the following situations happens, the plant establishes TSC (HA1):
1. When typhoons or strong winds with 10/15-minute sustained wind exceeds 60km/sec (134mph), and they cause serious threat to safety of operation of the plant or hinder plant workers to perform safe operation. (513)

Sea alerts for typhoons are issued.

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

Sea and land alerts for typhoons are issued.

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

Start arrangement and preparedness after sea and land alerts for typhoons are issued.

1.All departments should complete inspection of items on the typhoon checklists before the typhoon emergency response center is established. (Please refer to appendix in 104.22A~M1)
2.Operation shift watches latest status of typhoons via the Internet at all time and request typhoon meetings when needed. (104)
3.When operation shift leader expects weather conditions may hinder changing shifts, request next shift workers to come in to the plant in advance or ask workers who just finish their shift to stay in order to help with operation, and make sure shift workers stay in good conditions to ensure safety of operation. (104)

Operation actions after sea and land alerts for typhoons are issued.

After receiving sea and land alerts for typhoons from Central Weather Bureau:
1.Water latest status of typhoons at all time. When judging typhoons may seize the plant, abide by procedure 515 to open flood gates.
2.Close doors and windows of all rooms in buildings in advance.
3.Electric shift leader verifies all communicative systems and NDS connection are normal. When typhoons have reached the alert area of the plant, immediately sign in “Natural event notification system” to report. If change load due to typhoons, abide by rules of “Natural event notification system” to complete notification process.
4.The plant sends more workers to help clean screens at inlets of emergency seawater pumps and remove debris.
5.After sea and land alerts for typhoons are issued, obey the following tests if judging typhoons may seize the plant:
a. The plant should verify if emergency diesel generators can operate in 8 hours. Conduct function tests on the generators that had their last tests more than a half of the time duration of a periodic inspection cycle ago.
b. The plant should verify if gas turbine generators can operate in 8 hours. For those that have stopped operating for more than a day, the plant comply with procedure to conduct starting tests on them (including their own diesel generators).
c. Use daytime to obey procedure 513 Appendix1 “Pre/post typhoon checklists for Shimmen Wind turbine generators (#1-6)” to confirm if they operate normally before typhoons arrive to ensure their reliability.

One hour before the radius of the typhoon with Beaufort Force 7 (13.9m/s) arrives the plant.

1. Confirm the reactor system boundary stays intact and water the situation of reactors operating at all time. Workers can not connect diesel generators and the system in order to prevent diesel generators from tripping if power system is out of order.
2.Immediately start a gas turbine generator and connect it with 69kV essential bus and make the generator start operating to supply power. Also, start the breaker of offsite 69kV system for another gas turbine generator to use as a standby power source.
3.Stop related RPS and NSSS system tests.
4.When radius of typhoons with wind of Beaufort Force 10 reaches the alert area of the plant and the actual 10/15-minute sustain wind measured at the plant is Force 10 (24.5m/sec), make wind turbine generators operate in idle speed mode “PAUSE”.

When the plant is within radius of typhoons, follow procedure 513

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

Situation note:
A. The actual 10/15-minute wind measured at the plant reaches Beaufort Force 10 (24.5m/sec) and above.
B. The actual 10/15-minute wind measured at the plant reaches Beaufort Force 12 (32.7m/sec) and above.
C. The actual 10/15-minute wind measured at the plant reaches Beaufort Force 15 (46.2m/sec) and above.
D. When any of the following situations happens to any units:
(1) The plant loses one emergency diesel generator (This means the other one can not operate.). Or,
(2) Among all 345kV offsite loops, only two or fewer is available for use. Or,
(3) The plant loses 69kV offsite power source and 1 gas turbine generator.
E. When any of the following situations happens to any units:
(1) The plant loses two offsite power sources (ST-A(S) and ST-B). Or,
(2) The plant loses 1 emergency diesel generator and 1 offsite power source. Or,
(3) The plant loses 2 emergency diesel generators.

When external/internal flooding happens, obey procedure 515 & 515.2.

1.When the plant does not need to continue taking emergent actions and meteorological information shows less threat of typhoons to the plant, the plant can stop reducing power of reactors after the superintendent (or his authorized person) considers the actual situation at the plant and thinks there no more concern of plant safety.
2.When the actual 10/15-minute sustain wind measured at the plant has decreased to Force 9 or radius of typhoons with wind of Beaufort Force 10 has left the alert area of the plant and meteorological information shows less threat of typhoons to the plant, the plant can start increasing power of reactors or make them start operating after the superintendent (or his authorized person) considers the actual situation at the plant and thinks there no more concern of plant safety.

Appendix 4-3 New addition in procedure 576 "Procedure for operation during typhoons”

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)

To cope with LOOP events, Chin Shan units 1 & 2 are equipped with seismic category I design Emergency Diesel Generators (1A and 1B on unit 1; 2A and 2B on unit 2;, with a 5th one shared between the two units as substitute for any of the four when unavailable) and 2 sets of Gas Turbine Generators with associated startup diesel generators located at a higher elevation; besides, there are 1 set of 4.16kV/1500kW diesel generator, 4 sets of 480V/200kW diesel generators and 8 sets of 480V/500 kW diesel generators which are of movable type, and stationed at higher elevation seismic-qualified buildings. Also there are provisions in procedure 1452.1 for directly supplying electrical power to both units via cables to mitigate the consequences due to earthquake or flooding.

5.1.1.1 Design basis of on-site power supply and distribution systems

On-site power supplies are classified into safety-related system and non-safety-related system. The safety-related power system provides power to emergency cooling systems to ensure reactor safe shutdown and prevent core meltdown; while non-safety related power system provides power to various auxiliary systems needed for unit operation and ensure reliable operation of main turbine generator system.

The design features of power supply and distribution systems are as follows (refer to Figure 5-1):

1. The supply of Non-safety-related power system(4.16kV Bus #1/Bus #2) can be selected from auxiliary transformer which is connected to the main generator, or from the startup transformer which is connected to the 345kV system grid or the 69kV system grid. In normal operation, auxiliary transformer is usually selected. If necessary, the power supply can be manually shifted from the main generator to 345kV or 69kV startup transformer. When a reactor is scrammed, the power supply will be switched to 345kV or 69kV startup transformer automatically.

2. The power of safety-related essential bus (4.16kV Bus #3 /Bus #4) is from 4.16 kV Bus #1 /Bus #2, through 4.16 kV tie breaker 3-1 / 4-2 respectively.

3. Each unit has 2 independent 3600kW safety-related emergency diesel generators (EDG A and B), all of the same model. These EDGs are located at elevation of 11.2 meters and housed in combined building. Upon loss of off-site power, EDGs can start automatically; and reach rated speed and voltage within 10 seconds; and provide 4.16kV emergency power to emergency cooling systems through Bus #3 / Bus #4 (for DIV Ⅰ/ Ⅱ).

4. EDG system is divided into two divisions - DIV I and II. independently providing power to the ESSENTIAL bus corresponding to each division. The downstream emergency loads of these two

divisions are redundant to each other. As long as the emergency diesel generator, the ESSENTIAL bus, and the equipment of the downstream emergency loads in either DIV. I or Div. II can function normally, safe reactor shutdown and cooling can be achieved.

5. There is one 4000kW air-cooled safety-related EDG (the 5th EDG) which is shared by both units. This EDG is located at elevation of 11.2 meters in a separate building. The 5th EDG can be started manually in control room to substitute any EDG of either unit (EDG 1A/1B/1AS/1BS). Thus, it can effectively increase the reliability of each essential bus.

6. The designs of above safety-related EDGs are based on the requirements of design basis event (DBE). In case of DBE, EDGs can provide the required electrical power to ensure safe reactor shutdown and cooling.

7. In case of scram, the 4.16kV bus power supply will be switched automatically. The 4.16kV Bus #1 and Bus #2 are supplied by 69kV and 345kV offsite power system grid, respectively. The power of essential buses (4.16kV Bus #3 and Bus #4) is provided by 4.16 kV Bus #1 and Bus #2, respectively. Switching can be achieved within 10 cycles without concerns of power interruption. In addition, there are two gas turbines for SBO. Either one of them has capacity enough to serve as the 69kV offsite power for two units.

8. The power of safety-related 480 Power Center (PC) 3A/4A are supplied from 4.16 kV Bus #3 / Bus #4 via Station Service Transformer (SST 3A/4A).
   (1) 480 PC 3A/4A provide power to 480V Swing Bus 3-4A/3-4B as normal power source and 480 PC 4A/3A provide power to 480V Swing Bus 3-4A/3-4B as backup power source.
   (2) 480V Swing Bus 3-4A/3-4B provide power to 480V MCC 3A-1 / 4A-1 and RHR MCC A/B. 480V Swing Bus 3-4A also provides power to Hydrogen Recombiner system.
   (3) 480 PC 3A provides power to downstream 480V MCC 3A-2 / 3A-5 / 3A-4 /3A-7. 480V MCC 3A-4 provide power to downstream 480V MCC 3A-3 / 3A-6.
   (4) 480 PC 4A provides power to downstream 480V MCC 4A-2 / 4A-5 / 4A-4 /4A-7. 480V MCC 4A-4 provide power to downstream 480V MCC 4A-3 / 4A-6.

9. Hydrogen and Oxygen Monitoring System (HOMS) monitors H_2 and O_2 concentration in drywell and torus as the reference for purge preparation. This system is powered from CR-PDP-1A/1B .

Based on the above description, the design features in responding to loss of off-site power event is to automatically start the EDG attached to the DIV. I or II 4.16kV ESSENTIAL bus. The EDG can reach rated speed and voltage within 10 seconds, and then the power output breaker can be closed automatically to provide ESSENTIAL bus with sufficient power required. As long as either DIV. I or DIV. II EDG can provide power to ESSENTIAL bus, safe reactor shutdown can be ensured.

The 5th air-cooled diesel generator serves as the back up for DIV. I and DIV. II EDG. If any EDG of either unit is unavailable, it can be started to perform the design function. In addition, the two non-safety grade gas turbine generators can be used as supplementary to provide power to 69 kV buses through their step-up main transformers. Either of these gas turbine generators has enough capacity to provide power for two units safe shutdown.

5.1.1.2 Autonomy of the on-site power sources

Emergency diesel generator A and B (EDG A /B):

1. Fuel: The Station has one $850x10^3$gallons fuel storage tank, which is filled with more than $450x10^3$ gallons normally. This amount can provide 4 EDGs to run continuously for 17days.

2. Cooling type: Water-cooled.

3. Supporting systems:
   (1) Starting and control power is supplied by 125VDC from 125V SWBD #1 or 125V SWBD #2, which can back up each other to support EDG operation.
   (2) Each EDG has one independent air starting system. This system has two motor driven air compressors to transport the compressed air through the air dryer to four air tanks. The outlets of these four tanks are connected into a common header, then, air is distributed into four lines. Each line gets into the two air starting motors of the diesel engines. The EDG starting air storage tank can store air for 6 times of startup.
   (3) Combined Structure Cooling System (CSCW) provides cooling water to EDG.. Sea water is used as the media to remove heat from CSCW. Sea water must be available as the ultimate heat sink to support EDG long term operation.

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

Emergency diesel generator A and B (EDG A /B):

1. Each EDG has one fuel day tank. This tank has an outdoor emergency fuelling cap. In case fuel can not be supplied normally from the $850x10^3$ gallons fuel storage tank, fuel can be supplied through this cap.

2. If it is difficult for fuel suppliers to supply fuel, the fuel for auxiliary boilers and gas turbines can be used to support EDG operation. The capacity of gas turbine fuel storage tank is 35 $x10^3$ kiloliters and normally is filled with 12 $x10^3$ kiloliters. Thus, the EDGs can be run continuously for an extended period.

3. The Auxiliary Boiler Fuel Tank is not assessed or planned to be enhanced because its capacity is very small in comparison to the capacity of the Gas Turbine Oil Storage Tank (35,000 KL). Sino-tech Co. is committed to evaluating the seismic-resisting enhancement of the Gas Turbine Oil Storage Tank, the assessment plan has been completed and construction is scheduled to complete by 2014/12/31.

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4. Temporary oil transfer pumps are readily available for delivering fuel from Auxiliary Boiler Fuel Tank to EDG Day Tank A/B.

5.1.1.4 Envisaged measures to increase robustness of the plant

1. To ensure the integrity of EDGs and the 4.16kV switchgear room, the following enhancing measures will be implemented.

All EDGs, fuel storage tanks, and accessories are located at elevation above ground level. Part of the piping is located below ground level, but is designed to meet the requirement of industrial standard for underground piping. Except for the low voltage MCCs in Corner Room located below ground level, all 4.16kV switchgears and MCCs are located above ground level. For the purpose of protecting the 4.16kV switchgears, low voltage MCCs, and all the ECCS components below ground level (included), a modification request (MMR-C0-0407) has been proposed and approved. Watertight equipment will be installed at doors and openings to prevent against flooding the 5th EDG, besides, we also plan to build a 170 m long anti-tsunami wall which is 17 m above the sea level and to establish an another anti-tsunami wall in ESW pump house in order to protect the site equipment.

2. The Station has the following measures to ensure electrical power supply to the required loads in case of loss of offsite power.

   In "1452.1 URG-POWER establishment" procedure, if one unit is in SBO, emergency power can be supplied from the EDG of another unit in normal operation, through the distribution panel of 5th EDG. Procedure 1452.1 clearly describes the steps for providing power from another unit, dispatching the estimated loads, and isolating unnecessary loads, etc.

3. The maximum possible tsunami level and rainfall intensity will be reviewed to confirm that they are still within station design basis.
4. Chin Shan had experienced a heavy rainfall which resulted in the blockage of Shiaokern Creek by upstream debris during the invasion of Typhoon Xianshen. At that time, rainfall water overflowed and inundated Shiaokern low-lying area, and then flowed into Chien-Hua parking lot through tunnel. Finally the flood flowed into the sea via Chien-Hua Creek. We learned from this experience that in this accident, the heaviest rainfall ever was not sufficient to flood the administration building in Chien-Hua district and that huge water can be drained smoothly because of the topography and contour in this area... Therefore, tsunami wave rising up and flooding derived from extreme rainfall shall not result in cliff-edge effect to this station. However, under conservative consideration, MMR-C0-0407 was still issued for the installation of waterproof door at the building outward openings to prevent against flooding the 5th EDG.

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

5.1.2.1 Design provisions

In case of loss of offsite power and onsite back-up power, station has other emergency back-up power as follows:

1. The 5th EDG

   Station has one air-cooled 4000kW EDG. the 5th EDG, as the backup for the four EDGs of Unit 1 and Unit 2. It can perform the same function as the specific EDG being substituted. The 5th EDG can be placed to substitute only one of the four EDGs at any one time. The target EDG to be substituted has to be pre-selected. The 5th EDG, in full load operation, can provide all the AC power required by ECCS.

2. Gas turbine generators

   the station has two air-cooled gas turbine generators with capacity 69,600kVA and power factor 0.85. These two gas turbines are primarily for emergency startup AC power for the station when SBO occurs. They also provide power during grid peak load period or power shortage due to tripping of a big unit from the grid. It takes about 10 min from gas turbine start to engaging into the distribution system; and about 7.5 more minutes to reach full load (50MW).

   Normally, the power to start gas turbine is provided from 69kV Bus-2 (or Bus-1 if Bus-2 is unavailable). Through the main transformer (69/13.8kV) and start-up transformer (1500kVA 13.8kV/4.16kV) to step down the voltage to 4.16kV, the power can be supplied to the startup motor to actuate gas turbine generator. In case of SBO, the 24VDC battery set of diesel generator can be used to start diesel generator to provide 4.16kV AC power to gas turbine startup motor. This is the power source to start gas turbine in SBO.

   The gas turbine generators can be started up and monitored from the local control room or from the 69kV switchyard control room in normal operation. In case of emergency, they also can be started up and monitored remotely from 345kV switchyard control room.

3. During SBO, reactor water level can be maintained by running RCIC. The operation of RCIC relies on 125V DC power. The battery set can provide DC power for 8 hours. Based on the “Evaluation of Station Black Out for MUR” performed by Institute of Nuclear Energy Research (INER) on Nov. 2006, under the most conservative condition without considering the availability of the 5th EDG and gas turbines, the station battery set can provide DC power for 8 hours. Station has planned measures to control the DC loads during such events. Following this plan, station battery set can provide DC power for 24 hours. The report “Evaluation of Station Black Out for MUR” is attached as Appendix 1.

5.1.2.2 Battery capacity and sustained duration

The capacity of the 5th EDG 125VDC battery set is 410AH. This capacity can provide DC power to the essential loads for 8 hours to ensure the safety of nuclear systems.

The capacity of each gas turbine 125V DC battery set is 400AH. It is also enough for 8 hours continuous operation.

5.1.2.3 Autonomy of the site before fuel degradation

1. The 5th EDG
   (1) Autonomy of operability
   Not affected by other systems. It is an independent system with autonomous operability.
   (2) Control Power
   Starting and control power is 125VDC, which is provided by independent battery set.
   (3) Fuel
   The capacity of fuel day tank is 1300 gallons, which can provide fuel for 4 hours continuous running. There is also one fuel storage tank with 52000 gallons capacity normally, which can provide fuel for 8 days continuous running. Fuel storage tank has an outdoor fuelling cap for refilling fuel.
   (4) Cooling
   Air-cooled
   (5) Supporting Systems: NA

2. Gas Turbines
   (1) Autonomy of operability: Not affected by other systems. It is an independent system with autonomous operability.
   (2) Control Power: Control power is supplied by independent DC battery set.
   (3) Fuel: The gas turbine set has one 35,000 kiloliters storage tank. Diesel fuel is transferred to the 3 daily tanks, each with capacity 600 kiloliters, then to the inlet of gas turbines. The total amount of diesel fuel is normally maintained at more than 12,000 kiloliters, which is enough for one gas turbine continuous running for 30 days to provide the emergency power to ESSENTIAL and BOP buses.
   (4) Cooling: Air-cooled.
   (5) Supporting Systems
   The starting power for the two appurtenant diesel generators to the gas turbines is provided by the 24 VDC battery sets. The two diesel generators, each with capacity of 1,500kVA, voltage 4.16kV, and power factor 0.73, are independent from each other. However, if one of them is unavailable, the other can be used to support starting the gas turbine via the closure of the tie-breaker. This will not affect the SBO starting capability of the gas turbines.

3. During SBO, the reactor water level and pressure can be maintained by RCIC for at least 8 hours. If reactor and spent fuel pool water levels are maintained by raw water (Ultimate Response Guideline), the amount of water can be provided continuously for 220 hours (9.17days). The

estimation is as follows: For combined events, the total required amount of reactor and spent fuel pool makeup water is 1600gpm (363.4 Tons/hour). Based on average of 80% of raw water storage capacity, or $80x10^{3}$ Tons, $80x10^{3}$ /363.4=220 hours can be achieved. If continuous actuation of ADS/SRV is considered, the air source can supply for 43.2 hours. Therefore, the station can withstand the effects of SBO at least for 43.2hours (RCIC+Raw water Injection).

5.1.2.4 Foreseen actions to prevent fuel degradation with external support

1. The Station equipment, e.g., equipment for inter-unit support

(1) Based on the operating procedure "1452.1 URG-POWER establishment", any of the emergency diesel generators of either unit can supply emergency power to other unit via the 5th EDG distribution panel. This procedure also describes the steps for load control and power saving.

(2) Each unit has its own ADS/SRV, HPCI, RCIC, and instrument N_2 system. The following systems can be inter-supported between the two units: DST, CST, raw water system, instrument air system and service water system.

(3) The Station has fire engines as listed in the following table. These fire engines can take suction from raw water reservoir, Chien-hua Creek, or sea water. The outlet of the fire engines can be connected to BCSS to inject water into reactor or suppression pool to prevent fuel degradation.

Chin Shan Station Fire Engines				
Name	Quantity	Capacity (Liters)	Discharge Pressure	Remark
Fire Foam Vehicle	1	3,000	0～20 kg/cm^2	Discharge flow rate : 3000 liters/min@8.78 kg/cm^2
Reservoir Vehicle	1	10,000	0～20 kg/cm^2	Discharge flow rate : 3000 liters/min@ 10.97 kg/cm^2

2. Supports available from offsite if all station equipment are unavailable

(1) If all the mitigating systems are unavailable, and ultimate heat sink is lost (loss of power supply), offsite supports include fire equipment at site and from Kuosheng station, and also from Shiman, Chin Shan, and Shanzhi districts. However, the prerequisites are ADS and SRV must be operable, and the piping of BCSS and RHR system has to be workable.

Fire Engines in the Vicinity Districts of Chin Shan Station (Shanzhi and Shiman Districts)

Shanzhi District Fire Engines				
Name	Quantity	Capacity (tonss)	Discharge Pressure	Remark
Water Tank Vehicle	2	1.5	10 kg/cm^2	Total 3 Tons
Reservoir Vehicle	1	12	10 kg/cm^2	
Shiman District Fire Engines				

Name	Quantity	Capacity (tonss)	Discharge Pressure	Remark
Water Tank Vehicle	1	2	10 kg⁄cm^2	
Water Tank Vehicle	2	1.5	10 kg⁄cm^2	Total 3 Tons
Total	6	20		

Fire Engines in the Vicinity Districts of Kuosheng Station (Wanli and Chin Shan Districts)

Kuosheng Station Fire Engines and Movable Pump				
Name	Quantity (Unit)	Capacity (tonss)	Discharge Pressure	Remarks
Reservoir Vehicle	1	10	10～12kg⁄cm^2	Discharge flow: 3000 liters/min.
Chemical Foam Vehicle	1	2	10 kg⁄cm^2	
Mobile Pump	4			Discharge flow: 1500 liters/min.
Chin Shan District Fire Engines				
Name	Quantity (Unit)	Capacity (tonss)	Discharge Pressure	Remarks
Water Tank Vehicle	1	3	10 kg⁄cm^2	
Water Tank Vehicle	1	1.5	10 kg⁄cm^2	
Reservoir Vehicle	1	12	10 kg⁄cm^2	
Chemical Foam Vehicle	1	1	10 kg⁄cm^2	
Wanli District Fire Engines				
Name	Quantity (Unit)	Capacity (tonss)	Discharge Pressure	Remarks
Water Tank Vehicle	1	2	10 kg⁄cm^2	
Water Tank Vehicle	1	3	10 kg⁄cm^2	
Reservoir Vehicle	1	10	10 kg⁄cm^2	
Total	9	Water: 41.5 Chemical: 3		

(2) Offsite supports include one 4.16kV 1500kW mobile diesel generator and four mobile diesel generators from Kuosheng station. In addition, mobile diesel generators supported from Lungmen station are also available.

(3) Chin Shan station and New Taipei city government have signed a protocol of fire fighting support. Depending on the characteristics of events, the Fire Bureau will support manpower, vehicles, and equipment to mitigate the calamity.

3. Power cables specially connected from the neighboring plants (such as hydro, gas turbine plant) to the power plants.

Kuosheng nuclear power plant and Linko fossil power plant are the two plants in the vicinity. However, currently no special power cables are connected to these two plants.

4. The required pre-stage time for above mentioned systems
   (1) It takes about 25 minutes for station fire engines to take suction from the raw water pump room, through BCSS and RHR piping system, and inject into reactor core.
   (2) It takes about 10 minutes to drive the fire engines from Shiman district to the station (assuming water is filled and in standby). If the water injection path has already been lined-up, the total time will be 10 minutes.
   (3) It takes about 20 minutes to drive the fire engines from Shanzhi or Chin Shan district to the station (assuming water is filled and in standby); and 30 minutes for fire engines from Wanli district. If the water injection path has already been lined-up, the total time will be 20 to 30 minutes.
   (4) It takes about 25 minutes to drive the fire engines from Kuosheng nuclear power plant to the station (assuming water is filled and is standby). If the water injection path has already been lined-up, the total time will be 25 minutes.
   (5) It takes 2 and 5 hours to move the Kuosheng and Lungmam mobile diesel engines to the station, respectively. Once engines arrive at site, the station personnel will connect the cables and start to provide power.

5. Availability of qualified operators to perform above actions

   How to operate the systems and equipment is described in Appendix II, and the systems and equipment are operated by the plant shift staff. Other manpower required must be supported from offsite. The support manpower is directed by the shift supervisor. The fire engines and other fire equipment are performed by firemen.

   The operators, who are responsible for the above mentioned actions, are well trained and exercised. They can meet the mission requirements.

6. Confirming timing of cliff edge effects

   If the 5th EDG and the two gas turbines are unavailable, then:
   (1) The reactor water level and pressure can be maintained for at least 8 hours with RCIC in operation.
   (2) If reactor and spent fuel pool water levels are maintained by raw water (<u>Ultimate Response Guideline</u>), water can be provided continuously for 220 hours (9.17days). The estimation is as follows: for combined events, the total required amount of reactor and spent fuel pool makeup water is 1600gpm (363.4 tons/hour). With 80% of raw water storage capacity of $80x10^3$ tons, sustaining time is. $80x10^3/363.4=220$ hours.
   (3) If continuous actuation of ADS/SRV is considered(DCR-C1/C2-3319/3320 have been completed), air supply can actuate ADS/SRV for 43.2 hours. If not operating continuously, N_2 can be supplied for longer time.

In addition, throttling the bypass valve V-108-340A/B, located between the outlet of liquid N_2 tank and N_2 piping in the primary containment N_2 purge system, operating gas can be provided to SRV/ADS for longer period (Reference Appendix 2).

(4) Based on above description, without offsite support, the station can withstand SBO for more than 43.2 hours by reactor depressurization and water injection. However, 40 hours after reactor depressurization and water injection, torus water level will increase to the elevation of vent port. This will result in torus being unable to vent and the integrity of containment will be impacted, and endanger reactor safety.

5.1.2.5 Envisaged measures to increase robustness of the plant back-up power

1. Running RCIC can maintain reactor water level and pressure for at least 24 hours, if procedure "1452.1 URG-POWER establishment" is followed, to isolate some DC loads and to shift 125VDC SWBD #6 to DC SWBD #2 . If reactor water level is maintained by raw water (per Ultimate Response Guideline), during combined events, the raw water can support for 220 hours (9.17days). If continuous actuation of ADS/SRV is considered, working air can support 43.2 hours (Appendix 2, CS.2-01). If actuation is intermittent, the duration can be longer. Based on above description, without offsite support, the station can withstand SBO for more than 43.2 hours (RCIC+ Raw water system). In addition, by throttling the bypass valve V-108-340A/B, located between the outlet of liquid N_2 tank and N_2 piping in the primary containment N_2 purge system, SRV/ADS operating gas can last for a longer period. (Reference Appendix 2 CS.2-01).

2. On the present planned DCR-C0-3294 (building an additional gravity pipe from the lower pool of 100,000 Tons raw water), we intend to add another fixed pipe to the discharge pipe of ESW Pumps to serve as the 2nd ultimate heat sink.
   When the Procedure 1451 「FNPS Ultimate Response Guideline」 is executed, the storage volume of 100000 Tons raw water is:
   (note: the quantity drawn out by the gravity pipe of the lower pool of 100,000 Tons raw water is 83000 Tons)
   a.Core injection 1,600gpm*8hr=768,000gal (2906880 liters); after 8 hours, 80,100 Tons raw water is left from the initial 83,000 Tons.
   b. The left 80,100 Tons raw water can serve as RHR heat exchanger cooling water for about 125.96 hours. And then, URG Phase III (within 36 hours after starting) is supposed to recover ESW PUMP already, and the RHR heat exchanger cooling water can be provided by ESW PUMP again.
   By adding a gravity pipe from the lower pool of 100,000 Tons raw water to provide RHR heat exchanger cooling water can independently maintain the supply of cooling water for more than 5 days.
   Estimated complete date: Unit #2: 2EOC26(2014.05.31); Unit #1: 1EOC27(2014.12.19)

3. The Station has proposed the following enhanced measures to provide emergency 4.16kV / 480V AC power in case of SBO.

(1) The procedure "1452.1 URG-POWER establishment" has been modified to give instructions for operation of the 5th EDG, under the loads control, to provide emergency power to 4.16kV bus-3 or bus-4 for both units simultaneously.

(2) The two appurtenant 4.16kV 1100kW diesel generators associated with the gas turbines can provide power to 4.1kV bus-7 and bus-7S, then through bus 1 and bus-2, to 4.16kV bus-3 or bus-4. The related plan and exercise have been completed (Appendix 2 CS.2-02).

(3) The Station has added eight 480V 500kW movable diesel generators. As proposed in DCR-C1/C2-3313/3314, cables and connection points will be arranged to connect movable diesel generators to 480V P.C./MCC, battery chargers, UPS, and control room lighting system, This modified system will provide AC power to battery chargers, then convert to DC power to provide 125VDC bus, vital UPS, and 480V loads.

DCR-C1-3313: Since the procurement of safety-related components takes longer time, the proposed modification of 480Vpower source will be completed in two stages. The wiring from the movable diesel generators to the manual switchgear box (non-safety related component) will be completed in the 1st stage. The wiring from the manual switchgear box to MCC (safety related component) will be completed in the 2nd stage. This DCR will be completed at Unit 1 EOC-27.

DCR-C2-3314: Since the procurement of safety-related components takes longer time, the proposed modification of 480Vpower source will be completed in two stages. The wiring from the movable diesel generators to the manual switchgear box (non-safety related component) will be completed in the 1st stage. The wiring from the manual switchgear box to MCC (safety related component) will be completed in the 2nd stage. This DCR will be completed at Unit 2 EOC-26.(March, 2014) (Appendix 2 CS.1-07).

(4) Taipower headquarter has purchased six 4.16kV 1500kW mobile diesel generators. Two of them have been allotted to CS station, of which one is placed on site, and the other one is placed at Lungmen station temporarily. As described in DCR-3313/3314, cable connecting points to the mobile diesel generators will be set up from the dummy breaker of 4.16kV bus-3 and bus-4. (Appendix 2 CS.2-03)

(5) The design change request DCR-C0-3312 has been approved. Based on this DCR, TSC lighting and ventilation control panel will be modified to have connecting points (including backup TSC) with movable diesel generators. The power transformer of the TSC building lighting system (including backup TSC has been removed from outdoor the 1st floor to a higher elevation.

(6) To ensure that power supply capability will not be affected by flooding, MMR-0407 has been

R1

approved to enhance the capability of flooding prevention for the 5th EDG building.

4. RCIC Emergency DC power

In SBO, by isolating some DC loads and shifting the power source to 125V SWBD-6, DC power provided to RCIC can be maintained for 24 hours (As modified in procedure "1452.1 URG-POWER establishment").

In addition, anyone of the measures described in (1) ~ (3) of Item 3 can ensure the availability and durability of DC power. These measures support the DC power required by RCIC and ADS.

5. Mobility of Injection Equipment

CS station has procured 8 large capacity movable fire engines to enhance station capability to inject water into reactor.

Capacity: 38.2kW 2000 lpm@6kg/cm^2, 1500 lpm@10kg/cm^2

6. The related emergency operating steps have been incorporated into procedure 1451. These steps describe the response actions under the above mentioned conditions.

7. When Fuel is used up

(1) The 5th EDG

The 5th EDG has independent fuel storage tank with outdoor fuelling cap. From tank truck, fuel can be made-up through this port.

(2) The Gas Turbines

The Gas turbines have a 600 kiloliters fuel storage reservoir with exterior fuelling cap. From tank truck, fuel can be make-up through this port.

8. The seismic-proof enhancement programs of the Gas Turbine Oil Storage Tanks and the Raw Water Reservoir had been submitted to AEC for scrutiny.

- Sino-tech Co. is to evaluate the seismic-proof enhancement of the Gas Turbine Oil Storage Tanks proposed by TPC Construction Department and its seismic-proof enhancement assessment has been completed and construction is scheduled to complete by 2014/12/31.
- Sino-tech Co. is committed to evaluate the seismic-proof enhancement of the Raw Water Reservoir proposed by TPC Construction Department and its seismic-proof enhancement assessment is scheduled to be completed prior 2013/12/31 and the construction will be completed by 2014/12/31.

（1）After the completion of the seismic-proof enhancement of the Gas Turbine Oil Storage Tanks, two sets of Gas Turbine generators can supply the required power to safety and non-safety related systems for both units after earthquake. Together with water source from the Raw Water Reservoir, the disparity and diversity of power sources and water sources can further protect reactors from core melt-down..

（2）After the installation of baffle plates over and above the plant level, which is already at a high elevation, flood can further be prevented from entering into plant buildings, and plant safety systems can not lose functions due to flooding of the plant buildings.

The cliff-edge effects shall be confirmed after the completion of the enhancement.

5.1.3 Loss of off-site power, back-up power, and other diverse back-up power (i.e., loss of 69/345/kV off-site power, EDGs, the 5th EDG and GTs)

5.1.3.1 Design provisions

In case the offsite power, the back-up power (EDG A&B), and the diverse back-up power (the 5th safety grade EDG and the Gas turbine generators) are lost, the station will have only DC power available. The DC power system and power for instrument systems are described as follows:

1. Safety related DC loads and control power for safety-related equipment

   The DC power of this category consists of 125V SWBD-1, SWBD-2, and SWBD-6. SWBD-1 provides DC power to ECCS-A train, while SWBD-2 and SWBD-6 provide DC power to ECCS-B train. With this design, safety functions of the reactor protection system and ESF systems will not be affected, if any of the 125 VDC SWBDs fails.

2. 120VAC instrument power, including instrument power from UPS output and instrument power from non-UPS

   (1) Instrument power from UPS output

   Each unit has one SUPS-1 and one SUPS-2 of battery with 8- hours capacity. Besides, Unit 2 has ERF-A and ERF-B, which provide power to Units 1 & 2 ERF systems and emergency standby power to Back-up TSC, respectively. The rated capacity of battery is 8 hours. The loads of UPS output power include: process computer, ERF computer, turbine control, feedwater control, communication system, etc.

   (2) Instrument power from Non-UPS

   Power is supplied from vital bus MCC 3A-1 and MCC 4A-1 to instrument bus IDP-120V-1 and IDP-120V-2 respectively. However, this non-UPS instrument power will be lost in case of SBO.

   (3) As long as battery is available, important control and instrument power from the vital DC and AC (via UPS) can be ensured.

3. Design of DC power for RCIC and HPCI

   During the period when the offsite power, the back-up power (EDG A&B), and the diverse back-up power (the 5th safety grade EDG and the Gas turbine generators) are lost, reactor water make-up relies on the operation of RCIC or HPCI. The operation of RCIC or HPCI needs only provided from 125V DC MCC 1A and MCC 2A respectively.

DC power and steam, and AC power is not required. The DC power of RCIC and HPCI can be provided from 125V DC MCC 1A and MCC 2A respectively.

5.1.3.2 Battery capacity and duration of operation

RCIC power source 125V DC MCC 1A is provided from 125V SWBD-1; while HPCI power source 125V DC MCC 2A is provided from 125V SWBD-6. The rated capacity of 125V SWBD-1 and SWBD-6 is 2320AH. Both of these two SWBDs can provide DC power for at least 8 hours.

5.1.3.3 Autonomy of the station operation before fuel degradation

The reactor water level and pressure can be maintained by RCIC for at least 8 hours. If the reactor water level is maintained by raw water (<u>Ultimate Response Guideline</u>), water can be provided continuously for 220 hours (9.17days). The estimation is as follows: For combined events, the total required amount of reactor and spent fuel pool makeup water is 1600gpm (363.4 tons/hour). Based on 80% of raw water storage capacity, which is $80x10^3$ tons, $80x10^3$ /363.4=220hours. If continuous actuation of ADS/SRV is considered, the air source can supply for 43.2 hours. Therefore, the station can withstand the effects of SBO for at least 43.2 hours (RCIC+Raw water Injection). In case of emergency, HPCI can be operated to makeup water and to depressurize CTMT pressure. However, since the ultimate heat sink is lost because of SBO, the operation of HPCI will cause torus 7water temperature to increase rapidly. Thus, whether to operate HPCI should be considered carefully.

5.1.3.4 Foreseen actions to prevent fuel degradation with external support

1. The Station equipment, e.g., equipment for inter-unit support

   (1) Establish capability for DC power supply for 24 hours during SBO

   Based on the SBO loads listed in FSAR Table 8.3-10a and Table 8.3-10b, the battery sets discharge capacity (amp-hour, AH) is calculated in the following table:

Battery-1	SBO discharge capacity (AH) = current (amp) x duration (hr)								
duration (minute)	0-0.5	0.5-1	1-44.5	44.5-45	45-180	180-479	479-480	Following 16 hours	24 hours accumulation surplus(+)/ insufficient(-)
Load in SBO (A)	813.2	220	220	220	195	115	129	129	
SBO Discharge Capacity (AH)	6.78	1.83	159.50	1.83	438.75	573.08	2.15	2064	3247.93 (AH) -927.93 (AH)
Battery-2	SBO discharge capacity (AH) = current (amp) x duration (hr)								
Load in SBO (A)	281	145	145	145	120	100	114	114	
SBO Discharge Capacity (AH)	2.34	1.21	105.13	1.21	270	498.14	1.9	1824	2704.12 (AH) -384.12 (AH)

Battery-6 SBO discharge capacity (AH) = current (amp) x duration (hr)									
Load in SBO (A)	1223.2	80	146	146	102	5	5	5	
SBO Discharge Capacity (AH)	10.19	0.67	105.85	1.22	229.50	24.92	0.08	80	452.43 1867.57
Battery-7 SBO discharge capacity (AH) = current (amp) x duration (hr)									
Load in SBO (A)	200	200	100	100	100	100	100	100	
SBO Discharge Capacity (AH)	1.67	1.67	72.50	0.83	225.00	498.33	1.67	1600	2401.67 -81.67

a. It is shown that 125V DC Battery -1, -2, and -7 is insufficient for 928AH, 384AH, and 82AH, respectively. These battery sets can not supply DC power continuously for 24 hours. However, Battery-6 still has 1867AH margin. It can provide 125VDC to other loads. Therefore, the target to provide DC power continuously for 24 hours is accomplishable. Since the rated capacity of each battery set is 2320AH, thus, overall, it still has 473AH margin.

b. RCIC can maintain reactor water level and pressure for at least 24 hours via procedure "1452.1 URG-POWER establishment" to isolate some DC loads and shift 125VDC SWBD #6 to DC SWBD #2 (Appendix 2, CS.2-01). Loads can be shifted from 125V DC Battery-1, Battery-2, and Battery-7 to Battery-6 via existing three distribution panel - Ⅰ/Ⅱ/Ⅲ. (Appendix 2-CS.2-04)

(a) 125V DC SWBD -6 can be connected to SWBD -7 through Trans. Station Ⅲ.

(b) 125V DC SWBD-1 can be connected to SWBD -2 through Trans. Station Ⅰ and Ⅱ.

(c) 125V DC SWBD-7 can be connected to SWBD-3; it also can be connected to SWBD-1 if the interlock is isolated. The original design for power supply shifting among 125V DC Battery-1,-2,-6, and -7 is for the discharge test during outage. This power supply shifting can be temporarily used during SBO to prolong the battery capacity. For the purpose of ensuring reliable shifting, a DCR has been completed to modify the wiring to let Battery-6 directly provide power to SWGR-1, -2, and -7.

(2) In "1452.1 URG-POWER establishment" procedure, if one unit is in SBO, emergency power can be supplied from EDG of another unit through the distribution panel of the 5th EDG. Procedure 1452.1 clearly describes the steps for providing power from other unit, dispatching the estimated loads, and isolating unnecessary loads, etc.

(3) The Station has prepared movable diesel generators, which can be connected to battery chargers to prolong the battery capability of providing DC power.

(4) The Station has several fire engines as listed in the following table. These fire engines can

take suction from raw water reservoir, Chien-Hua Creek, or sea water. The outlet of the fire engine can be connected to BCSS to inject water into reactor or suppression pool to prevent fuel degradation.

Chin Shan Station Fire Engines				
Name	Quantity	Capacity (Liter)	Discharge Pressure	Remark
Fire Foam Vehicle	1	3,000	0～20 kg⁄cm^2	Discharge flow rate : 3000 liters/min@8.78 kg⁄cm^2
Reservoir Vehicle	1	10,000	0～20 kg⁄cm^2	Discharge flow rate : 3000 liters/min@ 10.97 kg⁄cm^2

2. Supports available from offsite if all station equipment are unavailable

   Same as described in Section 5.1.2.4 Item 2.

3. Power cables specially connected from neighboring plants (such as hydro, gas turbine plant): to the power plants

   Same as described in Section 5.1.2.4 Item 3.

4. The required pre-stage time for above mentioned systems

   Same as described in Section 5.1.2.4 Item 4.

5. Availability of qualified operators to perform the above actions

   Same as described in Section 5.1.2.4 Item 5.

6. Confirming timing of cliff edge effects

   If DC power is unavailable, then:

   (1) The reactor pressure will be released by safety function of ADS/SRV, if DC power is unavailable. DCR-C1/C2-3319/3320 have been completed, air supply can actuate ADS/SRV for 43.2 hours. In addition, throttling the bypass valve V-108-340A/B, located between the outlet of liquid N_2 tank and N_2 piping in the primary containment N_2 purge system, can provide SRV/ADS with operating gas for a longer period (Appendix 2-CS.2-01).

   (2) If reactor and spent fuel pool water levels are maintained by raw water (Ultimate Response Guideline), water can be provided continuously for 220 hours (9.17days). The estimation is as follows: for combined events, the total required amount of reactor and spent fuel pool makeup water is 1600gpm (363.4 tons/hour). With 80% of raw water storage capacity of $80x10^3$ tons, sustaining time is. $80x10^3$ /363.4=220 hours. If taking water from brook, time duration can be longer.

   (3) Approximate 40 hours after reactor depressurization and water injection, torus water level will

increase to the elevation of vent port. This will result in torus being unable to vent and the integrity of containment will be impacted, and endanger reactor safety.

5.1.3.5 Envisaged measures to increase robustness of the plant

1. Operation of RCIC/HPCI without DC supply (manual startup)

   The operating steps "Utilizing RCIC steam line to depressurize in case of loss of DC power and steam" has been incorporated into procedure 1452.2/1452.3, so that operators can manually start the RCIC turbine by throttling "Trip & Throttle Valve" locally to consume steam in reactor and depressurize.

2. Power Source Enhancement Measures

   It has been planned to provide AC power to battery chargers by movable diesel generators. This measure can prolong battery capability to provide DC power.

3. Procedure for Power Source Rescuing Actions

   Procedure1451 has the following power source rescuing actions (Appendix 2):
   CS.2-08 Power supply from 480V movable diesel generators
   CS.2-02 Unit 1 and 2 power supply from gas turbine SBO diesel generators
   CS.2-03 Power supply from 4.16kV mobile diesel generators

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

5.1.4.1 Design provisional autonomy of the site before fuel degradation

1. Normal ultimate heat sink

   In normal operation, four Circulating Water (CW) pumps, each with capacity 137,000gpm, take suction from sea to provide cooling water as ultimate heat sink. The CW intake structure is Seismic Category II design. It is designed to have a capability to withstand 75 lb/ft^2 wind, tsunami, highest or lowest tide. The intake structure is also designed with breakwater to protect canal from wave. However, if the magnitude of earthquake is larger than Seismic Category II, the intake structure may lose its design function.

2. Ultimate heat sink

   If the normal intake structure is damaged in an event, pumps can not take water from this source. Sea water can be taken from the emergency intake structure for continuous cooling. Emergency Service Water (ESW) intake structure is located just beside Chien-Hua Creek. The structure is of Seismic Category I design. Each unit has two vertical type ESW pumps. As ultimate heat sink, each pump can provide sufficient cooling water for safe reactor shutdown. The ultimate heat sink is the cooling water mixed with sea water (East Sea) and water from Chien-hua Creek. Emergency intake structure is designed with the capability to operate under most severe weather and sea meteorology. The tsunami prevention gate can ensure the integrity of the emergency intake structure and Chien-Hua Creek.

The ultimate heat sink of emergency sea water intake has the capability to maintain one unit under control following an event; and at the same time, safe shutdown another unit and maintain it in safe shutdown condition. Or, this ultimate heat sink has the capability to safe shutdown both units, and maintain them in safe shutdown condition. In addition, the ultimate heat sink has the capability to withstand the most severe natural disaster. Any single failure caused by human error will not induce loss of ultimate heat sink. Because of the unlimited water source of UHS, reactor cooling water can always be provided by UHS in normal and emergency conditions.

The design of the ESW vertical pumps is such that they can be operated at all design water levels. These pumps are separated from each other by concrete structural wall. The Seismic Class I piping of ESW system is laid out underground on the two sides of Chien-Hua Creek to prevent multiple failures. Each unit has 2 trains of 100% capacity pump and related piping to meet the design requirements for redundancy.

(1) ESW system capacity

The two units have a total of four ESW pumps. Each has a capacity of 8,000gpm. The height of the ESW building is 11.2 meters (Figure 5-2). The pump motor and electrical distribution panels are located inside ESW pump rooms. For a tsunami on design basis, pump motors and electrical distribution panels will not be flooded.

(2) Supporting systems

a. Power sources

The EDGs of Division I, II, and III are located in a building at the elevation of 11.2 meters. These EDGs need cooling water from ESW system. The 5th EDG is air-cooled, which is located in a building at the elevation of 11.2 meters. All these EDGs are of Seismic Class I design.

b. Ventilation

There are four roof fans (E-118-1A, E-118-1B, E-118-1AS, and E-118-1BS) in emergency pump room. Normally, one of E-118-1A /B and one of E-118-1AS/1BS are running to prevent from sultry and moist.

(3) ESW intake structure and tsunami prevention evaluation

a. Based on FSAR 2.4.6.3, the design basis for tsunami is based on historic data of tsunami that occurred at Keelung in 1867. The highest tide is estimated to be 7.5 meters. Based on the description in FSAR 2.4.6.5 when the slope of the coast is 1/5, the height of tide can reach 9 meters due to tsunami and wind force. Together with 1.73 meters due to the rainfall from storm, the height of tide could reach as high as 10.73 meters.

b. CS station has tsunami prevention facilities (including tsunami gate). The top elevation of these facilities is 11.34 meters. They are designed to prevent site from flooding caused by tsunami. When the gate is closed, the bottom of the gate still has a room of 1.57 meters above the creek bed, which is for cooling water discharge passage during full load operation. To prevent tsunami invasion, the gate, which was normally open before Fukushima nuclear accident, is kept closed. The mechanism to open the gate has been established. In addition, a fast-acting motor-operated gate has been installed. This additional tsunami preventing gate can be closed within 5 minutes after receiving tsunami pre-warning.

5.1.4.2 Foreseen actions to prevent fuel degradation with external support

1. The Station existing equipment, e.g., equipment for inter-unit support

Referring to Fukushima Daiichi NPP strategy dealing with loss of ultimate sink, after water is injected into reactor, it will be vaporized by decay heat. Through opening of ADS/SRV, the steam is discharged into torus and condensed. The mixture of non-condensable gas and non-condensed steam is released to the atmosphere through containment venting system. This forms a temporarily heat removal path. For loss of ultimate heat sink, CS station has the following measures:

(1) Ultimate Heat Sink Path

a. Heat Removal Path 1:

After depressurizing reactor by ADS/SRV actuation, low pressure raw water or sea water is injected into reactor to cool down fuel and to remove decay heat. The injected water is heated by the fuel and vaporized. Steam is discharged into torus by ADS/SRV actuation. The mixture of non-condensable gas and non-condensed steam is released to the atmosphere through containment venting system. This forms a temporary heat removal path, pending establishment of the long term cooling system, to take over the mission of decay heat removal.

b. Heat Removal Path 2:

Each unit has 2 ESW pumps, which take suction from emergency intake and transport sea water to the heat exchangers of Combined Structure Cooling Water (CSCW) System and Residual Heat Removal (RHR) System, etc., to remove heat from CSCW and RHR systems and dump to the sea. Each loop of this heat removal path is designed with 100% capacity, with Seismic Category I structures and components, and with separated layout. If an event occurs, with only one loop in operation it is possible to remove core decay heat and heat generated by safety-related components. The Station has established a mechanism to expeditiously replacing the motor of the ESW pump if damaged.

c. Heat Removal Path 3:

Alternative power supply mode for Water-cooled EDGs (A/B) (Procedure 1452.4)

a) If a combined event occurs, ESW may become unavailable due to earthquake and/or tsunami, indirectly causing inoperability of the water-cooled EDGs, and reactor and torus will lose heat sink. Even if CSCW and EDGs (cooled by CSCW) is operable at the beginning of the event, they will eventually lose its design function due to loss of the ultimate heat sink. Under this situation, the Station has the following alternative method to operate EDG 1A/1B/2A/2B. In principle, EDG 1B/2B is the preferred choice, if they are unavailable, EDG 1A/2A will be the 2nd choice to perform alternative operation.

b) Description of alterative operation method: The cooling capability of the SFPCS and SFPACS is 3.42E6 Btu/hr*2 and 16.2E6 Btu/hr*2, respectively. The heat generated, which should be removed through CSCW for each EDG (1A, 1B, 2A, or 2B) at rated load is 5.9E6 Btu/hr (jacket water cooler total duty load). Thus, heat generated by EDGs can be removed by CSCW, through SFPCS, and then transferred to SFP. The heat taken by SFP can be removed by SFPACS and dissipated into the atmosphere through cooling tower. In this way, the EDGs can be maintained in operation without ESW available, and emergency power can be supplied to safety-related equipment to establish the ultimate heat sink for the reactor and torus, and ensure plant in safe condition.

Note: Local area heat loads

WC-4	3.6E6 Btu/hr
AH-15	219,850 Btu/hr (CSCW 30gpm)
AH-13	219,850 Btu/hr (CSCW 30gpm)
AH-10	744,200 Btu/hr (CSCW 100gpm)
AH-11	744,200 Btu/hr (CSCW 100gpm)

(2) Reactor water makeup:

a. Prolong/enhance RCIC water injection duration

Running RCIC can consume steam in reactor and can inject water into reactor. Maintaining RCIC in operation can achieve multiple purposes. The speed governor of RCIC turbine-driven pump requires DC power. Based on the existing design, DC power can last for 8 hours. However, it can be extended to 24 hours if some unnecessary DC loads are isolated. During SBO, controlling the DC loads can prolong the period of DC power for use by RCIC and SRV/ADS.

b. Alternative measures for reactor water injection when RCIC is unavailable

If ECCS becomes unavailable due to SBO, while HPCI and RCIC are also unavailable, the reactor has to be depressurized immediately. Reactor pressure must be depressurized to below 6 kg/cm^2 by actuating SRVs, to allow alternative water injection from low pressure water source, e.g, fire water (raw water), movable water pumps, or fire engines. RHR piping system can be used as the injection flow path. The station has still another alternative injection flow path. By this path, the 3000 tons (x2) water in the raw water reservoirs, at the elevation of 78 meters, can be injected into reactor by gravity. The flow path is described as follows: (Reference: Appendix 2 CS.1-01 attached figure)

Path: The two 3000 tons of raw water tanks on the west hill at the elevation of 78 meters will serve as the water source for BCSS system, while the two $100x10^3$ tons raw water reservoirs on the west hill at the elevation of 62 meters will serve as the water source for the 3000 tons of raw water tanks .

3000 tons(x2)raw water reservoirs → MO-E11-FF027(manual valve , normally open, inside 2nd containment) → MO-E11-FF028 (MOV, normally closed, inside 2nd containment) → BCSS water pump(inside 2nd containment)→ MO-E11-FF030(MOV, normally closed, inside 2nd containment) → MO-E11-FF031(MOV, normally closed, inside 2nd containment) → MO-E11-F017A(F017B, MOV, normally closed, inside 2nd containment) → MO-E11-F015A(F015B, MOV, normally closed) → RPV.

(3)Containment heat removal and venting:

If ultimate sink is lost, reactor has to be depressurized. Heat generated in reactor should be removed to the primary containment. The temperature of Torus water would be increased rapidly. If fuel is overheated, hydrogen should be generated. It is likely that torus temperature and primary containment pressure would be higher than the design limit. Therefore, the containment pressure has to be released to protect the integrity of the containment.

Once an event occurs, before suppression tank pressure reaches its design limit, the Primary Containment Air Control System (PCACS) can be used first for venting primary containment pressure. Torus water can absorb some radioactive material and decrease the amount of radioactive material release. Subsequently the gas is treated by Standby Gas Treatment System (SBGT); then gas is released to the atmosphere to decrease primary containment pressure. If pressure is not decreased as expected,. Venting will be performed from drywell. The Station has installed Direct Torus Venting System. As primary containment pressure increases to 50 psig, venting can be performed by operating this system to limit the pressure below the design value and to maintain containment integrity.

2. Supports available from offsite if all station equipment are unavailable

   Same as Section 5.1.2.4 Item 2.

3. The required pre-stage time for above mentioned systems

   Same as Section 5.1.2.4 Item 4.

4. Availability of qualified operators to perform the above actions

   Same as Section 5.1.2.4 Item 5.

5. Confirming timing of cliff edge effects

   Forty hours after reactor depressurization and water injection, torus water level will be increased to the elevation of the vent port. This will cause the torus to be unable to vent, and the containment integrity will be impacted.

5.1.4.3 Envisaged measures to increase robustness of the plant

1. Ultimate Heat Sink Enhancement

   Based on existing design basis, operation of only one train Essential Service Water (ESW) System can ensure the removal of core decay heat and other heat generated by safety related equipment. CS station has already established the ESW pump motor expeditious replacing procedure. Originally, the station has only one spare ESW motor. In order to ensure the availability of spare motor, a second spare motor has been purchased, and stored in a warehouse at higher elevation(Currently there are a total of two spare motors). (Appendix 2 CS.3-02)

2. Add the 2nd ultimate heat sink

   On the present planned DCR-C0-3294 (building an additional gravity pipe from the lower pool of 100,000 Tons raw water), we intend to add another fixed pipe to the discharge pipe of ESW Pumps to serve as the 2nd ultimate heat sink.

   When the Procedure 1451 「FNPS Ultimate Response Guideline」is executed, the storage volume of 100000 Tons raw water is:

   (note: the quantity drawn out by the gravity pipe of the lower pool of 100,000 Tons raw water is 83000 Tons)

   a.Core injection 1600gpm*8hr=768000gal (2906880 liters); after 8 hours, 80100 Tons raw water is left from the initial 83,000 Tons.

   b. The left 80100 Tons raw water can serve as RHR heat exchanger cooling water for about 125.96 hours. And then, URG Phase III (within 36 hours after starting) is supposed to recover ESW PUMP already, and the RHR heat exchanger cooling water can be provided by ESW PUMP again.

   By adding a gravity pipe from the lower pool of 100,000 Tons raw water to provide RHR heat exchanger cooling water can independently maintain the supply of cooling water for more than 5 days. Estimated complete date:Unit #2: 2EOC26(2014.5.31); Unit #1: 1EOC27(2014.12.19)

3. Reactor water make-up

   Path 1: Three raw water tanks (total 3600 Tons) on the east hill at the elevation of 108 meters will serve as the water source for BCSS system (Figure 5-4). The water source of the fire hydrant located at the east of site comes from the 2nd pumping station on the hill.

Water is transported by gravity. Piping can be connected from hydrant to the inlet of BCSS.

Path 2: Fire engine takes creek water or sea water as the water source for BCSS (Appendix 2 CS.1-04 attached figure)

Water in Chien-Hua and Shiaokern Creek is abundant in all seasons. The 3 fire engines (1200L/min, discharge head 70M, suction head 9M), reservoir vehicle (capacity 10 tons, pump is driven by vehicle engine, discharge rate is 3 tons/min at 8.78 kg/cm^2), and Chemical Foam Vehicle (capacity 3 tons, pump is driven by vehicle engine, discharge rate is 3 tons/min at 10.97 kg/cm^2) can be used to take suction from Chien-Hua Creek or from sea water. Through fire hose, water is supplied to the inlet of BCSS system. Related working crew has been trained and exercised.

Note: CS station has 210, size 2 1/2” ×25 meter, outdoor fire hoses. These fire hoses can be connected within a short time.

Path 3: Hotwell residual water (Figure 5-3)

If ECCS is unavailable, the 371 tons high quality hotwell residual water can be used to cool down reactor. A DCR has been proposed to install the connecting piping. Once it is implemented, hotwell residual water can be made available for injecting into reactor.

Note: Condensate storage tank (CST) is Seismic Category I design with 1892 tons ($500x10^3$ gallons) capacity. CST water can be supplied to hot well by gravity. This can serve as the cooling water source for reactor, primary containment, and spent fuel pool.

Path 4: The $100x10^3$ tons raw water reservoir is the water source. Water is transported to raw water loop by gravity and injected into reactor.

A DCR has been proposed to install connecting pipes for the $100x10^3$ tons raw water reservoir (Appendix 2 Figure 5-3). Once it is implemented, raw water can be transported to site by gravity. Taipower headquarter Construction Department is performing “Seismic Evaluation and Enhancement for Raw Water Reservoir in Nuclear Power Plants”. This evaluation also includes the seismic evaluation for raw water supply system.

4. As RCIC is running, steam is discharged into torus. Long term operation of RCIC will increase the back pressure and finally obstruct the operation of RCIC. Therefore, the station has proposed measures to enhance venting capability of primary containment. The primary containment pressure will be decreased and RCIC operating duration can be prolonged.

   The station has proposed a DCR (FCVS) for the venting capability of primary and secondary containments in case of loss of ultimate heat sink or SBO. A SGBT bypass, including filter, related valves and piping, is planned. A removable 480VAC diesel generator is also planned to be implemented. The modified system is beneficial to venting, hydrogen dilution and removal. Related measures are described as follows (Figure 5-5):

a. If SBGT is unavailable or primary containment humidity is high, the primary containment venting path is:

   ① Drywell → MO-108-206 or 207 → AO-108-214 (the original motor-driven MOV-108-214 is changed to air-driven AOV-108-214) → newly installed air-driven isolation valve (normally closed) →filter →vent at top of combination structure building.

   ② TORUS → MO-108-204 or 205 →AO-108-214(the original motor-driven MOV-108-214 is changed to air-driven AOV-108-214)→ newly installed air-driven isolation valve (normally closed) →filter →vent at top of combination structure building.

b. Secondary containment venting path:

   ① 2^{nd} containment → SB-HV-15 or 16(FAIL OPEN) → MO-108-209 →AO-108-214 (the original motor-driven MOV-108-214 is changed to air-driven AOV-108-214) →newly installed air-driven isolation valve (normally closed) →filter →vent at top of combination structure building.

5. Makeup water source structure integrity evaluation and enhancement:

The station has performed seismic-withstand capability enhancement evaluations to respond to the possible damages by strong earthquake.

(1) The station is performing a project to move fire piping from underground to above ground. This will improve the reliability of fire raw water piping, and the maintainability and piping replacement efficiency after an event will also be improved. This project will be completed before July 31,2013.

(2) A DCR is being executed to improve the flexibility of some main raw water pipes. Flexible pipes, which can absorb displacements due to earthquake, so as not to be damaged easily, will be installed in specific locations. (Completed after December 31, 2013)

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

5.1.5.1 Autonomy of station design capability before fuel degradation

In case of SBO and Loss of ultimate heat sink, alternative measures for reactor cooling are listed as follows:

1. The reactor water level and pressure can be maintained by RCIC for at least 8 hours. With some DC loads isolated, the duration can be extended to 24 hours. If reactor water level is maintained by raw water (Ultimate Response Guideline), the amount of water can be provided continuously for 220 hours (9.17days). The estimation is as follows: For combined events, the total required amount of reactor and spent fuel pool makeup water is 1600gpm (363.4 tons/hour). The 80％of raw water storage capacity is $80x10^3$ tons. $80x10^3/363.4$=220 hours. If continuous actuation of ADS/SRV is

considered, , air supply can actuate ADS/SRV for 43.2 hours (RCIC + Raw Water System). In addition, throttling the bypass valve V-108-340A/B, located between the outlet of liquid N_2 tank and N_2 piping in the primary containment N_2 purge system, the working gas can last a longer period. (Appendix 2 Ultimate Response Guideline CS.2-01).

5.1.5.2 Foreseen actions to prevent fuel degradation with external support

1. <u>The station existing equipment, e.g. equipment of other unit</u>

(1) Each unit has its own ADS/SRV, HPCI, RCIC, and instrument N_2 system. The following systems can provide inter-unit support: DST, CST, raw water system, instrument air system, and service water system

(2) Following "CS Ultimate Response Guideline 3 phase Strategy", inject raw water (fire water) into reactor (Appendix2, CS.1-01).

(3) Following the steps in Phase 1 of "CS Ultimate Response Guideline 3 phase Strategy", connect the station fire engines to inject raw water into reactor. (Appendix2, CS.1-04).

(4) The station has several fire engines as listed in the following table. These fire engines can take suction from raw water reservoir, Chien-Hua Creek, or sea water. The outlet of the fire engines can be connected to BCSS to inject water into reactor or suppression pool to prevent fuel degradation.

Chin Shan Station Fire Engines				
Name	Quantity	Capacity (Liter)	Discharge Pressure	Remark
Fire Foam Vehicle	1	3,000	0～20 kg/cm^2	Discharge flow rate : 3000 liters/min@8.78 kg/cm^2
Reservoir Vehicle	1	10,000	0～20 kg/cm^2	Discharge flow rate : 3000 liters/min@ 10.97 kg/cm^2

2. Supports available from offsite if all station equipment are unavailable

(1) If all the mitigating systems are unavailable, and ultimate heat sink is lost (loss of power supply), offsite supports include fire equipment at site and from Kuosheng station, and also from Shiman, Chin Shan, and Shanzhi districts. However, the prerequisites are ADS and SRV must be operable, and the piping of BCSS and RHR system has to be workable.

Fire Engines in the Vicinity Districts of Chin Shan Station (Shanzhi and Shiman Districts)

Shanzhi District Fire Engines

Name	Quantity	Capacity (tons)	Discharge Pressure	Remark
Water Tank Vehicle	2	1.5	10 kg/cm^2	Total 3 tons
Reservoir Vehicle	1	12	10 kg/cm^2	
Shiman District Fire Engines				
Name	Quantity	Capacity (tons)	Discharge Pressure	Remark
Water Tank Vehicle	1	2	10 kg/cm^2	
Water Tank Vehicle	2	1.5	10 kg/cm^2	Total 3 tons
Total	6	20		

Fire Engines in the Vicinity Districts of Kuosheng Station (Wanli and Chin Shan District)

Kuosheng Station Fire Engines and Movable Pump				
Name	Quantity (Unit)	Capacity (tons)	Discharge Pressure	Remarks
eservoir Vehicle	1	10	10～12kg/cm^2	Discharge flow: 3000 liters/min.
Chemical Foam Vehicle	1	2	10 kg/cm^2	
Mobile Pump	4			Discharge flow: 1500 liters/min.
Chin Shan District Fire Engines				
Name	Quantity (Unit)	Capacity (tons)	Discharge Pressure	Remarks
Water Tank Vehicle	1	3	10 kg/cm^2	
Water Tank Vehicle	1	1.5	10 kg/cm^2	
Reservoir Vehicle	1	12	10 kg/cm^2	
Chemical Foam Vehicle	1	1	10 kg/cm^2	
Wanli District Fire Engines				
Name	Quantity (Unit)	Capacity (tons)	Discharge Pressure	Remarks
Water Tank Vehicle	1	2	10 kg/cm^2	
Water Tank Vehicle	1	3	10 kg/cm^2	
Reservoir Vehicle	1	10	10 kg/cm^2	
Total	9	Water 41.5 Chemical 3		

(2) Offsite supports include one 4.16kV/1500kW mobile diesel generator and one movable diesel generator from Kuosheng station. In addition, mobile diesel generators supported from Lungmen station are also available.

(3) Chin Shan station and New Taipei city government has signed a protocol of fire fighting (or

other calamity) support. Depends on the characteristic of event, Fire Bureau will support manpower, vehicles, and equipment to site to mitigate calamity.

3. The required pre-stage time for above mentioned systems

(1) It takes 25 minutes for the station fire engine taking suction from raw water pump room, through BCSS and RHR piping system, and inject into reactor core.

(2) It takes 10 minutes for fire engines driving from Shiman district to the station (assuming water is filled and in standby). If the water injection path has already lined-up, the total time is 10 minutes.

(3) It takes 20 minutes for fire engines driving from Shanzhi or Chin Shan district to the station (assuming water is filled and in standby); and 30 minutes for fire engines from Wanli district. If the water injection path has already lined-up, the total time is 20 to 30 minutes.

(4) It takes 25 minutes for fire engines driving from Kuosheng nuclear power plant to the station (assuming water is filled and in standby). If the water injection path has already lined-up, the total time is 25 minutes.

(5) It takes 2 and 5 hours to move the Kuosheng and Lungmam mobile diesel engines to the station, respectively. Once engines arrive at site, the station personnel will connect the cables and start to provide power.

4. Availability of qualified operators to perform the above actions

How to operate the systems and equipment is described in Appendix II, and the systems and equipment are performed by the plant shift staff. The other manpower required must be supported from offsite. The support manpower is directed by the shift supervisor. The fire engines and other fire equipment are performed by firemen.

The operators, who are responsible for the above mentioned actions, are well trained and exercised. They can meet the mission requirements.

5. Confirming timing of cliff edge effects

Forty hours after reactor depressurization and water injection, torus water level will increase to the elevation of vent port. This will result in torus being unable to vent and the integrity of containment will be impacted, and endanger reactor safety.

5.1.5.3 Envisaged measures to increase robustness of the plant

1. In response to loss of power event due to earthquake, Chin Shan is designed with category I 1A/1B/2A/2B/5th EDGs (EDG 1A/1B are for unit 1, EDG 2A/2B are for unit 2). The design capacity of each EDG is 100％ such that with one EDG successfully operated, it is sufficient to provide power to the essential bus. Besides, the 5th EDG is designed for common use for both units, and can provide full power required for a single unit, or it can provide power for both units under load control.
2. To cope with LOOP events due to floods, Chin Shan is equipped with 2 sets of Gas Turbine

Generators with associated startup diesel generators located at a higher elevation, besides there are 1 set of 4.16kV/1500kW, 4 sets of 480V/200kW and 8 sets of 480V/500 kW movable diesel generators which are staged on the roof of seismic-proof buildings located at a higher elevation. Also Chin Shan had already definitely listed the operation provisions for directly supplying power to both units via cables in procedure 1452.1 to mitigate the impact by earthquake or flooding.

3. For response to loss of heat sink accident due to flooding, the station shall follow URG to carry out reactor water makeup measures including: RCIC water makeup, raw water reservoir water makeup via gravity, and makeup with normal water source and backup water source via fire engine or mobile water pumps to deliver water to reactor to maintain reactor core fuel covered, so as to prevent severe nuclear accidents from occurring. This is irrelevant with the cliff-edge effect resulting from loss of equipment room cooling. Furthermore, in procedure 1452.2, section 1, it is stipulated that the RCIC relevant valves can be manually opened, and then RCIC can be manually operated to carry out reactor water makeup, such that the cliff-edge effect would not occur.
4. Enhanced measures for Loss of Ultimate Sink

   As described in Section 5.1.4.3.

5. Enhancement of Emergency AC and DC Power

   As described in Section 5.1.3.5.

6. Alternative long term cooling

   Appendix 2. Chin Shan Station Ultimate Response Guideline -3 Phases Strategy, CS.3-03 Alternative Long Term Cooling (Procedure1451, p. 134)

5.2 Spent fuel pool

5.2.1 Loss of offsite power (loss of 69/345kV outside power)

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

1. Spent Fuel Pool (SFP) make up water system:

   (1) Condensate Storage Tank (CST) has a capacity of $500x10^3$ gallons. It is of Seismic Category I design. The CST system is of Seismic Category II design. The system has two water transfer pumps each with a rated capacity of 500gpm. The motors are rated at 60HP., and are powered by 480V MCC 1A-2 or 2A-2, which are classified as non-essential power source. In normal operation. The CST can maintain at least $250x10^3$ gallons of water supply.

   (2) Demineralized Water Storage Tank (DST) has a capacity of $50x10^3$ gallons. It is of Seismic Category II design. The DST system has two water transfer pumps with a rated capacity of 275gpm each. The motors are rated at 40HP. and are powered by 480V MCC 1A-2 or 2A-2, which are classified as non-essential power source. In normal operation, DST is can maintain at least $10x10^3$ gallons of water supply.

2. SFPCS & SFPACS power supply

(1) The power for Spent Fuel Pool Cooling System (SFPCS) is supplied from essential power source (480V MCC 3A-1or 4A-1).

(2) The power for Spent Fuel Pool Additional Cooling System (SFPACS) is supplied from essential power source (480V MCC 3A-7or 4A-7). Its back up power, is from non-essential power source(480 V MCC 2A or 1A).

(3) SFP water level/temperature monitoring instrument power is supplied from control room 120V instrument power source(IDP-120V-1 & 2, supplied from essential 480V MCC 3A-1&4A-1 respectively).

The electrical power distribution system is described as follows (Figure 5-1 CS Electrical distribution one-line diagram):

a. The supply of Non-safety-related power system(4.16kV Bus #1 /Bus #2) ca be selected from the auxiliary transformer which is connected to the main generator, or from the startup transformer which is connected to the off-site the 345kV grid or the 69kV system grid. In normal operation, the auxiliary transformer is usually selected. If necessary, the power supply can be manually shifted from the main generator to the 345kV or 69kV startup transformer. When the reactor is scrammed, the power supply will be switched to the 345kV or 69kV startup transformer automatically.

b. The power of safety-related essential bus (4.16kV Bus #3 /Bus #4) is supplied from 4.16 kV Bus #1 /Bus #2, through the 4.16 kV tie breaker 3-1 / 4-2 respectively.

c. Each unit has 2 independent 3600kW safety-related emergency diesel generators (EDG A and B) , all of the same model. These EDGs are located at elevation of 11.2m and housed in combined building. Upon loss of off-site power, EDGs can start automatically and reach rated speed and voltage within 10 seconds, and provide 4.16kV emergency power to emergency cooling systems through 4.16kV Bus #3 / Bus #4 (DIV Ⅰ/Ⅱ) .

d. EDG system is divided into two divisions - DIV I and II, independently providing power to the ESSENTIAL bus corresponding to each division. The downstream emergency loads of these two divisions, Div. I & II are redundant to each other. As long as the emergency diesel generator, ESSENTIAL bus, and the equipment of the downstream emergency loads in either DIV. I or Div. II can function normally, safe reactor shutdown and cooling can be achieved.

e. There is one 4000kW air-cooled safety-related EDG (the 5th EDG) which is common to both units. This EDG is located at elevation of 11.2 meters in a separated building. The 5th EDG can be started manually in control room to substitute any EDG of either unit (EDG 1A/1B/1AS/1BS). Thus, it can effectively increase the reliability of each essential bus.

f. The design of above safety-related EDGs are based on the requirements of design basis event

(DBE). In case of DBE, EDGs can provide the required electrical power to ensure safe reactor shutdown and cooling.

g. In case of scram, the 4.16kV bus power supply will be shifted automatically. The 4.16kV Bus #1 and Bus #2 are supplied from 69kV and 345kV offsite power system grid, respectively. The power of essential buses (4.16kV Bus #3 and Bus #4) is provided from 4.16 kV Bus #1 and Bus #2, respectively. Switching can be achieved within 10 cycles without concerns of power interruption. In addition，there are two gas turbines for SBO. Either of them has enough capacity to serve as the 69kV offsite power for two units.

h. The power of safety-related 480 PC 3A/4A are supplied from 4.16 kV Bus #3 / Bus #4 through service transformer.

a) From 480 PC 3A/4A, power is supplied to 480V Swing Bus 3-4A/3-4B for normal operation; and from 480 PC 4A/3A, standby power is supplied to 480V Swing Bus 3-4A/3-4B.

b) 480V Swing Bus 3-4A/3-4B provide power to 480V MCC 3A-1 / 4A-1, and RHR MCC A/B. 480V Swing Bus 3-4A also provides power to Hydrogen Recombiner system.

c) 480 PC 3A provides power to downstream 480V MCC 3A-2 / 3A-5 / 3A-4 /3A-7. From 480V MCC 3A-4, power is extended to 480V MCC 3A-3 / 3A-6.

d) 480 PC 4A provides power to downstream 480V MCC 4A-2 / 4A-5 / 4A-4 /4A-7. From 480V MCC 4A-4, power is extended to 480V MCC 4A-3 / 4A-6 .

Based on the above description, the design features in responding to loss of off-site power event is to automatically start the EDG attached to the DIV. I or II 4.16kV ESSENTIAL bus. The EDG can reach rated speed and voltage within 10 seconds, then the power output circuit breaker can be closed automatically to provide ESSENTIAL bus with sufficient power required. As long as either DIV. I or DIV. II EDG can provide power to ESSENTIAL bus, safe reactor safe shutdown can be achieved.

The 5th air-cooled diesel generator serves as the back up for DIV. I and DIV. II EDG. If any EDG of either unit is unavailable, it can be started to perform the design function. In addition, the two non-safety grade gas turbines can be used as supplementary to provide power to 69 kV buses through their step-up main transformer. Either of these gas turbine generators has enough capacity to provide power for two units safe shutdown.

If loss of offsite power, the power required by heat removal equipment in SFP and water level/temperature monitoring system can be provided by 4.16kV bus connected to EDGs, 5th EDG, and/or gas turbine. The emergency AC power will not supply to SFP water make up system. However, in case of loss of offsite power, SFP water level and temperature will not immediately change to cause safety concern. The operators will have enough time to take response actions.

5.2.1.2 Autonomy of the on-site power sources

Emergency diesel generator A and B (EDG A /B):

1. Fuel: The station has one $850x10^3$gallons fuel storage tank, which is filled with more than $450x10^3$gallons normally. This amount can provide 4 EDGs to run continuously for 17days.
2. Cooling type: Water-cooled.
3. Supporting systems:
   (1) Starting and control power is supplied by 125VDC from 125V SWBD #1or 125V SWBD #2, which can back up each other to support EDG operation.

   (2) Each EDG has one independent air starting system. This system has two motor-driven air compressors to transport the compressed air through the air dryer to four air tanks. The outlets of these four tanks are connected into a common header, then, air is distributed into four lines. Each line gets into the two air starting motors of the diesel engines. The EDG starting air storage tank can store air for 6 times of starting.

   (3) Combined Structure Cooling System (CSCW) provides cooling water to EDG. Sea water is used as the media to remove heat from .Sea water must be available as the ultimate heat sink to support EDG long-term operation.

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

Emergency diesel generator A and B (EDG A /B):

1. Each EDG has one fuel day tank. This tank has an outdoor emergency fuelling cap. In case fuel can not be supplied normally from the $850x10^3$gallons fuel storage tank, fuel can be supplied through this cap.
2. If it is difficult for fuel suppliers to supply fuel, fuel for auxiliary boilers and gas turbines can be used to support EDG operation. The capacity of gas turbine fuel storage tank is 35 $x10^3$kiloliters and normally is filled with 12 $x10^3$kiloliters. Thus, the EDGs can be run continuously for an extended period.

5.2.1.4 Envisaged measures to increase robustness of the plant

1. To ensure the integrity of EDG and the 4.16kVswitchgear room, the following enhancing measures will be implemented.

   All EDGs, fuel storage tanks, and accessories are located at elevation above ground level. Part of the piping is located below ground level, but is designed to meet the requirement of industrial standard for underground piping. Except for the low voltage MCCs in Corner Room located below ground level, all 4.16kV switchgears and MCCs are located above ground level. For the purpose of protecting the 4.16kV switchgears, low voltage MCCs, and all the ECCS components

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below ground level (included), a modification request (MMR-C0-0407) has been proposed and approved. Watertight equipment will be installed at doors and openings of the 5th EDG, besides, we also plan to build a 170 m long anti-tsunami wall which is 17 m above the sea level and to establish an another anti-tsunami wall in ESW pump house in order to protect the site equipment.

2. The station has the following measures to ensure electrical power supply to the required loads in case of loss of offsite power.

   In “1452.1 URG-POWER establishment” procedure, if one unit is in SBO, emergency power can be supplied from the EDG of another unit in normal operation through the distribution panel of 5th EDG. Procedure 1452.1 clearly describes the steps for providing power from another unit, dispatching the estimated loads, and isolating unnecessary loads, etc.

5.2.2 Loss of off-site power and on-site back-up power (i.e., loss of 69/345kV offsite power to EDGs)

5.2.2.1 Design provisions

In case of loss of offsite power and onsite back-up power, the station has other emergency back-up power as follows:

1. The 5th EDG

   The station has one air-cooled 4000kW, the 5th EDG, as. the backup for the four EDGs of Unit 1 and Unit 2. It can perform the same function as the specific EDG being substituted. The 5th EDG can be placed to substitute only one of the four EDGs at any one time. The target EDG to be substituted has to be pre-selected. The 5th EDG, in full load operation, can provide all the AC power required by ECCSs.

2. Gas turbines

   The station has two air-cooled gas turbines with capacity 69600kVA and power factor 0.85. These two gas turbines are primarily for emergency startup AC power for the station when SBO occurs. They also provide power during grid peak load period or power shortage due to tripping of a big unit from the grid. It takes about 10min from gas turbine start to engaging into the distribution system; and about 7.5 more minutes to reach full load (50MW).

   Normally, the power to start gas turbine is provided from 69kV Bus-2(or Bus-1 if Bus-2 unavailable).Through the main transformer (69/13.8kV)and start-up transformer (1500kVA 13.8kV/4.16kV)to step down the voltage to 4.16kV , the power can be supplied to the starting motor to actuate gas turbine . In case of SBO, the 24VDC battery set of diesel generator can be used to start diesel generator to provide 4.16kV AC power to gas turbine starting motor. This is the power source to start gas turbine in SBO.

   The gas turbine generators can be started up and monitored from local control room or from the 69kV switchyard control room in normal operation. In case of emergency, they also can be started up and monitored remotely from 345kV switchyard control room.

5.2.2.2 Battery capacity and sustained duration

The capacity of the 5th EDG 125VDC battery set is 410AH. This capacity can provide DC power to the essential loads for 8 hours to ensure the safety of nuclear system.

The capacity of each gas turbine 125V DC battery set is 400AH. It is also enough for 8 hours continuous operation

5.2.2.3 Autonomy of the site before fuel degradation

1. The 5th EDG
   (1) Autonomy of operability
   Not affected by other systems. It is an independent system with autonomous operability.
   (2) Control Power
   The starting and control power is 125VDC, which is provided by independent battery set.
   (3) Fuel
   The capacity of fuel day tank is 1300 gallons, which can provide fuel for 4 hours continuous running. There is also one fuel storage tank with 52000 gallons capacity normally, which can provide fuel for 8 days continuous running. Fuel storage tank has an external fuelling cap for making up fuel.
   (4) Cooling
   Air-cooled
   (5) Supporting Systems: NA

2. Gas Turbines
   (1) Autonomy of operability
   Not affected by other systems. It is an independent system with autonomous operability.
   (2) Control Power
   Starting and control power is supplied by independent DC battery set.
   (3) Fuel
   The gas turbine set has one 35,000 kiloliters storage tank. Diesel fuel is transported to the 3 daily tanks, each with capacity 600kiloliters, then to the inlet of the gas turbines. The total amount of diesel fuel is normally maintained at more than 12,000 kiloliters, which is enough for one gas turbine continuous running for 30 days to provide the emergency power to ESF and BOP buses for two units.
   (4) Cooling
   Air-cooled.
   (5) Supporting Systems
   The starting power for the two appurtenant diesel generators to the gas turbines is provided by the 24 VDC battery sets. These two diesel generators, each with capacity 1,500kVA, voltage 4.16kV, and power factor 0.73, are independent from each other. However, if one of them is

unavailable, the other can be used to start the gas turbine via the closure of the tie-breaker. This will not affect the SBO starting capability of the gas turbines.

5.2.2.4 Foreseen actions to prevent fuel degradation with external support

1. The station equipment, e.g., equipment for inter-unit support

(1) Based on the operating procedure "1452.1 URG-POWER establishment", any of the emergency diesel generator of either unit can supply emergency power to other unit via the 5th EDG distribution panel. This procedure also describes the steps for load control and power saving.

(2) The station has fire engines as listed in the following table. These fire engines can take suction from raw water reservoir, Chien-Hua Creek, or sea water. The outlet of the fire engines can be connected to BCSS to inject water into reactor or suppression pool to prevent fuel degradation.

Chin Shan Station Fire Engine				
Name	Quantity	Capacity (Liter)	Discharge Pressure	Remark
Fire Foam Vehicle	1	3,000	0～20 kg⁄cm^2	Discharge flow rate : 3000 liters/min@8.78 kg⁄cm^2
Reservoir Vehicle	1	10,000	0～20 kg⁄cm^2	Discharge flow rate : 3000 liters/min@10.97 kg⁄cm^2

(3) On the 5th floor of the Combined Structure building, there is a fire system. Fire water can be supplied to SFP by using fire hose from hydrant (The normal capacity is 3600 metric Tons. Or it can be connected to the two 3000 metric tons raw water storage tanks. The back up for these tanks is a 100x10^3 metric tons raw water reservoir).

(4) Based on the recommendation of NEI 06-12, the station has completed DCR-C1-3292/C2-3293 to install new SFP make up water pipes and spray equipment, with the same seismic qualification as the SFP, to increase at least 500gpm water make up capability and 200gpm water spray capability. That will enhance the cooling and make up capability, in an alternative way, for the pool water in case SFP normal make up is unavailable.

2. Supports available from offsite if all station equipment are unavailable.

(1) If all the mitigating systems are unavailable, and ultimate heat sink (loss of power supply), offsite supports include fire equipment at site and Kuosheng station, and also from Shiman, Chin Shan, and Shanzhi districts. However, the prerequisites are ADS and SRV must be

operable, and the piping of BCSS and RHR system has to be workable.

Fire Engines in the Vicinity Districts of Chin Shan Station (Shanzhi and Shiman District)

Shanzhi District Fire Engines				
Name	Quantity	Capacity (tons)	Discharge Pressure	Remark
Water Tank Vehicle	2	1.5	10 kg/cm^2	Total 3 tons
Reservoir Vehicle	1	12	10 kg/cm^2	
Shiman District Fire Engines				
Name	Quantity	Capacity (tons)	Discharge Pressure	Remark
Water Tank Vehicle	1	2	10 kg/cm^2	
Water Tank Vehicle	2	1.5	10 kg/cm^2	Total 3 tons
Total	6	20		

Fire Engines in the Vicinity Districts of Kuosheng Station (Wanli and Chin Shan District)

Kuosheng Station Fire Engines and Movable Pump				
Name	Quantity (Unit)	Capacity (tons)	Discharge Pressure	Remarks
Reservoir Vehicle	1	10	10～12kg/cm^2	Discharge flow: 3000 liters/min.
Chemical Foam Vehicle	1	2	10 kg/cm^2	
Mobile Pump	4			Discharge flow: 1500 liters/min.
Chin Shan District Fire Engines				
Name	Quantity (Unit)	Capacity (tons)	Discharge Pressure	Remarks
Water Tank Vehicle	1	3	10 kg/cm^2	
Water Tank Vehicle	1	1.5	10 kg/cm^2	
Reservoir Vehicle	1	12	10 kg/cm^2	
Chemical Foam Vehicle	1	1	10 kg/cm^2	
Wanli District Fire Engines				
Name	Quantity (Unit)	Capacity (tons)	Discharge Pressure	Remarks
Water Tank Vehicle	1	2	10 kg/cm^2	
Water Tank Vehicle	1	3	10 kg/cm^2	
Reservoir Vehicle	1	10	10 kg/cm^2	
Total	9	Water 41.5 Chemical 3		

(2) Offsite supports include one 4.16kV 1500kW mobile diesel generator and one movable diesel generator from Kuosheng station. In addition, mobile diesel generators supported from Lungmen station are also available.

(3) Chin Shan station and New Taipei city government has signed a protocol of fire fighting (or other calamity) support. Depends on the characteristic of event, Fire Bureau will support manpower, vehicles, and equipment to site to mitigate calamity.

3. Power cables specially connected from the neighboring plants (such as hydro, gas turbine plant) .

Kuosheng nuclear power plant and Linko fossil power plant are the two plants in the vicinity. However, currently no special power cables are connected to these two plants..

4. The required pre- stage time for above mentioned systems

(1) It takes about 25 minutes for the station fire engine to take suction from the raw water pump room, through BCSS and RHR piping system, and inject into reactor core.

(2) It takes about 10 minutes to drive fire engines from Shiman district to the station (assuming water is filled and in standby).If the water injection path has already lined-up. The total time will be 10 minutes.

(3) It takes about 20 minutes to drive the fire engines from Shanzhi or Chin Shan district to the station (assuming water is filled and in standby); and 30 minutes for fire engines from Wanli district. If the water injection path has already lined-up, the total time will be 20 to 30 minutes.

(4) It takes about 25 minutes to drive the fire engines from Kuosheng nuclear power plant to the station (assuming water is filled and in standby). If the water injection path has already lined-up, the total time will be 25 minutes.

(5) It takes about 2 and 5 hours to move the Kuosheng and Lungmam mobile diesel engine to the station, respectively. Once arriving site, the station personnel will connect the cables and start to provide power.

(6) It takes about 15 minutes to line up for make up water from the 3000 tons raw water storage tank; and it takes about 25 minutes to line up for make up water by fire engines through the purposed SFP new seismic grade pipes.

There is about 90 hours before the cliff-edge effects start,,. At this time, the members of the emergency response organizations, e.g., TSC, AMT, OSC, HPC and EPIC, should have arrived at R1
site already, and the supporting resources are ready.

5. Availability of qualified operators to perform the above actions

How to operate the systems and equipment is described in Appendix II, and the systems and equipment are operated by the shift staff. Other manpower required must be supported from offsite. The support manpower is directed by the shift supervisor. The operation of the fire engines and other fire equipment is performed by firemen.

The operators , who are responsible for the above mentioned actions, are well trained and exercised. They can meet the mission requirements.

6. Confirming timing of cliff edge effects

The safety and appropriateness for off-loading the entire core during refueling outage and the water temperature rise, under loss of spent fuel cooling condition, of the SFP loaded with the entire core fuel is evaluated. With both SFPCS and SFPACS being unavailable, the SFP water temperature will reach to boiling point at 9.4 hours, and water level will drop to 10 feet above top of fuel at 47.0 hours which lost an adequate shielding. Assuming the most limiting fuel loading pattern and no recovery actions, the time for the hottest fuel cladding to reach degradation temperature is approximately 90 hours

5.2.2.5 Envisaged measures to increase robustness of the plant

1. The station has proposed the following enhanced measures to provide emergency 4.16kV / 480V AC power in case of SBO.

   (1) The procedure "1452.1 URG-POWER establishment" has been modified to give instructions for operation of the 5th EDG , under the loads control , to provide emergency power to 4.16kV bus-3 or bus-4 for both units simultaneously.

   (2) The two appurtenant 4.16kV 1100kW diesel generators associated with the gas turbines can provide power to 4.1kV bus-7and bus-7S, then through bus 1 and 2, to 4.16kV bus-3 or bus-4. The related plan and exercise have been completed (Appendix 2 CS.2-02).

   (3) The station has added eight 480V 500kW moveable diesel generators. As proposed in DCR-C1/C2-3313/3314， cables and connection points will be arranged to connect moveable diesel generators to 480V PC/MCC, battery charger, UPS, and control room lighting system. This modified system will provide AC power to battery charger, then convert to DC power to provide 125VDC bus , vital UPS, and 480V loads.

   DCR-C1-3313: Since the procurement of safety-related components takes longer time, the proposed modification of 480Vpower source will be completed in two stages. The wiring from movable the diesel generators to the manual switchgear box (non-safety related component) will be completed in the 1st stage. The wiring from the manual switchgear box to MCC (safety related component) will be completed in the 2nd stage. This DCR will be completed at Unit 1 EOC-27. (Nov. 2014)

   DCR-C2-3314: Since the procurement of safety-related components takes longer time, the proposed modification of 480Vpower source will be completed in two stages. The wiring from the movable diesel generators to the manual switchgear box (non-safety related component)will be completed in the 1st stage (before Nov. 30, 2012). The wiring from the manual switchgear box to MCC (safety related component) will be completed in the 2nd stage. This DCR will be completed at Unit 2 EOC-26. (Mar. 2014)(Appendix 2 CS.1-07).

(4) Taipower headquarter has purchased six 4.16kV 1500kW mobile diesel generators. Two of them has been allotted to CS station, of which one is placed on site, and the other one is placed at Lungmen station temporarily. As proposed in DCR-3313/3314, cable connecting points to the mobile diesel generators will be set up from the dummy breaker of 4.16kV bus-3 and bus-4. (Appendix 2 CS.2-03)

(5) The design change request DCR-C0-3312 has been approved. Based on this DCR, TSC lighting and ventilation control panel will be modified to have connecting points (including backup TSC) to moveable diesel generator. The power transformer of TSC building lighting system (including backup TSC) has been removed from outdoor 1st floor to a higher elevation.

(6) To ensure that power supply capability will not be affected by flooding, MMR-0407 has been approved to enhance the capability of flooding prevention for some buildings, e.g., the 5th EDG building.

2. Mobility of Injection Equipment

CS station has purchased 8 large capacity movable fire engines to enhance the station capability to inject water into reactor.

Capacity: 38.2kW 2000 lpm@6kg/cm^2, 1500 lpm@10kg/cm^2

3. The related emergency operating steps have been incorporated in procedure 1451. This steps describe the response actions under the above mentioned conditions.

4. When Fuel is used up

(1) The 5th EDG

The 5th EDG has independent fuel storage tank with outdoor fuelling cap. From tank truck, fuel can be made-up through this port.

(2) The Gas Turbines

The Gas turbines have a 600 kiloliters fuel storage reservoir with exterior fuelling cap. From tank truck, fuel can be made-up through this port.

5. Improved measures (MMR-0407) has been purposed to enhance the flooding prevention capability of the 5th EDG and other buildings to ensure the emergency power supply will not be affected by flooding.

5.2.3 Loss of off-site, back-up power, and other diverse back-up power (i.e., loss of 69/345kV off-site power, EDGs, the 5th EDG and GTs)

5.2.3.1 Design provisions

If case of loss of the off-site power, the emergency standby power (EDG), and other types of standby power, the SFP will lose normal water make up and forced cooling functions, and the pool bulk temperature will increase to 100℃. However, there is enough time for operators to take other alternatives for make up of water in SFP.

5.2.3.2 Battery capacity and duration of operation

This system does not use DC power.

5.2.3.3 Autonomy of the station operation before fuel degradation

Although SFP will lose normal water make up and forced cooling functions, the station has emergency pool water make up capability. The 5th floor of Combined Structure building has a fire system. Fire water can be supplied to SFP by using fire hose from the hydrant (Its normal capacity is 3600 metric Tons. It can be connected to the two 3000 metric tons raw water storage tanks. The back up for these tanks is a $100x10^3$ metric tons raw water reservoir).

The SFP water can also be made up by using newly installed pipes and spray components. These pipes and components are seismic design. The water make up rate is at least 500 gpm and the spray rate is 200 gpm. If SFP water temperature continues to increase, Ultimate Response Guideline 1451 can be followed to change out air in the 2^{nd} containment or to vent air for releasing heat into the atmosphere.

5.2.3.4 Foreseen actions to prevent fuel degradation with external support

1. The station existing equipment, e.g., equipment for inter-unit support

   (1) In “1452.1 URG-POWER establishment” procedure, if one unit is in SBO, emergency power can be supplied from an EDG of another unit through the distribution panel of the 5th EDG. Procedure 1452.1 clearly describes the steps for providing power from another unit, dispatching the estimated loads, and isolating unnecessary loads, etc.

   (2) The station has several fire engines as listed in the following table. These fire engines can take suction from raw water reservoir, Chien-Hua Creek, or sea water. The outlet of the fire engine can be connected to BCSS to inject water into reactor or suppression pool to prevent fuel degradation.

Chin Shan Station Fire Engine				
Name	Quantity	Capacity (Liter)	Discharge Pressure	Remark
Fire Foam Vehicle	1	3,000	0～20 kg/cm^2	Discharge flow rate : 3000 liters/min@8.78 kg/cm^2
Reservoir Vehicle	1	10,000	0～20 kg/cm^2	Discharge flow rate : 3000 liters/min@10.97 kg/cm^2

2. Supports available from offsite if all station equipment are unavailable

(1) Offsite supports include one 4.16kV 1500kW mobile diesel generator and one movable diesel generators from Kuosheng station. In addition, mobile diesel generators supported from Lungmen station are also available.

(2) Chin Shan station and New Taipei city government have signed a protocol of fire fighting (or other calamity) support. Depending on the characteristics of events, Fire Bureau will support manpower, vehicles, and equipment to mitigate the calamity.

(3) If all the mitigating systems are unavailable, and the ultimate heat sink (loss of power supply), offsite supports include local fire equipment and from Kuosheng station, and also from Shiman, Chin Shan, and Shanzhi districts.

Fire Engines in the Vicinity Districts of Chin Shan Station (Shanzhi and Shiman District)

Shanzhi District Fire Engines				
Name	Quantity	Capacity (tons)	Discharge Pressure	Remark
Water Tank Vehicle	2	1.5	10 kg/cm^2	Total 3 tons
Reservoir Vehicle	1	12	10 kg/cm^2	
Shiman District Fire Engines				
Name	Quantity	Capacity (tons)	Discharge Pressure	Remark
Water Tank Vehicle	1	2	10 kg/cm^2	
Water Tank Vehicle	2	1.5	10 kg/cm^2	Total 3 tons
Total	6	20		

Fire Engines in the Vicinity Districts of Kuosheng Station (Wanli and Chin Shan District)

Kuosheng Station Fire Engines and Movable Pump				
Name	Quantity (Unit)	Capacity (tons)	Discharge Pressure	Remarks
Reservoir Vehicle	1	10	10～12kg/cm^2	Discharge flow: 3000 liters/min.
Chemical Foam Vehicle	1	2	10 kg/cm^2	
Mobile Pump	4			Discharge flow: 1500 liters/min.
Chin Shan District Fire Engines				
Name	Quantity (Unit)	Capacity (tons)	Discharge Pressure	Remarks
Water Tank Vehicle	1	3	10 kg/cm^2	
Water Tank Vehicle	1	1.5	10 kg/cm^2	

Kuosheng Station Fire Engines and Movable Pump				
Name	Quantity (Unit)	Capacity (tons)	Discharge Pressure	Remarks
Reservoir Vehicle	1	12	10 kg/cm^2	
Chemical Foam Vehicle	1	1	10 kg/cm^2	
Wanli District Fire Engines				
Name	Quantity (Unit)	Capacity (tons)	Discharge Pressure	Remarks
Water Tank Vehicle	1	2	10 kg/cm^2	
Water Tank Vehicle	1	3	10 kg/cm^2	
Reservoir Vehicle	1	10	10 kg/cm^2	
Total	9	Water 41.5 Chemical 3		

3. Power cables specially connected from the neighboring plants (such as hydro, gas turbine plant) Kuosheng nuclear power plant and Linko fossil power plant are the two plants in the vicinity. However, currently no special power cables are connected to these two plants..

4. The required pre-stage time for above mentioned systems

(1) It takes about 25 minutes for the station fire engines to take suction from the raw water pump room, through BCSS and RHR piping system, and inject into reactor core.

(2) It takes about 10 minutes to drive the fire engines from Shiman district to the station (assuming water is filled and in standby).If the water injection path has already been lined-up, the total time will be 10 minutes.

(3) It takes about 20 minutes to drive the fire engines from Shanzhi or Chin Shan district to the station (assuming water is filled and in standby); and 30 minutes for fire engines from Wanli district. If the water injection path has already been lined-up, the total time will be 20 to 30 minutes.

(4) It takes about 25 minutes to drive the fire engines from Kuosheng nuclear power plant to the station (assuming water is filled and in standby). If the water injection path has already been lined-up, the total time will be 25 minutes.

(5) It takes about 2 and 5 hours to move the Kuosheng and Lungmam mobile diesel engine to the station, respectively. Once they arrive at site, the station personnel will connect the cables and start to provide power.

(6) It takes about 15 minutes to line up for make up water from the 3000 tons raw water storage tank; and it takes about 25 minutes to line up for make up water by fire engines through the purposed SFP new seismic grade pipes.

There is about 90 hours before cliff-edge effects occur. At this time, members of the emergency response organizations, e.g., TSC, AMT, OSC, HPC and EPIC, should have arrived at site already, and the supporting resources are ready.

5. Availability of qualified operators to perform the above actions

How to operate the systems and equipment is described in Appendix II, and the system and equipment are operated by the plant shift staff. Other manpower required must be supported from offsite. The support manpower are directed by the shift supervisor. The operation of fire engines and other fire equipment is performed by firemen.

The operators, who are responsible for the above mentioned actions, are well trained and exercised. They can meet the mission requirements.

5.2.3.5 Envisaged measures to increase robustness of the plant

1. When SFP and reactor cavity are in connection during outage, Backup Containment Spray System (BCSS), fire engines, or movable fire pumps can be used to provide make up water to reactor or SFP through RHR piping system.

2. When SFP and reactor cavity are not in connection during non-outage period, BCSS, fire engines, or movable fire pumps can be used to provide make up water to SFP through RHR piping system. (The blind plate SSF-116-200 shall be disassembled).

3. On the 5th floor of Combined Structure building there is a fire system. Its fire water can be supplied to SFP by using fire hose from the hydrant(The normal capacity is 3600 metric tons. It can also be connected to the two 3000 metric tons raw water storage tanks. The back up for these tanks is a $100x10^3$ metric tons raw water reservoir).

4. Raw water is filled into DST through the make up demineralizer bypass pipe by gravity. Normally, DST is maintained with $10x10^3$ gallons of water at least. DST pumps can be powered from MCC 1A-2 or 2A-2 which is sourced from 480V removable diesel generators. Since the cover plate of the SFP surge tank overflow port is not watertight, pool water may overflow to reactor cavity. Therefore, temporary hose shall be connected to Service Box to provide make up water during non-outage period.

5. Upon loss of all AC power, the newly procured movable diesel generators can be connected to MCC to provide power to SFPACS to support fuel pool cooling.

6. The emergency response procedures for making up water in case of abnormal SFP cooling have been issued (procedure 503.6 “Spent Fuel Pool Cooling and Purification System Malfunction” and procedure 1451 “ CS Station Ultimate Response Guideline”). The operators have been trained and exercised.

7. Based on the recommendation of NEI 06-12，the station has completed DCR-C1-3292/C2-3293 to install new SFP make up water pipes and spray equipment (seismic grade)to increase at least 500gpm water make up and 200gpm water spray capability. That will enhance the pool water cooling and make up capability in an alternative way in case SFP normal make up is unavailable.

8. New movable 480V diesel generators has been purchased to provide emergency power for use for emergency response by the SFPACS. The seismic class of this new cooling system will be improved, and thus the depth of defense is enhanced.

9. Procedure 1024 is modified to stipulate arrangement of the fuels in the SFP in a checkerboard-like pattern, including the just-off-loaded fuel, the re-used fuel which is with higher decay heat , the fuel which is long stored in the SFP and is with lower decay heat, and the new fuel which does not generate heat,. In this pattern, the spent fuel with lower decay heat can serve as the “heat sink” for the fuel with higher decay heat, and the principle is to place any spent fuel with higher decay heat in a scattered way so as to delay ignition of fire from zirconium alloys of the fuel clad.

5.2.4 Loss of ultimate heat sink (after air-cooled SFPACS is added)

5.2.4.1 Design provisional autonomy of the station before fuel degradation

Besides East China sea and Chien-Hua Creek, the station has newly installed an air-cooled SFPACS to also serve as an ultimate heat sink by dissipating heat into the atmosphere. When the 2 trains of SFPACS are in operation, SFPACS can be remove maximum heat. The pool water temperature can be maintained at less than 65.5 ℃ for the heat load generated by 3083 total fuel bundles, which include the full core off-load for 150 hours after reactor shutdown , the previous cycle fuels off-loaded 36 days ago, and the historic off-loaded spent fuels. SFPACS includes two trains of heat exchangers and raw water/air-cooled cooing towers. The required power for this system is supplied from the essential power (480V MCC 3A-7or 4A-7), while the standby power is supplied from the non-essential power (480V MCC 2A or 1A). The heat removal capability is 16.2E+6 Btu/hr x 2 @ 125°F pool bulk temperature. The piping is Seismic Category I design. The 2nd side is also Seismic Category I design, but cooling tower is Seismic Category II design.

The original ultimate heat sink is the East China Sea and Chien-Hua Creek. In case of loss of ultimate heat sink, power can be provided to the SFP cooling system and water makeup system to maintain the design function. However, finally the design function will be lost because of loss of ultimate heat sink. In this circumstance, SFPACS can remove the decay heat generated in SFP and dissipate into atmosphere via cooling tower. This air-cooled heat removal system will not be affected by loss of ultimate heat sink, and the cooling function can be ensured.

If SFPACS is unavailable, heat can be removed from SFP only by making up water and by natural convection (natural vaporization).

Under this condition, SFP has the following ways to make up water:

1. When SFP and reactor cavity are in connection during outage, Backup Containment Spray System (BCSS), fire engines, or movable fire pumps can be used to provide make up water to reactor or SFP through RHR piping system.

2. When SFP and reactor cavity are not in connection during non-outage period, BCSS, fire engines, or movable fire pumps can be used to provide make up water to SFP through RHR piping system. (The blind plate SSF-116-200 shall be disassembled).

3. On the 5th floor of Combined Structure building there is a fire system. Its fire water can be supplied to SFP by using fire hose from the hydrant(The normal capacity is 3600 metric tons. It can also be connected to two the 3000 metric tons raw water storage tanks. The back up for these tanks is a 100×10^3 metric tons raw water reservoir).

4. Raw water is filled into DST through the make up demineralizer bypass pipe by gravity. Normally, DST is maintained with 10×10^3 gallons of water at least. DST pumps can be powered from MCC 1A-2 or 2A-2 which is sourced from 480V movable diesel generators. Since the cover plate of the SFP surge tank overflow port is not watertight, pool water may overflow to reactor cavity. Therefore, temporary hose shall be connected to Service Box to provide make up water during non-outage period.

5. Based on the recommendation of NEI 06-12，the station has completed DCR-C1-3292/C2-3293 to install new SFP make up water pipes and spray equipment (seismic grade)to increase at least 500gpm water make up and 200gpm water spray capability. That will enhance the pool water cooling and make up capability in an alternative way in case SFP normal make up is unavailable.

At this time the SFP is cooled by natural convection (natural vaporization) and Ultimate Response Guideline 1451 should be followed to vent 2nd containment to remove heat.

5.2.4.2 Foreseen actions to prevent fuel degradation with external support

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

   If air-cooled SFPACS is operable, it can be utilized to remove the decay heat generated in the SFP. If it is unavailable, SFP heat can be moved only by water makeup and natural convection (natural vaporization).

   In procedure “1452.1 URG-POWER establishment”, it is described that the emergency power of one unit can be provided from the EDGs of another normal unit through the distribution panel of the 5th EDG .

2. Supports available from offsite if all station equipment are unavailable

   (1) Offsite supports include one 4.16kV 1500kW mobile diesel generator and one movable diesel

generators from Kuosheng station. In addition, mobile diesel generators supported from Lungmen station are also available.

(2) Chin Shan station and New Taipei city government have signed a protocol of fire fighting (or other calamity) support. Depending on the characteristics of the event, the Fire Bureau will support manpower, vehicles, and equipment to site to mitigate calamity.

3. The required pre-stage time for above mentioned systems

(1) It takes about 25 minutes for the station fire engines to take suction from raw water pump rooms, through BCSS and RHR piping system, and inject into reactor core.

(2) It takes about 10 minutes to drive fire engines from Shiman district to the station (assuming water is filled and in standby). If the water injection path has already been lined-up, the total time will be 10 minutes.

(3) It takes about 20 minutes to drive the fire engines from Shanzhi or Chin Shan district to the station (assuming water is filled and in standby); and 30 minutes for fire engines from Wanli district. If the water injection path has already been lined-up, the total time will be 20 to 30 minutes.

(4) It takes about 25 minutes to drive the fire engines from Kuosheng nuclear power plant to the station (assuming water is filled and in standby). If the water injection path has already been lined-up, the total time will be 25 minutes.

(5) It takes about 2 and 5 hours to move the Kuosheng and Lungmam mobile diesel engine to the station, respectively. Once they arrive at site, the station personnel will connect the cables and start to provide power.

(6) It takes about 15 minutes to line up make up water from the 3000 tons raw water storage tank; and it takes about 25 minutes to line up make up water from fire engines through the purposed SFP new seismic grade pipes.

There is about 90 hours before the cliff-edge effects start. At this time, the members of the emergency response organizations, e.g., TSC, AMT, OSC, HPC and EPIC, should have arrived at site already, and the supporting resources are ready.

4. Availability of qualified operators to perform the above actions

The operations of the systems and equipment are described in Appendix II, and are performed by the shift staff. The other manpower required must be supported from offsite. The support manpower is directed by the shift supervisor. The operation of fire engines and other fire equipment are performed by firemen.

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

5. Confirming timing of cliff edge effects

The safety and appropriateness for off-loading the entire core during refueling outage and the water temperature rise, under loss of spent fuel cooling condition, of the SFP loaded with the entire core fuel is evaluated. With both SFPCS and SFPACS being unavailable, the SFP water temperature will reach to boiling point at 9.4 hours, and water level will drop to 10 feet above top of fuel at 47.0 hours which lost an adequate shielding. Assuming the most limiting fuel loading pattern and no recovery actions, the time for the hottest fuel cladding to reach degradation temperature is approximately 90 hours.

5.2.4.3 Envisaged measures to increase robustness of the plant

1. Ultimate heat sink enhancement:

   (1) Based on the existing design basis, the operation of only one train Essential Service Water (ESW) System can ensure the removal of core decay heat and heat generated by safety related equipment. CS station has already established the ESW pump motor replacing procedure.

   Originally, the station has only one spare ESW motor. In order to ensure the availability of spare motor, a second spare motor has been purchased, and stored in a warehouse at high elevation(Currently there are a total of two spare motors).

   (2) The SFPACS cooling tower CT-15A/B and related piping will be upgraded to Seismic Category I design.

   (3) A modification request (MMR-C0-0407) has been proposed and approved. Watertight equipment will be installed at doors and openings of the 5th EDG, besides,we also plan to build a 170 m long anti-tsunami wall which is 17 m above the sea level and to establish an another anti-tsunami wall in ESW pump house in order to protect the site equipment.

   (4) The station is purchasing two 4.16kV 1500kW diesel generators. One is placed on site; the other one is placed at Lungman station temporarily. Kuosheng station has the same type diesel generators, which can be an offsite support in case of emergency. All of these can improve the availability of emergency power supplied to ESW.

5.2.5 Loss of the ultimate heat sink combined with station blackout (SBO+LUHS)

5.2.5.1 Design provisions for autonomy of the station before fuel degradation

Upon SBO and loss of ultimate heat sink, the SFP will lose normal cooling and make-up. The station will follow procedure 1451 “CS Station Ultimate Response Guideline” and SFP cooling emergency response process to monitor and take measures to recover the capability of SFP cooling and water makeup functions.

5.2.5.2 Foreseen actions to prevent fuel degradation with external support

1. The station equipment, e.g., equipment for inter- unit support

(1)If the air-cooled SFPACS is available, power can be provided from the newly purchased movable/the stationary diesel generators connected to MCC. The SFPACS has enough capability to support SFP cooling. In addition, procedure "1452.1 URG-POWER establishment" can be followed to provide emergency power, for SBO, from the EDG of another unit through the distribution panel of 5th EDG.

(2) Backup Containment Spray System (BCSS) can make up water to SFP through RHR piping system by using fire engines, or movable fire pumps.

(3) On the 5th floor of Combined Structure building there is a fire system. Its fire water can be supplied to SFP by using fire hose from the hydrant(The normal capacity is 3600 metric tons. It can also be connected to two the 3000 metric tons raw water storage tanks. The back up for these tanks is a $100x10^3$ metric tons raw water reservoir).

(4) Raw water is filled into DST through the make up demineralizer bypass pipe by gravity(Water storage capacity is 10,000 gallons at least). DST pumps can be powered from MCC 1A-2 or 2A-2 which is sourced from 480V removable diesel generators. Make up water can be pumped from the DST to the SPF surge tank, and overflows to the SFP, or a temporary hose can be connected to the Service Box to provide make up water directly to the SFP.

(5) Based on the recommendation of NEI 06-12， the station has completed DCR-C1-3292/C2-3293 to install new SFP make up water pipes and spray equipment (seismic grade)to increase at least 500gpm water make up and 200gpm water spray capability. That will enhance the pool water cooling and make up capability in an alternative way in case SFP normal make up is unavailable.

2. Supports available from offsite if all station equipment is unavailable

(1) If SFPACS is available, offsite supports include one 4.16kV 1500kW mobile diesel generator and one movable diesel generator from Kuosheng station. In addition, mobile diesel generators supported from Lungmen station are also available.

(2) Chin Shan station and New Taipei city government have signed a protocol of fire fighting (or other calamity) support. Depending on the characteristics of the event, the Fire Bureau will support manpower, vehicles, and equipment to site to mitigate calamity.

3. The required pre-stage time for above mentioned system

(1) It takes about 25 minutes for the station fire engines to take suction from raw water pump room, through BCSS and RHR piping system, and inject into the reactor core.

(2) It takes about 10 minutes to drive the fire engines from Shiman district to the station (assuming water is filled and in standby). If the water injection path has already been lined-up, and the total time will be 10 minutes.

(3) It takes about 20 minutes to drive the fire engines from Shanzhi or Chin Shan district to the station (assuming water 9s filled and in standby); and 30 minutes for fire engines from Wanli

district. If the water injection path has already been lined-up, and the total time will be 20 to 30 minutes.

(4) It takes about 25 minutes to drive the fire engines from Kuosheng nuclear power plant to the station (assuming water is filled and in standby). If the water injection path has already been lined-up, and the total time will be 25 minutes.

(5) It takes about 2 and 5 hours to move the Kuosheng and Lungmam mobile diesel engines to the station, respectively. Once they arrive at site, the station personnel will connect the cables and start to provide power.

(6) It takes about 15 minutes to make up water from the 3000 tons raw water storage tank; and it takes about 25 minutes to make up water from the fire engines through the purposed SFP new seismic grade pipes.

There is about 90 hours before the cliff-edge effects start. At this time, the members of the emergency response organizations, e.g., TSC, AMT, OSC, HPC and EPIC, should have arrived at site already, and the supporting resources are ready.

4. Availability of qualified operators to perform the above actions

The operations of the systems and equipment are described in Appendix II, and are performed by the shift staff. The other manpower required must be supported from offsite. The support manpower is directed by the shift supervisor. The operation of fire engines and other fire equipment are performed by firemen.

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

5. Confirming timing of cliff edge effects

The safety and appropriateness for off-loading the entire core during refueling outage and the water temperature rise, under loss of spent fuel cooling condition, of the SFP loaded with the entire core fuel is evaluated. With both SFPCS and SFPACS conservatively being unavailable, the SFP water temperature will reach to boiling point at 9.4 hours, and water level will drop to 10 feet above top of fuel at 47.0 hours which lost an adequate shielding. Assuming the most limiting fuel loading pattern and no recovery actions, the time for the hottest fuel cladding to reach degradation temperature is approximately 90 hours

5.2.5.3 Envisaged measures to increase robustness of the plant

1. When SFP and reactor cavity are in connection during outage, Backup Containment Spray System (BCSS), fire engines, or movable fire pumps can be used to provide make up water to reactor or SFP through RHR piping system.

2. When SFP and reactor cavity are not in connection during non-outage period, BCSS, fire engines,

or movable fire pumps can be used to provide make up water to SFP through RHR piping system. (The blind plate SSF-116-200 shall be disassembled).

3. On the 5th floor of Combined Structure building there is a fire system. Its fire water can be supplied to SFP by using fire hose from the hydrant(The normal capacity is 3600 metric tons. It can also be connected to two the 3000 metric tons raw water storage tanks. The back up for these tanks is a $100x10^3$ metric tons raw water reservoir).

4. Raw water is filled into DST through make up demineralizer bypass pipe by gravity. Normally, DST is maintained with $10x10^3$ gallons water at least. DST pump can be powered from MCC 1A-2 or 2A-2 which is sourced from 480V movable diesel generator. Since the cover plate of SFP surge tank overflow port is not watertight, pool water may overflow to reactor cavity. Therefore, temporary hose shall be connected to Service Box to make up water during non-outage period.

5. If all AC power is lost, the newly procured movable diesel generators can be connected to MCC to provide power to SFPACS to support fuel pool cooling.

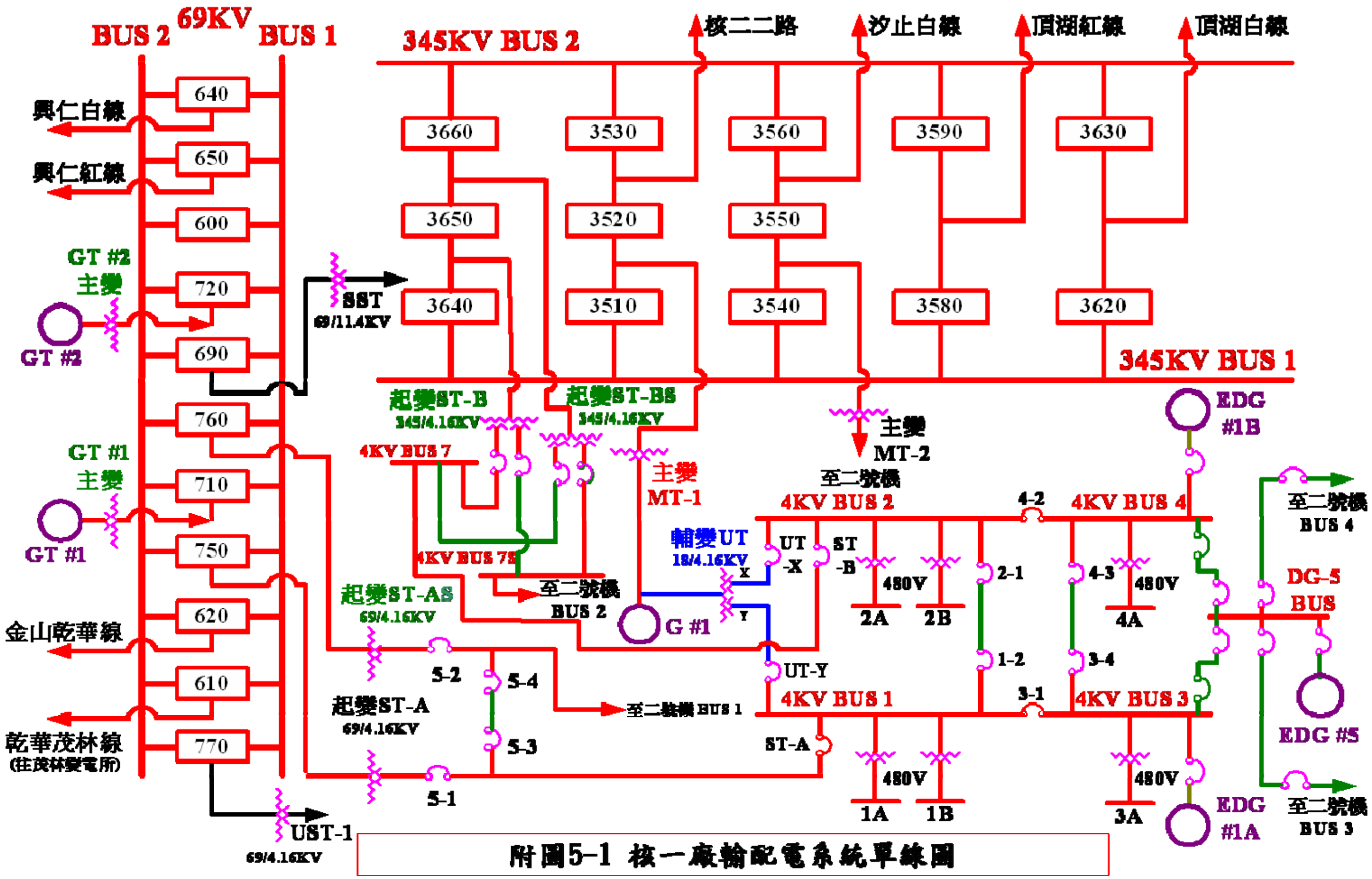
6. The emergency response procedures to make up water in case of abnormal SFP cooling have been issued(procedure 503.6 “Spent Fuel Pool Cooling and Purification System Malfunction” and procedure 1451 “CS Station Ultimate Response Guideline”. The operators have been trained and exercised.

7. Based on the recommendation of NEI 06-12，the station has completed DCR-C1-3292/C2-3293 to install new SFP make up water pipes and spray equipment (seismic grade)to increase at least 500gpm water make up and 200gpm water spray capability. That will enhance the pool water cooling and make up capability in an alternative way in case SFP normal make up is unavailable.

8. New movable 480V diesel generators has been purchased to provide emergency power for spent fuel pool cooling. The seismic class of the new cooling system will be improved to increase the depth of defense.

9. Procedure 1024 is modified to stipulate arrangement of the fuels in the SFP in a checker board-like pattern, including the just-off-loaded fuel, the re-used fuel which is with higher decay heat , the fuel which is long stored in the SFP and is with lower decay heat, and the new fuel which does not generate heat,. In this pattern, the spent fuel with lower decay heat can serve as the “heat sink” for the fuel with higher decay heat, and the principle is to place the spent fuel with higher decay heat in a scattered way so as to delay ignition of fire from zirconium alloys of the fuel clad.

10. Perform design change to upgrade the seismic capability of SFPACS Cooling tower CT-15A/B piping system to Seismic category I.



附圖5-1 核一廠輸配電系統單線圖

Figure 5-1

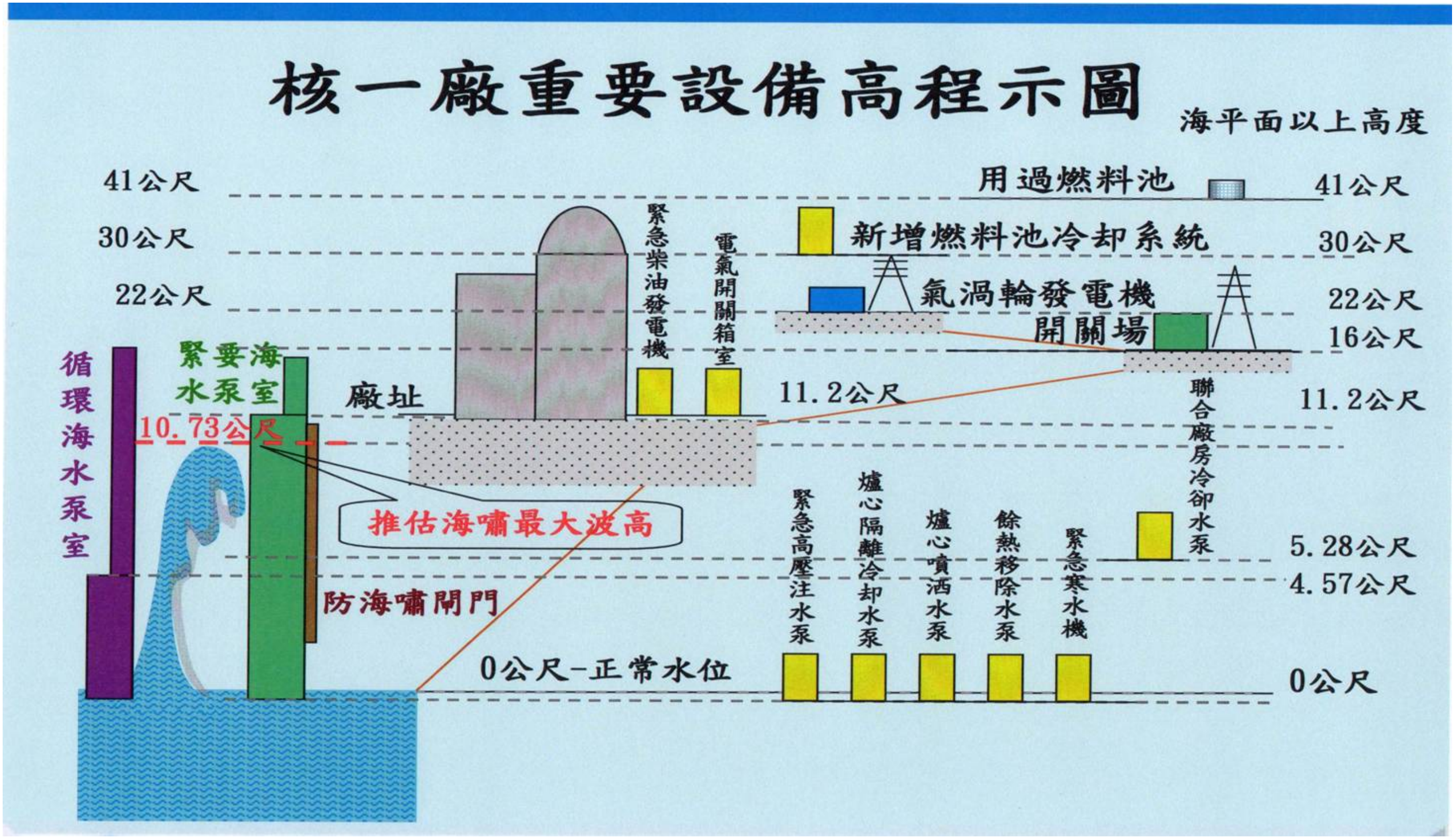


Figure 5-2 核一廠重要設備高程示圖

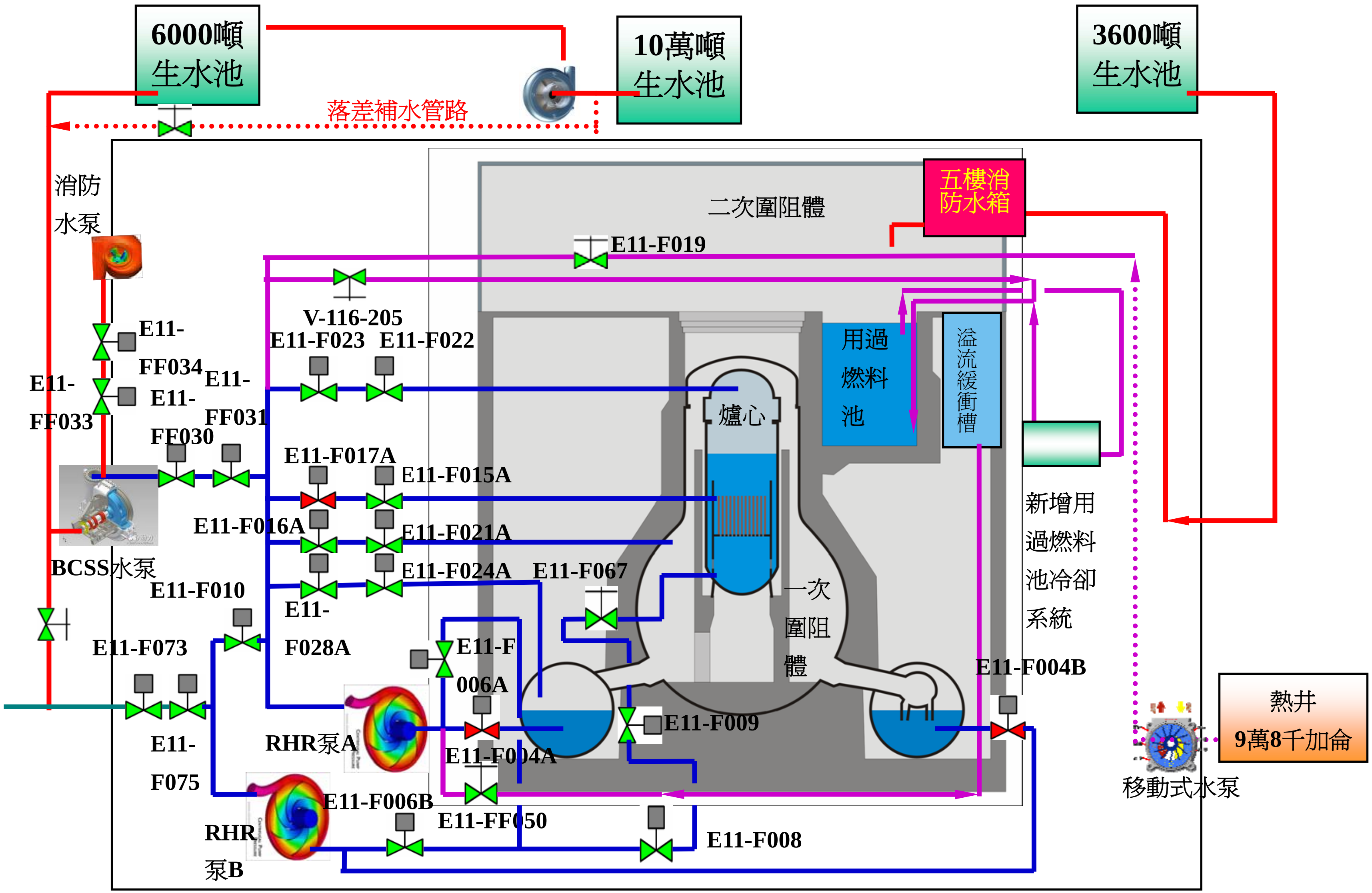


Fig. 5-3 反應爐注水、熱移除之設計改善

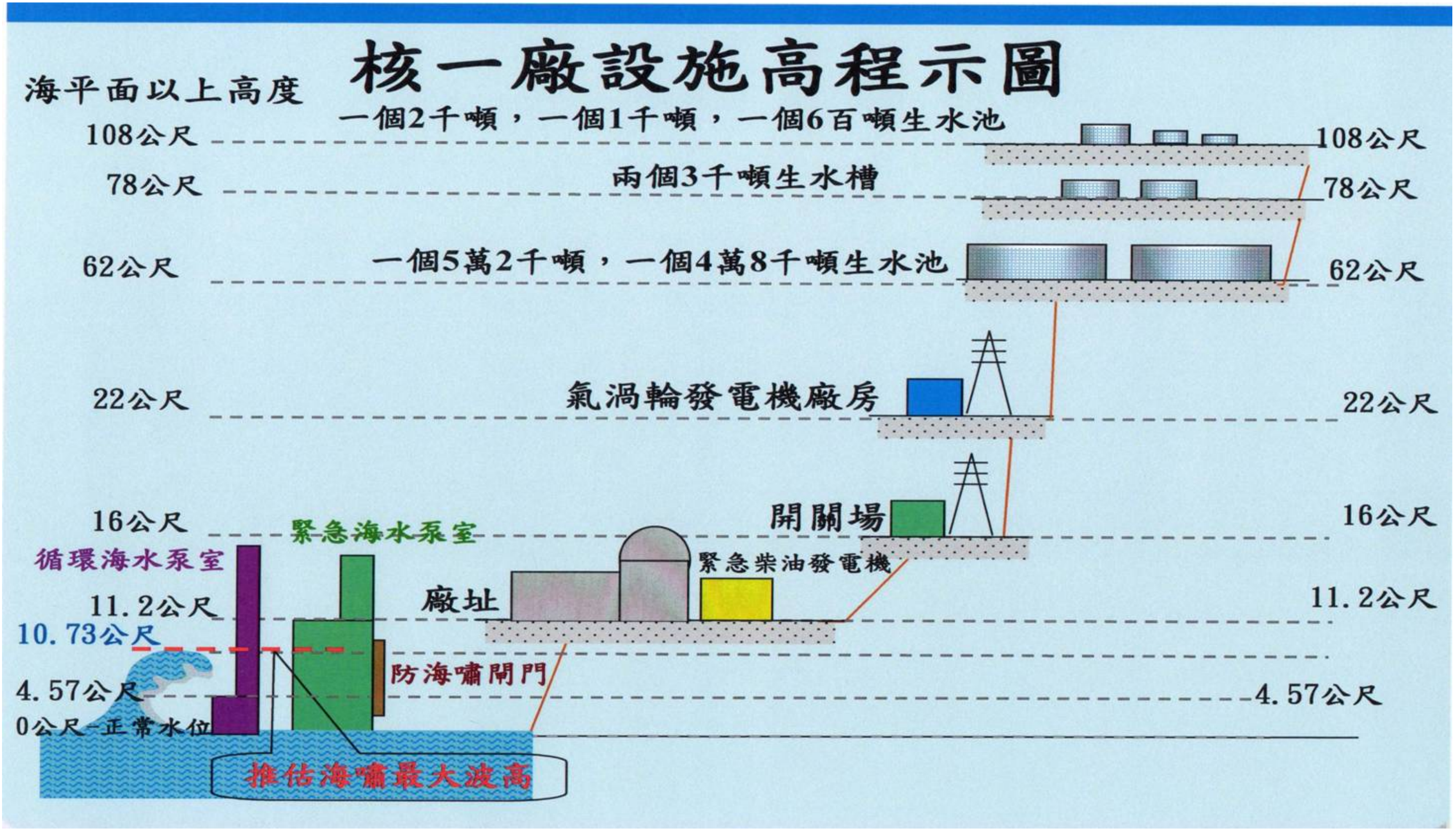


Fig 5-4 核一廠設施高程示圖

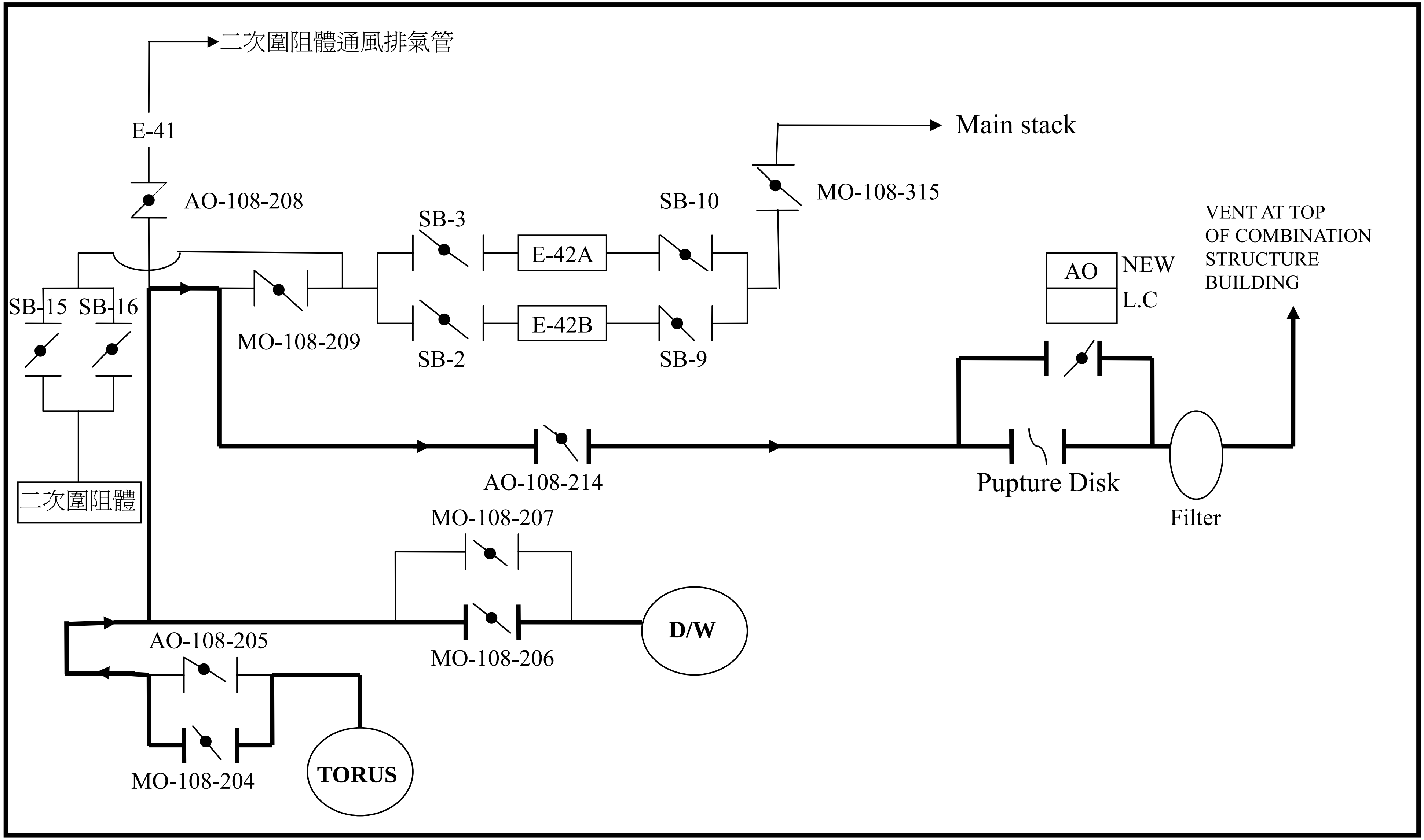


Fig 5-5 一次圍阻體／二次圍阻體排氣路徑

- ## Appendix 1 Available Response Time in SBO Based on "Safety Evaluation of SBO under MUR Power Uprate Condition"

Based on "Safety Evaluation of SBO under MUR Power Uprate Condition" issued by Institute of Nuclear Energy Research, November 9, 2006, which follows the 10 contribution factors pointed out in NUMARC 87-00 together with Chin Shan station existing measures, the available response time in SBO event are summarized in the following table:

No.	Contribution Factors	Evaluation of Response Time
1	SBO Event Scenario	SBO event is caused by loss of offsite power due to random failures of switchyard, grid interference, or climatic factors. Loss of offsite power will affect both units. If one of the two units is assumed to also lose its onsite emergency AC power (not including AAC), then, this constitutes SBO. Conservatively assume that the 5th emergency diesel generator and the two gas turbines will not serve as additional AC supports in this evaluation. The assumed power for evaluation is 102% rated power. At the early stage of the event, loss of offsite power will cause turbine control valve fast closure, Recir. pump trip(MG Set A motor power supply 4.16 kV #1 Bus and MG Set B motor power supply 4.16 kV #2 Bus de-energized), and MSIV closure. Reactor will scram due to turbine control valve fast closure. Recir. pump will trip due to loss of power. MSIV closure will cause reactor pressure up and down intermittently and will cause SRV actuation. Steam releasing from SRV will cause reactor water level decreasing and torus water temperature increasing. As reactor water level drops to L2, RCIC and HPCI will start automatically to maintain reactor water level and consume some steam. Torus water temperature will continue to increase because no RHR suppression pool cooling mode is available. If the support from AAC is not considered, SBO long-term scenario is determined by the measures taken, which are defined in Procedure "1452.1 URG-POWER establishment" and include: (1) Ensure reactor water level can be maintained by RCIC and HPCI, (2) Under the condition that reactor temperature decreasing rate is less than 55 ℃/hr, SRV or ADS can release reactor pressure to 150psig, (3) Avoid RCIC turbine trip due to high discharge pressure (10psig), bypass RCIC discharge high pressure trip signal before drywell temperature reaches 10 psig.
2	Nuclear Steam Supply System (NSSS)	The time to core uncovered and the time that RCIC and HPCI have to run under SBO event is evaluated. The results can be used to justify whether the capability of NSSS is enough for 8 hours after SBO to prevent core uncovered. Based on FSAR and this report (102% rated power), RCIC and HPCI can run continuously for 8 hours after SBO. At 102% rated power, under SBO condition, reactor core will not be uncovered if suction water is available. Therefore, NSSS system can supply steam for 8 hours after SBO; and reactor water level can be maintained. However, the actual running duration of RCIC and HPCI depends on RCIC/HPCI system and the characters of the environment. Based on lesson learned from Fukushima Daiichi NPP Unit 2 and Unit 3, RCIC can run continuously for more than 24hours(1~3 days).

No.	Contribution Factors	Evaluation of Response Time
<3	Condensate Water Required for decay Heat Removal	Based on ANSI/ANS-5.1-1979 and assume reactor has operated for 100 days; the required CST water for decay heat removal is 54712 gallons at 8 hours after SBO. The required water to reduce reactor pressure by actuating SRV/ADS is 55218 gallon. The total required water during the 8 hours after SBO is 54712+55218 =109930 gallons. The design capacity for CST is 206000 gallons. Thus, it is concluded: As power increases to 102 % rated power, the CST water can provide RCIC/HPCI continuous running for 8 hours after SBO. Based on the plan to respond to beyond design basis accident, the required cooling water can be made up from DST(50,000 gallons capacity) and CST of the other unit; or can be made up by fire engine to transport raw water into CST(500,000 gallons capacity). Therefore, the water is available for 24 hours requirement after SBO.
4	Capability of Compressed Air System	During the first 8 hours of SBO, decay heat is removed by the intermittent actuation of SRV. If the reactor pressure touches the pressure set point, SRV will be opened and steam is discharged into torus. Totally there are 10 SRVs. Each has safety function and relief function. Five of which has automatical discharge function (ADS) also. Each valve has an accumulator to store the working gas (N2) or instrument air (the ADS has one more accumulator). If working gas supply is unavailable, the pressure of each accumulator can supply working gas to actuate valve 5 times. There are 10 SRVs. Therefore, the total actuation number is 5×5+5×5×2=75 times. Based on the evaluation of SBO under 102 % rated power condition, if there are no other pressure relieving actions but only the automatic discharge function of SRV, the total actuation number is 88 times. Therefore, the safety function of SRV would have to be actuacted. However, during SBO, liquid nitrogen can be provided to ADS air header through isolation valve V-107-233B, which is controlled by essential AC power. The instrument nitrogen system is adequate for 8 hours of SBO. Enough nitrogen can be provided to actuate ADS. The function of SRV can be ensured. The capability of instrument nitrogen system is not affected by the power level. In addition, the station has 14 bottles of backup instrument gas(N2). This amount can continuously supply for 11.2 hours. Besides this, 40 bottles of nitrogen from HCU can also support as working gas for 32 hours by using temporary hose and connectors. Thus, the supply of working gas for 24 hours can be maintained.
5	Instrument and Control System (I&C)	FSAR Table 15.1.45-1 lists all the systems, equipment, components, I&Cs, and power required for SBO, including RCIC system, HPCI system, Condensate Water system, ADS, reactor pressure and water level indicator, torus water temperature and level indicator. Their capability for 8 hours SBO has been evaluated. For I&Cs, the design capability is enough for 8 hours of SBO and this conclusion is valid for MUR condition. As to interlock, start and control logic, they are designed with 8 hours capability and will not be affected by the duration of SBO.

<table>
<tr><th>No.</th><th>Contribution Factors</th><th>Evaluation of Response Time</th></tr>
<tr><td>6</td><td>Battery Loads</td><td>Based on IEEE Standard 485, FSAR Section 15.1.45 evaluates the adequacy of battery capacity and has the following conclusions:
• The design capacity of 125 VDC station battery set No. 1 is adequate for RCIC and other supporting systems operating for 8 hours after SBO.
• The design capacity of 125 VDC station battery set No. 2 is adequate for HPCI and other supporting systems operating for 8 hours after SBO.
Under the condition of 102% rated power, the DC power required for the operation of RCIC, HPCI, control room emergency lighting, reactor monitoring and instrumentation will be the same as the condition of 100% rated power. The existing result of FSAR evaluation is still valid.
Based on Procedure “1452.1 URG-POWER establishment”, if unneeded loads are isolated, the battery is adequate to support RCIC running for 24 hours. In addition, based on the plan to respond to beyond design basis accident, movable generator will be used to supply AC power to battery charger. The battery set will be operable as long as the movable generator is operating.</td></tr>
<tr><td>7</td><td>Loss of Ventilation</td><td>The main concerned areas for temperature increasing due to SBO include main steam tunnel, RCIC pump room, HPCI pump room, control room, and battery charger room. These areas have the equipment that is needed for reactor safe shutdown in case of SBO. High temperature of these areas will affect the function of these equipment. FSAR has the following results:
Temperature of main areas under SBO condition
<table>
<tr><th>Area</th><th>Normal Temperature (°F)</th><th>SBO Temperature (°F)</th><th>Equipment EQ Temperature (°F)</th></tr>
<tr><td>Main Steam Tunnel</td><td>135</td><td>193</td><td>NA</td></tr>
<tr><td>RCIC Pump Room</td><td>95</td><td>124</td><td>148</td></tr>
<tr><td>HPCI Pump Room</td><td>95</td><td>132</td><td>148</td></tr>
<tr><td>Control Room</td><td>75</td><td>113</td><td>120</td></tr>
<tr><td>Battery Charger Room</td><td>77</td><td>128</td><td>131</td></tr>
</table>
From the above table, the temperature of RCIC pump room, HPCI pump room, control room, and battery charger room will not be higher than the equipment environmental qualification (EQ) temperature during the period of 8 hours of SBO when ventilation is lost. The above table does not compare the main steam tunnel temperature with EQ temperature, because there is a temperature sensor inside main the steam tunnel to provide high temperature signal to close MSIV. Under SBO condition, MSIV is closed already. Thus, the function of this temperature sensor will not be considered. The main steam line temperature 193°F is still less than the temperature if there is main steam pipe break outside the containment. Therefore, there is no concern about the structure integrity. For RCIC pump room, HPCI pump room, control room, and battery charger room, temperature will not be affected by the initial power of SBO. The existing results in FSAR are also applicable to 102% OLTP. As to main steam tunnel, it is expected that the effect is very</td></tr>
</table>

No.	Contribution Factors	Evaluation of Response Time
		small and can be neglected. FSAR results still can be applied to 102% OLTP condition. Therefore, after 102% OLTP power uprate, the loss of ventilation under SBO condition will have the same results as 100% OLTP condition. That is, the temperature of RCIC pump room, HPCI pump room, control room, and battery charger room will not be higher than the EQ temperature limit within 8 hours after SBO when ventilation is lost. Per Procedure 1452.1, the doors of control room, computer room, control panel, HPCI, RCIC, and DC battery room have to be opened to dissipate heat. The temperature of the above areas can be maintained below the temperature of their EQ limits.
8	Discussion of HPCI and RCIC System	HPCI and RCIC pump are driven by steam and are controlled by DC power. The water source, DC power, I & C and ventilation are discussed under other items. The effects to temperature and pressure are covered by operating procedures. Based on FSAR description on containment integrity and loss of ventilation under SBO condition, there is no signal to trip HPCI turbine or to isolate HPCI system during 8 hours after SBO. In order to prevent RCIC turbine trip due to high discharge pressure (25 psig), this trip signal has to be bypassed during SBO. The station has already included this action into Procedure “1452.1 URG-POWER establishment”. Following this procedure, HPCI and RCIC can be operated for 8 hours continuously. Based on Procedure 1452.1, the battery can supply DC power for 24 hours to support RCIC operation by isolating some unneeded loads. Based on lesson learned from Fukushima Daiichi NPP Unit 2 and Unit 3, RCIC can run continuously for more than 24 hours(1~3 days).
9	Containment Integrity	During the 8 hours after SBO, the following isolation valves must be actuated to perform containment isolation function: • E51-F007 /F008 on RCIC turbine steam supply line, • E51-F031 on RCIC pump suction line, • RCIC pump discharge valve E51-F013; • compressed air isolation valve V-107-233B; • E41-F002/F003 on HPCI turbine steam supply line; • E41-F042 on HPCI pump suction line; • HPCI pump discharge valve E41-F006. The valves of HPCI and RCIC on the outboard of containment are actuated by DC power. Valves on the inboard of containment stay in the open position upon loss of AC power. Power of V-107-233B is supplied from essential bus. During the 8 hours of SBO, all the valves mentioned above have valve position indication in control room. Thus, containment isolation can be ensured as long as DC power can be maintained. Containment Structure Integrity Containment design pressure, temperature and its pressure and temperature at 8 hours after SBO are listed as follows: Design pressure: Drywell Wet well air space Torus 70.7psia 70.7psia 70.7psia Pressure at 8 hours after SBO: 37.7psia 37.2psia 37.2psia Design temperature: Drywell Wetwell air space Torus 340˚F 340˚F 340˚F

No.	Contribution Factors	Evaluation of Response Time
		Temperature at 8 hours after SBO: 295.0°F 190.2°F 207.9°F If SBO lasts for 8 hours, the maximum pressure and temperature of drywell and torus air space will still be below their design values with enough margins. The NPSH of RCIC and HPCI also meet the requirement. After SBO, containment temperature and pressure will increase gradually due to decay heat and cause SRV/ADS actuation (SRV/ADS actuation is caused by decay heat also). The margin of pressure is large and the decay heat will decrease. In addition, depressurization will be performed in time based on EOP 540.3. Thus, containment structure integrity can be maintained for 24 hours.
10	Other Systems, e.g., Lighting, Communication, etc.	FSAR shows that communication and lighting system, under both original rated power and 2% power uprate condition, have capability to perform their design function for 8 hours after SBO. Whether these two systems can work for 24 hours after SBO will depend on the capacity of battery set.

Appendix 2 Three Phases of Chin Shan Ultimate Response Guideline

(SAMPLE ONLY)

Phase	Item No.	Measures (Related Procedure and DCR)	Time Limit
Phase 1	CS.1-01	Raw Water (Fire Water) Injection into Reactor (Procedure 1451 p24 /540.7.4 SEC.2, DCR-C0-3294)	1 hour
	CS.1-02	Reactor Depressurization Under SBO (Procedure 1451 p44, DCR-C1/C2-3319/3320)	
	CS.1-03	Containment Venting Under SBO (Procedure1451 p28/304.17, DCR-C1/C2-3305/3306)	
	CS.1-04	Water Injection from Fire Engine (Procedure 1451 p38/ 540.7.4 SEC.5	
	CS.1-05	RCIC Manual Operation (Procedure 540.7.9 PCN Water Injection)	
	CS.1-06	Supply Power to both Units from 5th Diesel Generator (Procedure 1452.1)	
	NA	NA	
Phase 2	CS.2-01	SRV/ADS Air Supply from Mobile Air Compressor/ Nitrogen Bottle (Procedure 1451 p36, DCR-C1/C2-3319/3320)	8 hour
	CS.2-02	Supply Power to both Units from Gas Turbine Diesel Generator	
	CS.2-03	Supply Power from 4.16kV Mobile Power Vehicles (DCR-C1/C2-3313/3314)	
	CS.2-04	Prolong DC Power Supply (DCR-C1/C2-3313/3314)	
	CS.2-05	Spent Fuel Pool Water Makeup/Spray (Procedure 1452.2 and DCR-C1/C2-3292/3293)	
	CS.2-06	Operating Submerge Pump (Procedure 1451 p.42)	
	CS.2-07	Injecting Water into CST from Mobile Water Source (DCR-C1/C2-3292/3293)	
	CS.2-08	Supply Power from 480V Mobile Diesel Generator (Procedure 1451 p31, DCR-C1/C2-3313/3314)	
Phase 3	CS.3-01	Emergency Sea Water Intake Trash Cleaning (Procedure 1451 p50, DCR-C0-3308)	36 hour
	CS.3-02	ESW Motor Replacement (Procedure1451 p50)	
	CS.3-03	Alternative Long Term Cooling (Procedure 1451 p134)	

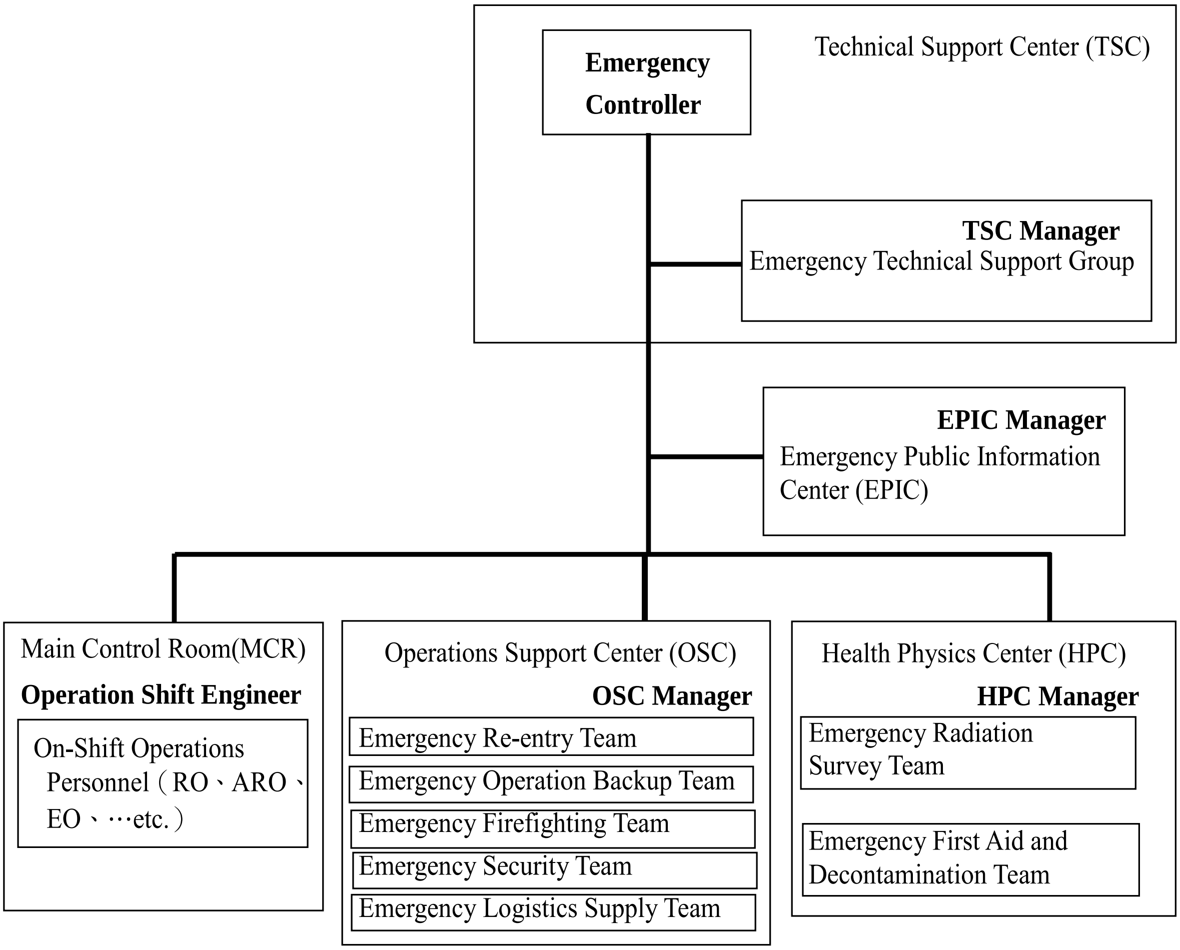
6. The management of severe nuclear accidents

6.1 Management organization of severe nuclear accidents

6.1.1Organization plan

Emergency Control Team (ECT) is the core of the site emergency program. It consists of the emergent Technical Support Center (TSC), eight Emergency Working Teams and one Emergency Public Information Center (EPIC).

Onsite Emergency Organization



6.1.1.1 Organization structure

Organization structure for severe nuclear accidents

1. Technical Support Center (TSC) - TSC is the head of management organization and also leadership of all rescue operations. During the accidental period, TSC make decisions of contingent operations based on damage reports provided by AMT.
2. Emergency Controller - Emergency Controller, assumed by the plant general manager who commands the response actions for emergency situations.
3. Accidents Management Team (AMT)

   To respond to severe nuclear accidents, a plant specific severe nuclear accidents management procedure is established (SAP-1/SAP-2 Severe Accident Procedure, figures 6-1 and 6-2) in CSNPP according to the severe nuclear accident guideline BWROG EPGs/SAGs Rev. 2 (2001/03) developed by BWROG. And the functioning group "Accident Management Team (AMT)"will be organized according to the accident scenario.

   AMT is established as a functioning group of TSC for severe accidents. When a severe nuclear accident occurs, if the cooling systems could not provide appropriate reactor core cooling, the additional approaches of water injection into the primary containment would be required, AMT provides TSC with the situation diagnostics and suggestions of responding strategy.

   AMT leader is served by the Manager of Nuclear Engineering Section, AMT includes 3 divisions with different mission assignments. In the simultaneous accident of two units, one additional AMT will be established and work independently. Leader of this additional AMT is still served by the Nuclear Engineering Section Manager. The members of AMT teams and their assignments are listed as follows:

The members of AMT teams and their assignments for single unit accidents (excerpt from procedure 1407)

Group	AMT leader	Operation coordination team	Nuclear safety evaluation team	Reactor evaluation team	Information platform
A group	Manager of Nuclear Engineering Section Manager of Operation Section (deputy leader)	Manager of Operation Section (concurrent)	Manager of Quality Control Section (concurrent)	Manager of Nuclear Engineering Section (concurrent)	1.Two communicators from Computer Section 2.Two TSC assistants from Nuclear Engineering Section
B group		Chief of Operation Subsection	Chief of Nuclear Safety Management Subsection	Chief of Nuclear Safety Evaluation Subsection	
Group members		1~2 in each group	1~2 in each group	1~2 in each group	
Missions	➢ Suggest to organize AMT ➢ Supervise AMT ➢ Follow SAGs ➢ Suggest the strategy ➢ Predict rescue actions	➢ Confirm the situation is transferred to SAGs ➢ Decide SAG items ➢ Evaluate the effect of water injection into containment ➢ Optimize the rescue timing ➢ Set the system recovery priorities	➢ Control the trending of the safety parameters ➢ Evaluate the RPV flow rate ➢ Evaluate the System status	➢ Confirm the reactor shutdown ➢ Confirm RPV breaks ➢ Confirm fuels damage ➢ Request TSC/ NEPEC to provide the information about --Gas sample in the containment --Estimated release rate of radioactive gas	The corresponding operation of the information platform of NNERC (National Nuclear Emergency Response Center)

The members of AMT teams and their assignments for the simultaneous accidents of two units (excerpt from procedure 1407)

<table>
<tr><th>Group</th><th>AMT leader</th><th colspan="2">Operation coordination team</th><th colspan="2">Nuclear safety evaluation team</th><th colspan="2">Reactor evaluation team</th><th>Information platform</th></tr>
<tr><td>A group</td><td rowspan="3">Nuclear Engineering Section Manager
Operation Section Manager (deputy leader)</td><td>Operation Section Manager (concurrent)</td><td>Senior Outage Engineer</td><td>Quality Control Section Manager (concurrent)</td><td>Section Head of Quality Control Section</td><td>Nuclear Engineering Section Manager</td><td>Section Head of Nuclear Engineering Section</td><td rowspan="3">The same as that in single unit accident</td></tr>
<tr><td>B group</td><td>Section Head of Operation Section</td><td>Instructor of the Simulation Center</td><td>Section Head of Quality Control Section</td><td>Section Head of Quality Control Section</td><td>Section Head of Nuclear Safety Evaluation Section</td><td>Section Head of Nuclear Engineering Section</td></tr>
<tr><td>Group members</td><td>1~2 member in each</td><td>1~2 member in each</td><td>1~2 member in each</td><td>1~2 member in each</td><td>1~2 member in each</td><td>1~2 member in each</td></tr>
<tr><td>Missions</td><td>➢ Suggest to set up AMT
➢ Supervise AMT
➢ Follow SAGs
➢ Suggest the strategy
Predict rescue actions</td><td colspan="2">➢ Confirm the situation is transferred to SAGs
➢ Decide SAG items
➢ Evaluate the effect of water injection into containment
➢ Optimize the rescue timing
Set the system recovery priorities</td><td colspan="2">➢ Control the trending of the safety parameters
➢ Evaluate the RPV flow rate
Evaluate the System status</td><td colspan="2">➢ Confirm the reactor shutdown
➢ Confirm RPV breaks
➢ Confirm fuels damage
➢ Request TSC/ NEPEC to provide the information about
--Gas sample in the containment
--Estimated release rate of radioactive gas</td><td>The same as that in single unit accident</td></tr>
</table>

4. Control Room

Whenever the severe nuclear accident is occurred, and TSC is not yet in-work, the on-duty Operation Section Manager/ Shift Manager execute necessary treatment directly in accordance with the emergency operating procedures (EOP 540.1～540.4, 540.7) and CSNPP ultimate response guideline (procedure 1451. After the establishment of TSC and TSC has received the accidental status of the control room's treatment for the affected units by following EOP, TSC will decide whether the conditions of SAP are met or not. The AMT leader (or his/her deputy) reports to the TSC leader to make decisions and then the accident management responsibility will be transferred to TSC for following emergency operation and AMT will follow the guidelines in SAP and provide TSC with the latest status evaluation and make recommendations.

6.1.1.2 The possibility of utilizing the current equipment

1. Chin Shan plant has followed the WANO SOER 2011-2 to verify the availability and the functionality of the equipment under the severe accidents, sifted the scope by SAP procedure (540.5 and 540.6) and EOP auxiliary procedure (540.7), precede the necessary tests according to the equipment's characteristics (Active/Passive) or complete the verification/inspection by the methods of Inspect/Walkdown. All the verification results meet the requirements.
2. After checking thoroughly the equipment of the corresponding procedures for mitigating the severe accidents, they are divided into two categories: one is those which had already established in the system (fixed, used in normal and emergency conditions), the other is used for supporting the emergencies (usually for handling emergency situation. with fixed and unfixed, partial mobility). The equipment items and check results are as follows:

    (1) The important equipment already established on the system (fixed, used in normal and emergent conditions)

    a. Fill water into RPV/Primary containment:

    ①Low Pressure Core Injection System(LPCI), ②Core Spray System (CS), ③High Pressure Core Injection System(HPCI), ④Reactor Core Isolation Cooling System(RCIC), ⑤Condensate Transport system (CST), ⑥Reactor Feedwater Pump (RFP), ⑦Fire Water system, ⑧Backup Containment Spray System (BCSS), ⑨Water pumps of Emergency Core Cooling System(ECCS), ⑩Standby Liquids Control System (SBLC) and RHR service water connection conduits.

    b. Venting of the primary containment:

    ①Primary Containment Ventilation System, ②Standby Gas Treatment System, ③.Drywell spray, ④.Suppression pool (TORUS) spray.

    c. Reactor power control

    ①MODE switch shutdown (MODE SW S/D), ②Repetitive Reaction Control System -- (Alternate Rod insertion, ARI), ③Control Rod (CR), ④ Standby Liquids Control System (SBLC).

    d. RPV pressure control

    ①Bypass valve of the main turbine, ②Water draining valve of the main steam line, ③The testing mode of LPCI, ④ The testing mode of RCIC, ⑤Steam Jet Air Ejector (SJAE), ⑥Turbine Seal Steam Bypass Valve, ⑦ Reactor Water Cleanup System (RWCU) of the reactor, ⑧RHR shutdown cooling mode, ⑨Safety Relieve Valve/Automatic De-pressure System (SRV/ADS).

e. Primary containment hydrogen control

①Hydrogen Detection System, ② Suppression Pool Ventilation System, ③Drywell ventilation, ④Primary Containment Air/Nitrogen Purge System, ⑤Hydrogen recombiner, ⑥Drywell spray, ⑦Suppression pool spray.

f. Primary containment air control:

①RHR & Suppression Pool Cooling System, ②Dry well Air Conditioning System.

g. Secondary containment control/ radioactive materials release control:

①Standby Gas Treatment System, ②Air Handling units in the secondary containment, ③Turbine building HVAC System, ④Rad-Waste buildings HVAC System.

h. Emergency power sources:

①Water cooled Emergency Diesel Generator; ②Air cooled 5th EDG, ③Gas Turbines.

i. Heat removal (heat sink)

①Combination Structure Cooling Water System, ②Essential Service Water System.

j. Spent fuel Pool water cooling:

①Spent fuel pool, ②Suppression pool cooling system.

k. Others:

① Instrument Air System, ② Combination Structure Cooling Water System, ③Service Water System, ④Emergency Chilled Water System

The above equipment has been included in Chin Shan plant's quality assurance (QA) system for regular test, maintenance, and controlled by MMCS (Maintenance management Control System). They are now all in available conditions.

(2) The equipment for supporting emergency situations (they are used for responding to the emergencies, with fixed, movable, and part of them are movable)

a. The hardware (including laptop PCs of the staff) and software on the working sites of AMT

b. The parameters indicating instruments (including ERF and board instruments panel) needed in the accidents processing

c. The equipment for injecting the boron-acid solution.

d. Replenish raw water into reactor core (including raw water reservoir, corresponding conduits and caps).

e. For the jump-wire in the EOP procedure that need to be crossed over or disconnected, verify amount of jump-wire and their storage positions

f. Mobile air compressor (used for backup to EDG starting air system)

g. TSC/OSC diesel generator.

h. Fireproofing (including water sources, CO_2 storage quantity, generators, fire hydrant water pump, water pumps, fire engines etc).

The above equipment has been under corresponding Test or Inspect / walkdown to confirm their availabilities and functionalities according to their (Active or Passive) characteristics, the results of all sorts of equipment are pretty good. For those extreme rare items that are not included in the prevention and maintenance, they are reviewed and modified to be controlled by MMCS, and these prevention and maintenance works will be regularly performed.

3. Verify on site or inspect the equipment (e.g. fireproofing equipment) and conduits for mitigating the accidental consequences to see whether they will fail in the interaction of earthquakes/tsunami/flood, and review/confirm the potential weaknesses:

Chin Shan plant has completed the verifications of the important equipment for mitigating consequences about the locations, the grades of seismic-proof, the power sources utilized and current maintenance measures, including: The water injection equipment of the reactor, reactivity control, hydrogen control, containment venting, reactor venting and pressure control, emergency water replenishing system of the spent fuel pool, emergency service water system and fireproofing equipment etc. The verification and on-site inspection results based on design basis of the plant for the equipment responding to fires, floods, earthquakes, and tsunamis are as follows:

(1) Fire:

a. Chin Shan plant has completed the tests, maintenance and inspection on the corresponding fire-fighting equipment based on the maintenance operation of the firefighting equipment and found no abnormalities, including: automatic fire hydrant water spray system, Carbon dioxide automatic spray system, Fire fighting foam spray system, Halon automatic fire extinguish system, indoors and outdoors fir hydrants.

b. The firefighting facilities of CSNPP (except source equipment, pipes) corresponding to safe shutdown are seismic 1 class.

(2) Floods:

A Tsunami wall (EL. 17 m from sea level) will be build to protect the reactor building, watertight doors will be installed for the 5thEDG building, and water-proof apparatus will be installed for the ESW equipment.

(3) Earthquakes:

a. reactor building and ECCS of CSNPP are both designed as seismic class I, same as the cranes in the reactor building. They are all installed with the mechanical brakes to prevent falling from slipping.

b. “special project team for seismic proof evaluation” for nuclear power plants has completed inspection of gas turbine system, diesel storage tanks and raw water reservoirs of CSNPP.

c. In generator and transformer buildings of CSNPP, there are management measures for all temporary or long-term storage of equipment, materials and accessories which are not belong to systems. To ensure the storage locations for these objects won’t damage safety equipment in normal time or during earthquakes.

(4) Tsunami

Based on latest collected information, studies and investigation (includes National Science Council simulation results) the current design base is commensurate to the assumed Tsunami stated in the FSAR.

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

Chin Shan plant has already purchased twelve 480V mobile diesel generators, one diesel generator vehicle (4.16kV) , two mobile diesel air compressors, three small mobile air compressors, and eight mobile large-type firefighting pumps, etc. If beyond design base accident happens, the units lose in-site and off-site AC power or lose the water replenishment into reactor. Chin Shan plant has already established the procedure 1451 “ ultimate response guidelines” (URG), including several kinds of responding measures(e.g. back-up power, water sources, compressed-air sources, water filling routes, hydrogen control, etc), maneuvering all possible manpower and materials, arranging all available water(includes sea water) sources in the shortest periods. If, after evaluation, the water filling and cooling functions of the design base can not be recovered in a short time, the available reserve water sources will be filled into reactor immediately to assure the fuels will be covered by water and to avoid the fuel damage and release of the radioactive materials to atmosphere.

The procedure 1451(Ultimate Response Guideline, URG) provides the guidelines and operations steps to achieve the following goals if the plants are under the compound disasters beyond design bases like earthquakes, tsunamis, etc.:

1. Maintain reactor core cooling.
2. Maintain monitoring function of control room.
3. Avoid (reduce) release of the radioactive materials.
4. Remove accumulated hydrogen in the plant buildings.
5. Maintain the fuel pool cooling and spent fuel pool being covered by water.
6. The goals of this guideline are maintaining core cooling for a long time, the fuel pool cooling and spent fuel pool covered by water, repairing the rescue equipment and recovering the long term cooling capability.

In which, all strategies are planned in advance and established in the attachment of procedure 1451(explained as below) and can be carried out immediately. The URG strategies of level 1/2/3 must be arranged completely in 1/8/36 hours after initiation of URG and are executed according to decisions.

Attachment 1of procedure 1451 : URG flow chart of Chin Shan NPP. (Figure 6-4)

Attachment 2 of procedure 1451: URG flow chart of Chin Shan NPP's spent fuel pool . (Figure 6-5)

Attachment 3 of procedure 1451 The criteria and report timing of URG flow chart of Chin Shan NPP. (Figure 6-6)

Based on the fact that if the compound disasters happen, every kind of current systems, equipment or water facilities in plant may fail simultaneously. Therefore, plant's on-site and off-site available resources need to be considered sufficiently so the mobile power, water sources and gas sources and their mobility arrangement and processing time are listed in the attachment 3 of procedure 1451 URG -- the substitute operations for the URG of the 2 units of Chin Shan plant" for reference to respond to all scenarios of compound disasters.

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

If emergency accidents happen, the Emergency Supply Team provides supports of backup and equipment according to the procedure 1411 "the backup service and equipment support procedure".

The supply section manager is the leader of the emergency supply team, and three subsection chiefs are specified as his/her deputy in sequence from the first to the third, the staff of the supply and accounting sections are team members, the Emergency Supply Team leader is responsible for the supply management of backup resources:

1. Coordinate the backup manpower to support the emergency responding team.
2. Coordinate the vehicles dispatch, materials supply, emergency materials preparing and purchase and the lodging/meal arrangement for the working staff.
3. Continuously update the emergency workers' name list and assembling locations.
4. Finance and accounting Support.
5. Evaluate the needs of the present and future manpower and equipment.
6. Dispatch coordinators to assembling locations.
7. Collect information of off-site environment.(e.g. wind directions, traffic routes in and out of the plant).
8. Request backup service to the corresponding departments.

6.1.1.5 Radiation release management and radiation confining preparation

If severe accidents happen, the management of radiation release and preparation of the limited radiation of Chin Shan plant can be divided into two parts as radioactive gases and radioactive fluids, they are explained as follow:

1. release of radioactive gases

   (1). In normal conditions, the primary containment can contain radioactive materials by the design of automatic isolation to avoid releasing fission products' of unexpected accidents and make sure the off-site dose on the plant peripherals dose not exceed the regulation of 10CFR100.

   (2). When emergency accidents occur and dose rate of the plant peripherals reaches 5Ci/sec, all releases must be isolated according to the EOP procedure 540.4 "The secondary containment and radioactive materials release control"；If the situation deteriorates and execution of SAP is required, according to the regulation of procedure 540.6 "Containment and radioactive materials release control(SAP-2)" , HVAC must be confirmed isolated and SBGTS must be started to effectively filter radioactive materials when the secondary containment's HVAC radiation over 100mR/hr.

   (3). During the EOP/SAP rescue operation, if the containment failed because of pressure, hydrogen concentration too high or containment is unable to sustain RPV blowdown energy (i.e. containment loss its pressure suppression capability), the primary containment must venting according to regulation of EOP/SAP, (operations details referenced in procedure 540.3) in order to maintain containment integrity and to avoid uncontrollable releasing large quantity of radioactive gases.

   (4). If compound disasters like Fukushima's accident occur; containment's blowdown/venting system may fail because of loss of power. Chin Shan plant will precede the operation according to the strategy of the first stage of URG CS.1-03--Venting operation during blackout of the plant.

2. The release of radioactive fluids

(1). The possible release route of radioactive fluids:

The most possible radioactive fluids release route by unexpected accidents is draining into plant sumps and overflow, or in the worst situation, the bottom floors of the reactor building may be flooded and the water overflows the buildings into the sewer in the plant or penetrates into the service water conduits with cracks of the bottom level. Both of them flow into the ocean from the exit of cooling service water of the plant.

According to the regulation of procedure 912, when earthquakes occur and the operators receive the commands to stop releasing waste water, the release of the waste water should be stopped immediately, and after the earthquakes, the release can only be proceeded again if the waste system and waste water release routes are checked normal and guaranteed to be safe without any concerns.

(2). Responding plan:

If the radioactive materials release is resulted from the unexpected accidents, the evaluation of the impact to Chin Shan plant is that the maximum storage for the waste fluids is 51,400 cubic meters (fluid will be guided flow to bottom floor of the turbine building in stead of radwaste tanks in radwaste building, there are total 51,400 cubic meters per unit of turbine buildings bottom floor).

The NEPEC and the central disaster response center will be immediately notified. If necessary, the central disaster response center coordinates radiation survey center to send professionals to the stations on shore to strengthen the monitoring.

Chin Shan plant has complete procedures for corresponding steps of entering the plant and radiation protection and control for the support manpower in the emergency repairs. However for some specialists required in the compound disasters, they are required to enroll in the emergency working team if the situation allowed, and then precede the assignment grouping for repair operation according to current procedures.

Considering the emergent conditions of time effectiveness of the rescue, and are not enrolled in advance, they will be instructed by Health Physics Center(HPC) staff for 5~10minutes about the safety rules of repairing under radiation, including the stipulations of emergency exposure, the risks of receiving radiation and the status of on site radiation protection and the alarming values of radiation dose of repairers, and asking the persons involved for permission signature for receiving the dose. They are accompanied to the site and are instructed the attention items of the corresponding radiation protection.

Before the rescue staff entering the radiation quarantine, every rescue worker is issued with a badge and auxiliary dose alarming meter from HPC staff, and is instructed for how to wear the radioactive protection clothes and how to utilize the radiation protective equipment etc.

After rescue operation, they are helped by Health Physicist and go to the specified temporary controlled HP station for whole body contamination detection and cleaning, make necessary dose registration according to their dose received and get proper medical care to assure the radioactive safety of the rescue staff.

6.1.1.6 Communication and information system (internal and external)

1. The current designs of normal/emergency communication system of the plant (including power, equipment, temporary cables, PHS base stations etc):

   (1) PA (Broadcasting system)

   a. Supply power by SUPS-1.

   b. Turbine building, reactor building and outdoors can be operated independently, in order to prevent the possibility of system failure propagation.

   (2) Satellite phone

   Batteries included, can stand by 48 hours, it can be charged from 110V AC outlet.

   (3) Plant's internal phones

   a. There are 48 VDC 300AH batteries established which can operate for 8 hours independently and charger on the primary side is 220VAC single phase power source. The power comes from the UPS of 11kV system/monitor room (reserve).

   b. The piping establishment of phone system of the Alternate Shutdown Panel (ASP) system according to the safety levels.

   (4) Personal Handyphone system (PHS)

   a. Attached to the plant's internal phones.

   b. Normally set up, used in the ordinary business communication.

   (5) Plant's external phones

   a. ChungHwa-Telecom (except the special lines) connects with plant's telephone central station.

   b. The microwave communication system has 48 VDC 300AH independent batteries and can run for 8 hours and the charger on the primary side is 220VAC single phase power source.

2. The responding measure and the strengthening plan of normal/emergency communication system over design bases:

   (1) The central exchange charger can use the established single phase 220V mobile gasoline generator as reserve power source to keep plant’s internal phones and PHS available.

   (2) Previously the central exchange room is located at the basement of the administrative building outside the main guards' room and is easily flooded by tsunami and loses its function, now it has been relocated at higher place.

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

After Fukushima’s accident, Chin Shan plant has reviewed the present designs, equipment, emergency responding measures, and etc. and concluded that Chin Shan plant is better than Fukushima plant in deep defense in the similar accidents based on design bases. Furthermore for the responding actions of the accidents over the design bases, Chin

Shan plant has improved the measures for deep defense to strengthen substantially the responding capability corresponding to the compound disasters.

A. Before Fukushima's accident, the nuclear power stations in our country have five superiors more than Fukushima Plant No. 1:

1.The Emergency Sea Water Pump of Fukushima Plant No. 1 is outdoor type; the pumps at Chin Shan site are protected in a building.

2.Unit 1~4 Emergency Diesel Generators for Fukushima Plant No. 1 are allocated in the Turbine Building Basement Floor, our nuclear power station are all allocated in the seismic category I building Ground Floor that the flood proof capabilities are relatively higher.

3.Fukushima Plant No. 1 had not equipped with the Fifth air-cooled Diesel Generators (5th EDG), our nuclear power station had equipped with the Fifth Air-cooled Diesel Generators at ground floor which can provide backup power in case that EDG lost its cooling water source.

4.Fukushima Plant No. 1 had not equipped with air-cooled Gas Turbine Generators, our nuclear power station had equipped with air-cooled Gas Turbine Generators at EL. 22 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, Chin Shan site had equipped with Raw Water Pool of 100,000 metric tons capacity at EL. 62 m which can fill into reactor via gravity.

B. After Fukushima's accident, the nuclear power stations in our country had already completed their URG procedures to add additional power sources including power truck, mobile diesel generators and water sources (raw water/seawater).

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

The Emergency Preparedness and Response Plan of the plant (procedures of 1400 series) has clearly specified the responsibilities and maneuvering ways for those organizations of the ECT, including the staff on duty, emergency backup operation team. Moreover the review results for the emergency responding manpower if the accidents occur in the "normal" or "abnormal" periods are:

1. Accidents occur in the office hours:

   (1). If accidents occur and the operators of next shift cannot arrive at the plant to take over, there is a on-job training shift manpower in the Simulation Center, and the 7 operators of the Mobile Supporting Team (all hold certificates) and the manpower of the Operation Section can take over and support the units' operation.

   (2). In addition to the maintenance staff on-site and off-site, there are more than 100 maintenance people of the contractors stationed in the plant with long-term contracts, therefore the requirement of the emergency situation can be met.

   (3). The Fire Brigade Team has 8 workers at daytime shift and 25 backup firefighters can be grouped according to the organization of the emergency plan to support the fire fighting.

2. Accidents happen in the off-duty hours:

(1) By survey, there are 23 shift operators(including operation section) residing in the off-duty dormitory at site (Maolin), they will be first informed to support operation of the affected units for situations that next shift team cannot get to the plant；Moreover there are 102 shift operators residing in Tamsui employee dormitory, and also in the Tamsui, Chin Shan, and Shimen neighborhood area. They can get to the plant to support operation before the external rescue arrives.

(2) By survey there are 45 maintenance workers residing in off-duty dormitory at site (Maolin) (mechanical, electrical, instrumental, repairing, health physics, and etc.). They can be maneuvered to precede the equipment repairing. Moreover, there are 186 maintenance workers residing in the employee dormitory at Tamsui district, and Tamsui, Chin Shan, Shimen neighborhood area. They can be notified to get to site to support the emergency repairing work. Furthermore, since the emergency repair items are listed in the contracts, there are many maintenance contractors living in Chin Shan, Shimen areas and they will be notified to get to site to support if emergencies happen.

(3). The Fire Brigade Station has 6 members at site during off-duty hours. All the other fire-fighting contractors live in Chin Shan, Shimen districts; they can be recalled to get to site under emergency situations. There are also security police guards residing at site and can support the rescue operation.

(4). If accidents happen in the off-duty hours and offsite staff cannot get to site, the impact of maintenance manpower shortage is higher and the helps of the skilled contractors living in the Chin Shan, Shimen, Keelung districts are needed.

(5). Chin Shan plant has signed “Fire fighting support agreement” with the fire department of New-Taipei city government, the supporting department's manpower, vehicles, equipment will enter the accidental areas to support rescue according to the characteristics of the accident.

3. Using plant's offsite supports as the accidents management (including the emergency responding measures when the outside supports are not available)

If emergencies happen in the plant and traffic is interrupted or other unexpected situations occur, nuclear power plant can notify『the central emergency operation center』in time to coordinate the transport tools, arrange the hoist equipment and transport manpower instantly to guarantee assistance in time.

If emergencies happen and there are not enough staff in OSC re-entering team, Chin Shan plant's all reserved manpower of the maintenance section(reserved re-entering team) and off-site suppliers are required to enter the plant to support the repair work.

If the off-site supports are not available because traffic routes are damaged by the tsunami, Chin Shan plant's all responding organizations have grouped and can alternate to repair the units with the reserved equipment in plant.

4. The procedures, training, and the drill

(1). The certificated operators are trained 30 hours annually on the simulator, the training curriculums include: normal exercise of plant's operation(including tests and administrative responsibilities), the exercise of the abnormalities of nuclear steam supply system, the exercise of equipment' abnormalities, the exercise of the emergency operation(EOP) that affecting the important safety functions, the exercise requirement proposed by the operation team, operation experience sharing, exercise of related abnormal and emergency situation, and the exercises biennially planned by AMT, furthermore the exercise for "URG" are included in the plant's regular exercises and the frequencies are the same as SAP training.

(2). Besides, for various levels of accidents, Taipower will follow the Emergency Preparedness Plan (procedures of 1400 series), maneuver the necessary organizations to integrate the in-site and off-site resources to achieve the goal of controlling the plant's accidents. Chin Shan plant carries out the annual drill and regularly cooperates with the local government to carry out the exercise of nuclear safety. Training for the staff of emergency plans is regularly held. According to the accidents' severity of the drill, the EOP/ SAP (the emergency plan exercise of year 2011 also includes URG) are followed in the exercise scenario.

(3). For some specialists required in the compound disasters, if time is allowed, they are still needed to perform the radioactive protection training before they proceed the rescue operation, the contents include the protection of the emergency radioactive protection and risks informed. Considering the very limited time in the rescue operation and for those offsite manpower can not be trained for radioactive protection before the accidents, they will be trained by Chin Shan plant for 5-10 minutes about the emergency repair, and they are escorted by the radioactive protection staff or industry safety personnel to do the rescue for repair and instructed by them about important items of radioactive protection and industry safety. The control regulations of the radioactive protection of their entering the plant are considered to be included in the regulation procedure 903 procedure about in and out of the plant.

5. External communication plan

The external communication include city phones, microwave phones, satellite phones, hot lines between AEC and NEPEC and Shimen Fire brigade, cellular phones and video communications, and etc.

Chin Shan plant's procedure "1420 Fire control procedure" has specified if serious fire, wind disasters, floods, earthquakes, explosions and compound disasters occur, the Fire Fighting Station leader on duty should call the members in the emergency communication name list of the Fire Fighting Station to enter the plant to rescue. Furthermore, the communication and list for Chin Shan plant's emergency responding manpower has been established and also supporting mechanism for those live in Chin Shan, Shimen, Tamsui to enter Chin Shan plant for rescue has been established.

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

For the severe accidents resulting in the high radiation at site, to deal with the radioactive contamination and many damaged facilities, Chin Shan plant's responding measures are as follows:

1. Before the rescue, HPC will send the staff to the site /main control room to carry out the detection of radiation, contamination and radioactive concentration in air.
2. According to the radiation detected on the accidental site/main control room and considering the habitability and

the accessibility of the main control room, the radioactive protection measures are specified as follows:

(1). For those high dose rate and contaminated area, the installation of radiation shielding or proceeding decontamination should be considered to reduce the radioactive dose rate and protect the personnel.

(2). Evaluate the longest time allowed for the workers, and implement a time-control process if necessary.

(3). Provide necessary radioactive protection equipment, e.g. radiation protection clothes, breathing protection masks, lead clothes, etc.

Chin Shan plant has 140 lead clothes, 2500 lead blankets. They should be enough to meet the requirement of short term accidents if the numbers of the rescue workers and lead clothes and blankets are carefully controlled. If the accidents are serious for long-term consideration, Chin Shan will request other plants for support.

The lead clothes, blankets are stored respectively on site and in the laundry room, they are checked half a year according to procedure 113.5 “The arrangement and management of accident rescue equipment”.

3. The radiation control during accidents. According to the procedure 1415, Chin Shan plant will precede the contamination detection and decontamination for rescue workers and evacuation of personnel to protect their safety and avoid the expansion of the contamination.

(1) The detection and decontamination of the rescue workers on site

a. There should be temporary control stations established including contamination isolation pad, portable contamination detector and necessary protection at the entrance and exit of the site.

b. Those who want to leave the temporary control station should take off the radioactive protection equipment and use the contamination detector to detect themselves.

c. If there is no contamination they can leave and stay standby in OSC.

d. For those who are contaminated, the emergency radiation survey team informs the Emergency First Aid and Decontamination Team to help remove the contamination. The contamination removal equipment is described in section 5 of procedure 913.

e. The Emergency First Aid and Decontamination Team follows section 6 of procedure 913 to remove the contamination of those contaminated according to the contaminated situations and contaminated parts. If the contaminated level is still higher than acceptable value to leave the station, special permission of the leader is required and TSC will inform the radioactive laboratory (backup decontamination station) and those contaminated will be escorted by the Emergency First Aid and Decontamination Team to the radioactive laboratory to carry out the decontaminations.

f. The process records of the personnel's radiation detection and the details of the contamination and decontaminations should be registered in specified form.

(2) The detection and decontamination of the evacuated personnel

a. The portable detector and decontamination kit and other protection equipment are well prepared by Emergency First Aid and Decontamination Team in advance and placed in the assembly location of the team.

b. When the commands of assembly and standby in the plant are issued, the non-emergency staff is evacuated to the standby locations depending on the situations. The Emergency First Aid and Decontamination Team should dispatch some members to the standby locations to carry out the detection and set up the temporary decontamination station at an appropriate position. The detection purpose should be emphasized on the whole body, i.e., from head to feet and the survey time and moving of detectors should be enough to respond and the actual contamination status.

c. The temporary decontamination station should be established with isolating fences, paved with Kraft paper, contamination isolation pad and equipped with the decontamination and detection devices.

d. In order to evacuate personnel out of site as soon as possible, immediately after the personnel arrive at the standby locations and get out of the vehicles, they are detected for contamination individually. Those who are not contaminated will stay at the standby location; the contaminated will first get wrapped at the contaminated parts for isolation and go to the temporary decontamination station to get decontaminated.

e. The waste materials produced during the decontamination process should be collected by plastic bags and they will be detected and labeled and transported by the staff of the Emergency First Aid and Decontamination Team as the radioactive wastes and transported back to the plant for processing.

f. The process records of the personnel's radiation detection and the details of the contamination and decontaminations should be preserved for one year.

g. If the person is detected and determined as internally contaminated, they will be arranged to the radiation laboratory to precede the whole body counting process or biochemical analysis.

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

1. Considering the changes resulted from the external natural disaster which triggered dangers or considering the monitor to understand the changes, Chin Shan plant has strengthened the monitoring mechanisms and modified/established the corresponding procedures, e.g. in the procedure of Chin Shan plant's “104 practical matters of management” about the monitoring of the mudslide in the Chien-Hua creek of the plant, it is required for regular and irregular monitoring. If the mudslide reaches to an alarming level or the rainfall reaches a torrential rainfall, a crisis management team will be established accordingly and the impact on the plant will be evaluated in order to foresee the crisis and fully understand the possible changes and take the responding measures in advance to reduce the harmful effects.
2. About the understanding of the changes of the terrain shapes and forms, real on site measurement have been done. The evaluations have been completed about the influences of the changes on the impact of the plant. Furthermore Taipower has currently processing a couple of projects e.g. Chin Shan plant's geological investigation and re-evaluation on the hazards of the earthquakes etc to confirm the possible effects.
3. If any changes resulted from the external dangers are really discovered and before they are improved and recovered, Chin Shan plant will evaluate and monitor regularly on the changes to confirm and grasp the impact on the plant.

4. Based on the Fukushima's experiences, the TPC's plants has performed "Total physical examinations on nuclear power safety protection of power plant" and reviewed the situations of accidents over the design bases and preceded the corresponding improvements for the plants' physical status. These improvements include the establishment of procedure 1451 "URG". In this procedure, in addition to the arrangements of all facilities are planned, the adoption timings and flow charts are included to carry out the "resolute actions" in the shortest time and all the available water resources are arranged to inject the available water into the reactor (or fuels pool) in time to assure the fuels are covered by water and release of the radioactive materials are avoided to achieve the major goal of large scale of evacuation of citizens.

   (1) Timing effectiveness: URG (procedure1451), the main strategy is to take clear actions (resolute actions) in the shortest time to avoid the deterioration of the conditions and control the plant's situation and to achieve the goal of protecting the safety of citizens. URG is different from EOP/SAP which is the strategy step by step evaluation by symptoms.

   (2) Feasibility: The Chin Shan plant has established various and multiple rescue systems/equipment to respond to various accidents specified in design. When accidents beyond the design base occurs, the Chin Shan plant will not only aggressively recover the rescue systems/equipment, but also can follow previously arranged and planned measures, and get easily accessible equipment (including the power, mechanical power and water sources) to achieve the above goal.

   (3) Effectiveness: The many strategies in the established "URG" , which comes from various evaluation results, have considered defense in depth and set up various and multiple schemes (e.g. various water sources, powers etc.) to assure the effectiveness for the plants responding to the rescue operation of the compound disasters.

6.1.2.4 Unavailability of power supply

1. DC power: Under the SBO of Chin Shan plant, the 125V DC power supply can sustain 8 hours specified in design, if 125V DC Battery #6 charges Battery #1, Battery #2 via the currently equipped 3 power distribution panels Ⅰ/Ⅱ/Ⅲ of the 125V DC, the power can sustained 24 hours during blackout.
2. AC power: Under the blackout of the plant, the corresponding evaluations and improvement have been done for urgently supplying 4.16kV/480V AC power, include:

   (1) The procedures have been modified to guide the 5th EDG urgently supply powers to two units simultaneously.

   (2) The power cables and corresponding procedure have been ready to provide emergency power for the units' 4kV BUS from two 4.16lV 1100kW diesel generators belong to gas turbines.

   (3) More tweleve 480V mobile diesel generators have been purchased and DCR installation like power supply connectors and cables have been established.

   (4) Six 4.16kV 1500kW diesel generators vehicles have been purchased by the Taipower headquarter; one of them is for Chin Shan plant.

6.1.2.5 The probability of failure for instrumentation control system

All the instruments related to safety in the plants are the first grade of seismic-proof. However similar to the compound disasters of Fukushima's accident, main instruments may lose their monitor capability by the interruptions of power supply. And the DC power(including UPS) in design for the instruments are able to provide power for 8～24 hours in the early stage of SBO. Since there are many detailed power recovery plans in the URG, there is enough time for the recovery of the power supply for the instruments.

Furthermore the major rescue strategies of URG are the emergency pressure release of RPV, emergency water replenishment and venting of the containment. Therefore even the instruments are not available, the plant needs only to take “resolute actions” according to the situations of the accidents (e.g. earthquakes, tsunamis or SBO) to achieve the goal of covering reactor core by water and therefore stopping the deterioration of accidents.

When the accidents occur, the plant will set up TSC (including the AMT). The leader of the AMT can request for more SPDS communication staff according to the real requirements to analyze and evaluate the availability and reliability of the controlling parameters of detecting EOP. The AMT team members make the most accurate evaluation and prediction corresponding to every parameter and submit the evaluation results to AMT leader and the Emergency Controller to fully understand the status of the plant and increase the capability of controlling the plant's accidents.

6.1.2.6 Potential effects from the other neighboring unit(s) at site

To respond to the situation that the compound accidents occur simultaneously on both units:

1. The review and strengthening plan of the equipment:

   In the overall review of the safety protection of Chin Shan plant's Emergency Preparedness and Response Plan , the water sources, power sources, gas sources which are classified in the items of “Responding measures of mutual supports between units #1 and #2” as:

   (1) The connection of service water of the plant

   (2) CST (Condensed water Storage Tank) transport system, DST (Demin. water Storage Tank) transport system

   (3) Cooling systems for air compressor during outage

   (4) Raw water (Fire fighting system)

   (5) Waste fluids processing system

   (6) The connection of air for instruments

   (7) The air systems for instrument supported by the compressors outside the plant

   (8) Emergency diesel generator (water cooling type, EDG-1A/1B/2A/2B) or the 5th emergency diesel generator (air cooling type) to provide the power for the essential buses of the accidental units.

   (9) The 69kVstart up transformer ST-A(S), 345kV start up transformer ST-B(S) provide the power coming from outside the plant to the essential buses of accidental units

   (10) Chin Shan plant had established 2 gas turbine generators. If the plant loses the external power, by running one of the gas turbine generator successfully, it can provide all the emergency powers needed for both units

   The support measures for the current equipment that are able to mutually support and the functions of rescue and mitigation of accidents have all been verified and the corresponding reviews and strengthening plans are proposed.

2. When accidents occur on both units simultaneously, the outside environments may be damaged seriously and

impede the effectiveness of maneuvering the manpower of the emergency control team of the technical support center. Chin Shan plant has fully reviewed to expand the manpower arrangements of the technical support center, emergency control team, AMT etc and accomplished the modifications of the procedures “1406 procedure for emergency organization manpower maneuvering” and “1407 TSC procedure for manpower maneuvering and responding” to appropriately plan and establish rotating substitute manpower during the operation of two emergency control teams and to assure the handling of the accidents is not affected by the continuous and long term effects.

3. Responding to the accidents occur on both units simultaneously, the strengthening of the technical support center and reserve technical support center is planned to connect to two units and display the situations simultaneously, therefore both units' situations can be understood and different situations can be handled instantly. Moreover the AMT members are trained twice a year to strengthen their operation capability and make sure no concerns of any situations.

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

When the plant lost reactor core cooling function, the RPV pressure will be immediately depressed to below 15 kg/cm^2 regardless the depressurized rate according to EOP 540.1/540.2 procedure, if necessary. In addition, the primary containment will be vented simultaneously. The RPV water can be made up by turbine-derived pumps of the systems like RCIC or HPCI system. Power may be provide to essential bus from EDG, 5th EDG, or gas turbines according to SBO procedure 535.

If there is a SBO induced by a beyond DBA, the injection task will be lined up first, then 5 ADS/SRVs will be opened to reduced reactor pressure to below 15 kg/cm2. If RCIC and HPCI systems are inoperable at the same time, the reactor pressure will further depressed to below after the line up has been accomplished. (details are illustrated in the Attachment 5 of strategic table CS.1-02 of procedure 1451). If SRV can not be open automatically, currently the station procedure 1452.3 section 2 had already had the relevant manual alternative operating procedure to provide required control power sources and air sources to open SRV. Its control power can be fed from the new procured mobile diesel generator and associated modification of compressed air supply system was completed.

6.2.1.2 Risks of cliff edge effects and deadlines

In the situation of loss of power and reactor make-up, reactor water level can be maintained by RCIC system. By the design basis, RCIC system can be operated continuously at last 8 hours by DC power or 24 hours by load control and switching to 125V SWBD #6 power supplies. In this period, backup power and air can be established by related strategies in procedure 1451 attachment 5 to execute the rescue actions. The reactor core cooling can be maintained in a long period, and the cliff edge effects of loss of power and reactor core make-up will not occurre.

The following is the SBO result simulated by MAAP5 program (See Attachment 1 of this chapter)

1. Assume that RCIC system can be operated for 8 hours, reactor water level will decrease from normal to fuel uncover in 11.19 hours after the accident. The fuel temperature will exceed 2200°F in 12.42 hours after the accident. The core

starts to damaged.

2. Assume that RCIC can be operated for 24 hours after SBO, reactor water level will decrease from normal to TAF in 27.94 hours after the accident. The fuel temperature will exceed 2200°F in 29.53 hours after the accident. The core starts to damage.

6.2.1.3 Adequacy of the existing management measures and possible additional provisions

In response to the situation of compound disaster, URG has planned the arrangement of on duty crew and three stages check sheet in detail that tasks need to be accomplished by crew inside the plant in short period (within one hour) alone. The on duty operator will integrate manpower in the plant, using existing resources, to implement URG procedure (1415) rapidly. The line up of raw water injection according to the first stage strategy of CS.1-01 in URS can be accomplished within one hour, It can inject water into reactor through raw water / fire protection system Line-up / connecting temporary pipe to prevent reactor core damage from fuel uncovering. It can mitigate the condition of the unit effectively for 24 hours and maintain the condition until the manpower of emergency response arrive take over the following actions. Therefore, plant's URG can line up the water sources and inject water into reactor to prevent fuel damage before the cliff edge effects can happen.

6.2.2 Loss of cooling: Accident management measures currently in place after occurrence of fuel damage in the reactor pressure vessel

6.2.2.1 Mitigation measures

After fuel is damaged, CSNPP will follow the Severe Accident Management Guideline (SAP-1), depending on the accident conditions (RC/F-1~RC/F-6), to implement the makeup of RPV and primary containment and the control strategies of containment pressure, hydrogen, and residual heat removing based on radioactive material release control procedure (SAP-2), to accomplish the purpose of termination of fuel degradation. In basic, URG and SAP both consist of the control strategies of containment pressure, hydrogen, and residual heat removing for maintaining the availability of containment and reducing the possibility of radioactive material releasing to atmosphere.

Additionally, the URG includes establishing the backup sources of electricity, air, and water for implementing rescue operations. Combined with SAP's best approach of injecting water into RPV/containment to maintain the reactor core covered by water, they can reduce the possibility of fuel damaged, ensure the integration of RPV and containment, reduce the possibility of radioactive material releasing to atmosphere, and achieve the situation of long-term stability and controllability.

6.2.2.2 Risks of cliff edge effects and deadlines

Based on the result of SBO timing analysis that is simulated by MAAP5 program, under the assumption of RCIC system can be operated for 8 hours, the reactor water level will decrease from normal to fuel uncovering in 11.19 hours after the accident. The fuel temperature will exceed 2200°F in 12.42 hours after the accident. The core starts to damaged.

For the most conservative situation, if emergency core cooling systems like RCIC and HPCI systems are inoperable at the moment of time zero because of a large-scale compound disaster, reactor water level will decrease from normal to fuel uncovering in 0.73 hours after the accident. The fuel temperature will exceed 2200°F in 1.33 hours after the accident.

6.2.2.3 Adequacy of the existing management measures and possible additional provisions

After fuel is damaged, CSNPP will follow the Severe Accident Management Guideline (SAP-1), depending on the accident conditions (RC/F-1~RC/F-6), to implement the makeup of RPV and primary containment and the control strategies of containment pressure, hydrogen, and residual heat removing based on radioactive material release control procedure (SAP-2), to accomplish the purpose of termination of fuel degradation. In basic, URG and SAP both consist of the control strategies of containment pressure, hydrogen, and residual heat removing for maintaining the availability of containment and reducing the possibility of radioactive material releasing to atmosphere.

Additionally, the URG includes establishing the backup sources of electricity, air, and water for implementing rescue operations. Combined with SAP's best approach of injecting water into RPV/containment to maintain the reactor core covered by water, they can reduce the possibility of fuel damaged, ensure the integration of RPV and containment, reduce the possibility of radioactive material releasing to atmosphere, and achieve the situation of long-term stability and controllability.

6.2.3 Accident management measures and installation design features for protecting containment integrity after occurrence of fuel damage

6.2.3.1 Management of hydrogen risks (inside and outside the containment)

The Hydrogen/Oxygen Monitoring System (HOMS) installed inside CSNPP containment can monitor the content of hydrogen. The purge of the containment nitrogen system and the operation of the Standby Gas Treatment System (SBGT) can ensure the dilution and release of hydrogen.

Secondary containment is the only space that can accumulate hydrogen in CSNPP. In order to reduce the accumulation of hydrogen, in current stage, a portable generator can be used to supply power to SBGT. Additionally, a modification was completed by adding a manual/remote opening blowout plate on the roof of 5th floor of reactor building. When compound disaster happens, blowout plates can be opened in advance to avoid hydrogen accumulation in reactor building.

After reactor vessel has been damaged, CSNPP will follow hydrogen control strategy (PC/G) in the corresponding guideline of SAP-2 to exhaust and purge containment to reduce hydrogen concentration in primary containment. Considering the possibility of the decrease of instrument reliability in a beyond design basis accident, during the process of emergent depressurization, CSNPP will open the truck double doors of secondary containment and blowout plates on the roof of secondary containment to reduce the accumulation of hydrogen and possibility of secondary containment explosion according to procedure 1451 (URG) regardless the radiation release rate.

In the process of plant rescue, besides to makeup the reactor core water according to URG for avoiding hydrogen being generated continually, the power for hydrogen control system also included in the scope of priority recovery of URG. Once the electricity is recovered, the hydrogen concentration can be reduced by post accident hydrogen recombiner, combined with the containment ventilation, the situation of hydrogen explosion can be avoided effectively.

6.2.3.2 Prevention of containment overpressure

In the situation of loss of power and core cooling water makeup, core pressure release and water makeup can be conducted by RCIC system. DC power supply can be maintained for RCIC system for 24 hours by proper power loading control and the power transfer mechanism of 125V SWBD#6. In this period, according to the first stage strategy of URG CS.1-01 of Ultimate Response Guideline Procedure (1415), raw water (fire water) must be injected to the reactor vessel. The pipes for raw water (fire water) injection can be established within one hour after action order. The emergency operation of raw water injection into RPV can effectively protect the core by recovering core water level and prevent the fuel from further damage.

According to CSNPP SAP-2 "Containment and radiation materials release control" PC/P, the primary containment pressure can be reduced by containment venting and containment spray systems. The pressure can also be released directly by containment pressure release system “Direct Torus Venting System DTVS” to avoid containment overpressure failure. The station DTVS system had installed a 14” bypass pipe and valves which design pressure is 80psig and allowable flow is 284,407 lbm/hr as per NU-TEC report.

6.2.3.3 Prevention of re-criticality

When implementing SAP-2 reactor power control (RC/Q), the crew will make sure that the switch position of reactor mode is "SHUTDOWN", the RRCS ARI has been actuated, the SBLC boron solution injection is implemented to RPV until tank of boron solution is empty and finally the reactor is shutdown. As RHR system is operating for core shutdown and cooling, the crew should closely watch the wide range neutron monitor WRNM to ensure that the injected boron solution is not diluted so that the reactor would not re-critical.

If SBLC system is not available because of accident, the responding measures of emergency boron solution injection are:

1. If the electric power is available, methods of boron solution injection are: (1) Inject the boron liquid to reactor core from the storage tank of standby boron liquid control system through reactor water cleanup (RWCU) system. (2) Inject borax/boric acid to reactor core through reactor water cleanup (RWCU) system. (3) Inject the boron liquid to reactor core from demineralized water storage tank through control rod drive system.
2. When Station blackout (SBO) happen, firstly make boron solution by spare boron acid, borax in warehouse and transport the solution to fire water tankers by sump pump, and then inject the solution in fire water tankers to reactor core through residual heat removal system to prevent the reactor core from re-criticality.
3. Besides considering the existing warehouse space, NPP has to purchase sufficient amount of spare boron acid and borax to satisfy the required boron liquid concentration for RPV safe shutdown and to implement containment flooding to TAF height.

6.2.3.4 Prevention of Base mat melt through: retention of the corium in the pressure vessel

The procedure SAP-1 RPV and the primary containment flooding accident management procedure includes the drywell spray/flooding guidelines. These procedures ensure that the vessel bottom surroundings will be covered by water as vessel failed. Even the inflow molten residue can be quenched fully to avoid the containment base mat being melted through.

According to the newly established procedure of ultimate response guideline (1451), NPP has also established back up power supplies and air sources which can support the secure operations.

6.2.3.5 Need and supply of electrical AC and DC power and compressed air to equipment used for protecting containment integrity

The CSNPP EOP’s response to the accident is to execute containment exhausting. The containment exhausting is controlled by the systems listed in EOP-PC 540.3 "Primary Containment Control". These systems include SBGT, Normal purge supply/exhaust system, post LOCA purge supply/exhaust system, drywell to primary containment exhaust valves and drywell emergency vacuum break valve. If necessary, the isolation interlock can be removed. The strategy has included the CTMT ventilation/dilution execution programs after station blackout (SBO).

When the beyond design basis accident occur and the related power is lost, plant crew can use the back up power established according to the procedure of ultimate response guideline (1451) to make the above mentioned system operable. These back up power includes the 5th EDG, gas turbine generator, and portable diesel generators.

To ensure that the essential emergency equipment can be powered in a short time as the beyond design basis accident occurred, the plant has established the following enhancement measures to make 4.16kV/480V AC power available

1. Has modified the procedures to make the 5th EDG to supply power to two units simultaneously in emergency.
2. Has prepared power cables and related operating procedures to connect the two 4.16kV/1100kW diesel generators attached to gas turbine generator to the 4kV essential power BUS.
3. Has purchased twelve 480V portable diesel generators and issued a DCR to install power supplying adapters and circuits.
4. Taipower headquarter purchased six 4.16kV/1500kW D/G power supply vehicles. CSNPP will acquire one of these.

6.2.3.6 Risks of cliff edge effects and deadlines

Department of Nuclear Safety of Taipower headquarter had contracted to Institute of Nuclear Energy Research to assess the risks of cliff edge effects and deadlines using MAAP5 program. The calculation is based on a conservative assumption that the RCIC system is failed 8 or 24 hours after the reactor scram caused by earthquake and core in loss of core makeup water and cooling situations. The calculated results are (timing is counted from the initiate of accident):

1. RCIC system operates for 8 hours:

   Containment overpressure (not considering the RPV exhausting and containment ventilation): 19.26 HR

2. RCIC system operates for 24 hours:

   Containment overpressure (not considering the RPV exhausting and containment ventilation): 33.78 HR

6.2.3.7 Adequacy of the existing management measures and possible additional provisions

CSNPP primary containment integration is maintained by heat removal and exhausting to prevent containment from overpressure:

1. Keep primary containment temperature by inside ventilation and prevent the equipment inside drywell from degradation.
2. As the design basis accident happened and for primary containment integrity, the Primary Containment Atmospheric Control System (PCACS) can first release primary containment pressure before the pressure of suppression pool reach its limiting value. Then release from drywell.
3. CSNPP has two loops of primary containment spray system. When primary containment pressure is large then 0.77 kg/cm2, the containment spray function of the residual heat removal (RHR) system will be actuated to decrease containment pressure and temperature.
4. The primary containment hydrogen recombiner system can synthesize hydrogen and oxygen into water. This will prevent the explosion caused by the increasing hydrogen concentration in primary containment.
5. Primary containment nitrogen supply system can keep the containment atmosphere inert. This will prevent hydrogen explosion caused by combustible gas generation.
6. As severe core damage or loss of primary containment was possible, the primary containment exhaustion has to be executed to ensure primary containment integrity. At this time, the exhaustion can ignore radiation release rate. The process is first to release the isolation interlock, then exhaust the primary containment air or gas by PCACS and

SBGT systems to outside atmosphere.

TSC will be already established after the core fuel damaged. The AMT team will follow the SAP-1 & SAP-2 strategies to maintain primary containment integrity and to decrease the release of fission productions. Corresponding guidelines are hydrogen control (PC/G), primary containment control, secondary containment control, and radiation material release control. Primary containment pressure can be decreased by containment ventilation and containment spray systems. Additionally, containment pressure can be released directly by containment exhaust system to avoid the containment overpressure failure.

Rescue operations can be executed by establishing backup power and air sources per URG Procedure (1451).

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

1. Units and systems emergency operation and response procedures:

   During reactor accident and general equipment/systems abnormality, the operator will follow the 500 series operating procedures to take necessary actions. As the units safety operations are challenged, the emergency operating procedures (EOP 540.1~540.4/540.7) will be carried out to maintain reactor safe shutdown. If the unit safety condition was getting worse further, the operators will be guided to follow the procedure 1450 "Process Guidelines of Severe Accident." At this situation, The TSC (Technical Supporting Center) must has been established and will command AMT (severe accident management team) to carry out the control parameter evaluation, the plant status evaluation, the system status evaluation and the rescue process evaluation per procedure 540.5/540.6. AMT will provide the severe accident process strategies to TSC to take an optimum operation strategy to ensure the public in safe.

2. Emergency response ability training:

   (1) TPC headquarters and all the NPPs have established nuclear accident emergency response measures, emergency response organizations, and emergency implement procedures. The kernel of the emergency response organization is the Emergency Control Team in each plant. This team is directly supported by TPC Emergency Plan Executive Committee (Refer to the fig. 6-3, the system of Taiwan nuclear accident emergency response organization). The Emergency Control Team is further off-site coordinated and supported by National Nuclear Emergency Response Centre. In accordance with the procedures, the related plant crews need be trained annually and participate the annual nuclear reactor facility emergency response maneuver.

   (2) The Common practice items in the maneuver include TSC technical support task, reactor operation and accident management. The year practice items in the maneuver include Personnel rescue, decontamination and hospitalization task, building and area radiation detection task, environment radiation detection task, firefighting task, OSC damage control task, emergency re-entry speedy repair task, public enquiry response task, plant congregation and standby task, plant security task. The year practice items to be executed in a particular year are determined by TPC Emergency Program Executive Committee year by year.

   (3) Every four year, there must be a comprehensive maneuver named nuclear safety maneuver to execute all practice items mentioned above.

   (4) In the ordinary or on-site maneuver, the plant can ask for supporting according to the contents of supporting agreement mentioned above.

3. Agreement / contract that assist accident management:

In the emergency accident period, the CSNPP will receive off-site emergency support mainly from TPC Emergency Program Executive Committee. The committee will integrate and command all manpower and resources of the company to support CSNPP to manage his emergency accident. The committee is also responsible to report and communicate to the supervising superior departments or agents. CSNPP also can receive the emergency medical support for radiation injury treatment from the contract hospitals. Further technical support can be acquired from contract nuclear establishments, either domestic or overseas, through TPC Emergency Program Executive Committee.

(1) TPC radiation injury prevention system

Radiation Accident Management Center in Northern Taiwan (Tri-Service General Hospital, Taipei)

(2) Nuclear accident medical system, department of Health, Executive Yuan

In the Taiwan nuclear accident medical net, there are several assigned responsibility hospitals for emergent nuclear accident treatments:

a. Responsibility hospitals (region hospitals, local hospitals) for nuclear accident level 2 emergency treatments:

Mackay Memorial Hospital, Tamshui Branch.

Chang Gung Memorial Hospital, Keelung Branch.

Keelung Hospital, Department of Health, Executive Yuan

b. Responsibility hospitals (Medical center) for nuclear accident level 3 emergency treatments:

Mackay Memorial Hospital

Chang Gung Memorial Hospital, Linkou Branch

National Taiwan University Hospital

(3) Technical supports from the special contract domestic or foreign nuclear establishments

If the emergency accident happened and the Emergency Program Executive Committee evaluates that it is necessary to request technical supports from foreign emergency response organizations, CSNPP can get the necessary support through the committee. These expertise emergency response organizations include Institute of Nuclear Power Operations (INPO), GE, Westinghouse, and Bechtel. According to "Taipower Nuclear Reactor Facility Emergency Response Program", the Emergency Program Executive Committee has the responsibility to sign contracts or agreements with these organizations.

(4) Fire fighting support agreement: CSPNS has already signed an agreement of fire fighting and the disaster support with the 6th Branch of Fire department, New Taipei City Government.

(5) Military and police support agreements: CSNPP has signed support agreements with the local military and police departments to avoid danger or damage events and natural disasters.

4. The management mechanism for the outside supporting rescue personnel entering radiation and/or contaminated

zones:

(1) According to the procedure 1426 "Off-site Personnel Enter the Plant for Supporting Process", TPC Emergency Program Executive Committee shall integrate and command the manpower and resources of whole company to support the emergency response activities. After completing the emergency plant entering process, the manpower and resources will be transferred to and direct by the director of Operation Support Center to carry out the speedy repair task. The director of Operation support center shall also, based on the expertise of the supporting personnel, manage them into the plant emergency task team.

(2) According to the procedure 1419 "Re-entry Process", Emergency re-entry team leader should, bases on the content of task and site condition, coordinately plans an adequate re-entry process with emergency radiation detection team leader. Before the re-entry, the emergency radiation team should detect the radiation, air borne, and contamination in route and site with best chosen detection instrument. After understand the site radiation conditions, the emergency radiation team should decide the re-entry crew office hours limit and other necessary process to minimize personnel doses. If the supporting personnel have to take doses above the limits because of the work, the arrangement and process must be approved by the emergency controller and inform the re-entry crew the site radiation, air borne, contamination, the possible exposure dose level, and related radiation prevention notes. The detection personnel and the re-entry working crew should wear auxiliary dose alarm counter, specified TLD badge and suitable protection cloths and equipment.

(3) If the site radiation dose rate is too high, raise the personal dosage authorized in legal but still control the crew dose not to exceed limit of the emergency exposure regulations. If necessary, change the re-entry personnel for ensuring to meet the regulations.

6.2.4.2 Risks of cliff edge effects and deadlines

Nuclear Safety Department of TPC had entrusted Institute of Nuclear Energy Research (INER) to assess the risks of cliff edge effects and deadlines by MAAP5 program. Under the conservative assumptions that the after the earthquake caused reactor scram, RCIC system is failed on 8 or 24 hours later and core water makeup and cooling were failed. The calculated results are shown below (time counted from the initiation of accident):

1. RCIC system kept in operation for 8 hours:

Containment overpressure (not including the RPV has been released and containment ventilation): 19.26 HR

2. RCIC system kept in operation for 24 hours:

Containment overpressure (not including the RPV has been released and containment ventilation): 33.78 HR

6.2.4.3 Adequacy of the existing management measures and possible additional provisions

If the reactor lost its normal makeup water and the water level was predicted to decrease below the top of active fuel (TAF), the reactor need to be pressure released emergently. Large quantity of the heat inside the reactor will be transferred to the primary containment interior and the suppression pool water temperature will be raised up rapidly. If the fuel temperature was too high, the hydrogen would be generated and the suppression pool heat capacity as well as the primary containment pressure would exceed the limits. The primary containment therefore has to exhaust to keep primary containment integrity.

CSNPP has issued a design change request (DCR) to prevent primary/secondary containment loss of ventilation during SBO. The design change include add booster fan, valves, and pipes in order to bypassing the backup SBGT system, and purchase an extra portable 480VAC diesel generator. These design changes can help primary containment rinsing and exhaust. Before the implementation of DCR, USNRC TI-2512-121 will be adopted to manual open rupture disc (valve) in order to vent the gas. The cumulative hydrogen in the primary containment hence can be diluted and excluded. Related measures accordance with the DCR is:

If SBGT is unavailable or primary containment humidity is high, the primary containment venting path is:

(1) Drywell → MO-108-206 or 207 → AO-108-214 (the original motor-driven MOV-108-214 is changed to air-driven AOV-108-214) → newly installed air-driven isolation valve (normally closed) →filter →vent at top of combination structure building.

(2) TORUS → MO-108-204 or 205 →AO-108-214(the original motor-driven MOV-108-214 is changed to air-driven AOV-108-214)→ newly installed air-driven isolation valve (normally closed) →filter →vent at top of combination structure building.

Secondary containment exhausting route:

Secondary containment → SB-HV-15 or 16(FAIL OPEN) → MO-108-209 →AO-108-214 (the original motor-driven MOV-108-214 is changed to air-driven AOV-108-214) →newly installed air-driven isolation valve (normally closed) →filter →vent at top of combination structure building.

With regard to the response measures before DCR completion, the station shall follow the methods of NRC TI-2515-121 to manually operate the air charging explosive valve SD-108-1 at site to exhaust air and its operation processes had been incorporated in the station procedure 1452.3 for operator follow. Its preventive measures also included the process for hydrogen spreading to the other unit.

6.3 Spent fuel pool

6.3.1 Accident management measures of losses of cooling capability of the spent fuel pool

6.3.1.1 Before and after losing adequate shielding against radiation

In CSNPP, adequate shielding against radiation is defined as 10 ft. water level remained above top of active fuel (TAF).

1. Before losing adequate shielding against radiation

   Plant crew can access to the spent fuel located on the 5th floor of reactor building. They can provide power to the new spent fuel pool cooling system using a 480V mobile generator to recover spent fuel pool cooling function. In addition, they can make up spent fuel pool water by the following approaches:

   (1) Make up spent fuel pool water from Backup Containment Spray System (BCSS) through RHR system piping using water reservoir car engine or mobile fire pump.

   (2) Make up spent fuel pool water using fire hose from fire hydrants (normal capacity is 3,600 MT, can be connected to two 3,000 MT tanks backup by a 100,000 MT water pool) on the 5th floor of reactor building.

   (3) Raw water can be provided to DST (storage capacity is usually no less than 10,000 gallon) through make-up demineralizer branch piping by gravity. DST pump can be supplied power by connecting a 480V mobile generator to MCC 1A-2 or 2A-2. The water can be pumped to the spent fuel pool skimmer tank and pump into the spent fuel pool, or be directly pumped to spent fuel pool using temporary hose through Service Box.

(4) CSNPP has added one seismic grade standby hard type firefighting make-up piping and one spray piping to provide 500gpm make-up water and 200gpm spray water to spent fuel pool, respectively, using reservoir car engine or mobile fire pump.

2. After losing adequate shielding against radiation

After losing adequate shielding against radiation, plant's crew may not access to spent fuel pool located on 5th floor of reactor building. In that case, above mentioned “using fire hose from fire hydrants” (Item (2)) cannot be conducted. But the other actions can still be feasible to make-up.

6.3.1.2 Before and after the water level of the spent fuel pool drop to the top of fuel

1. Before uncovering of the top of fuel in the SFP

If plant crew can access to the 5th floor of reactor building, then the approaches will be the same as described in section 6.3.1.1 item 1. Before losing adequate shielding against radiation”.

If plant crew cannot access to the 5th floor of reactor building, then the approaches will be the same as described in section 6.3.1.1 item 2. “After losing adequate shielding against radiation”.

In addition, if the water level is expected to be uncovering of the top of fuel in the SFP, plant crew will actuate immediately the seismic grade standby hard type firefighting make-up piping and the spray piping to provide 500gpm make-up water and 200gpm spray water to spent fuel pool, respectively, using reservoir car engine or mobile fire pump.

2. After uncovering of the top of fuel in the SFP

When spent fuel begin uncovered, radiation dose will rise around SPF on the 5th floor of reactor building. Besides to implement the same actions as described in section 6.3.1.1 item 2. "After losing adequate shielding against radiation", plant crew will actuate immediately the seismic grade standby hard type firefighting make-up piping and the spray piping to provide 500gpm make-up water and 200gpm spray water to spent fuel pool, respectively, using reservoir car engine or mobile fire pump.

6.3.1.3 Before and after severe damage of the fuel in the spent fuel pool

Before and after severe fuel damage in the spent fuel pool, besides the same actions as described in section 6.3.1.2 item 2. "After uncovering of the top of fuel in the SFP" to make-up and spray SPF, plant crew will continuously monitor the hydrogen concentration around SPF to avoid large scale hydrogen combustion or explosion.

For protecting the fuel from damage, CSNPP has implemented an additional URG procedure (1451) to setup backup power supply, water and air sources.

6.3.1.4 Risks of cliff edge effects and deadlines

According to the result of simulation analysis, which assumes the decay heat of the full fuel removed from core to SFP on the 7th day of outage, the initial temperature of SFP is 30℃, the SFP water temperature will reach to boiling point at 9.4 hours, and water level will drop to 10 feet above top of fuel at 47.0 hours which lost an adequate shielding. Assuming the most limiting fuel loading pattern and no recovery actions, the time for the hottest fuel cladding to reach degradation temperature is approximately 90 hours

6.3.1.5 Effectiveness of the existing management measures

SPF water can be made up by Condensation Storage and Transfer system (CST) or Demineralized water Storage Tank (DST) in emergency. During outage, the SPF is open to reactor cavity, SPF water can be made up from Backup Containment Spray System (BCSS) through RHR system piping using water reservoir car engine or mobile fire pump, or using fire hose from fire hydrants on the 5th floor of reactor building. It can effectively maintain the safe state of SFP.

Hydrogen detectors have been installed inside reactor building (Secondary containment). If a small amount of hydrogen accumulated at an area in the building, and the reactor building ventilation system or Standby Gas Treatment system (SBGT) are still operable, this hydrogen can still be diluted and vented. If SBGT lost its power, blowout panel will be opened and Secondary containment truck double door or personnel double door will be opened to form a natural convection current ventilation path so that it can functions its dilution and removal capability.

6.4 Substantial conclusions

6.4.1 Adequacy and availability of the instrumentation control

If coupled disasters (or compound accident) similar to Fukushima’s accident occur, major instruments will lose their monitoring functions because of interruptions of power supply even thought they are seismic class I designed. The DC power (includes UPS) of Chin Shan plant's instruments has the capability of sustaining SBO for 8 to 24 hours, however if the coupled disasters like Fukushima's plant resulting in the long term loss of AC power and service water heat sink, the plant will plunge into crisis.

In the URG of Chin Shan plant, it is planned in details in the project about the power recovery, therefore Chin Shan is fully confident to recover the instruments' power within adequate time.

Moreover, to execute URG needs no indication from instrumentation, the on duty operators just need to depressurize the RPV, injection water and vent the containment, if earthquake/tsunami/SBO occurred. The accident will be stop by core flooding eventually.

When accident occurred and TSC has been established, if AMT leader decides and suggests TSC leader to establish AMT, AMT members will be called to enter the plant, AMT leader may also suggest TSC to assign a SPDS personnel to assess whether indicated information in the control room is correct or not, so the TSC can correctly give instruction to mitigate the accident.

6.4.2 Availability and Habitability of Control Room

For the amenity (habitability) of main control room, it was equipped with a control room emergency ventilation system (F-1-SA/SB, AH-23-SA/SB), all are powered from emergency power source, control room instrumentation power and DC power.

To improve reliability of the system, CSNPP has issued DCR to add two 100% capacity, air-cooled water chillers, it can provide better air condition for the control room during compound accident situations. The new system can also be powered from newly purchased 480V EDG. Therefore the control room instrumentation and hospitality can keep their designed functions even compound accident occurred.

6.4.3 Hydrogen gas possibly accumulated in the buildings other than containment building

IF both containment ventilation system and SBGT failed due to lost power supply, hydrogen in the primary containment or high point of secondary containment will not be diluted or purged. CSNPP has issued DCR illustrated below:

1. Similar to the off-gas building, turbine building 3rd floor and battery room, reactor building 5th floor (secondary containment) is equipped with hydrogen detectors, which give operators the information of hydrogen concentration, in order for them to take correct respond actions.
2. During loss of power period, in order to purge out the accumulated hydrogen, additional blow out panels had been added, it can be operate by remote control switch or by hand in the reactor building.

DCR for the purge of hydrogen in primary containment was illustrated in 6.2.4.3.

6.5 Reference

EU Stress Test Chapter 6 (Belgium edition)

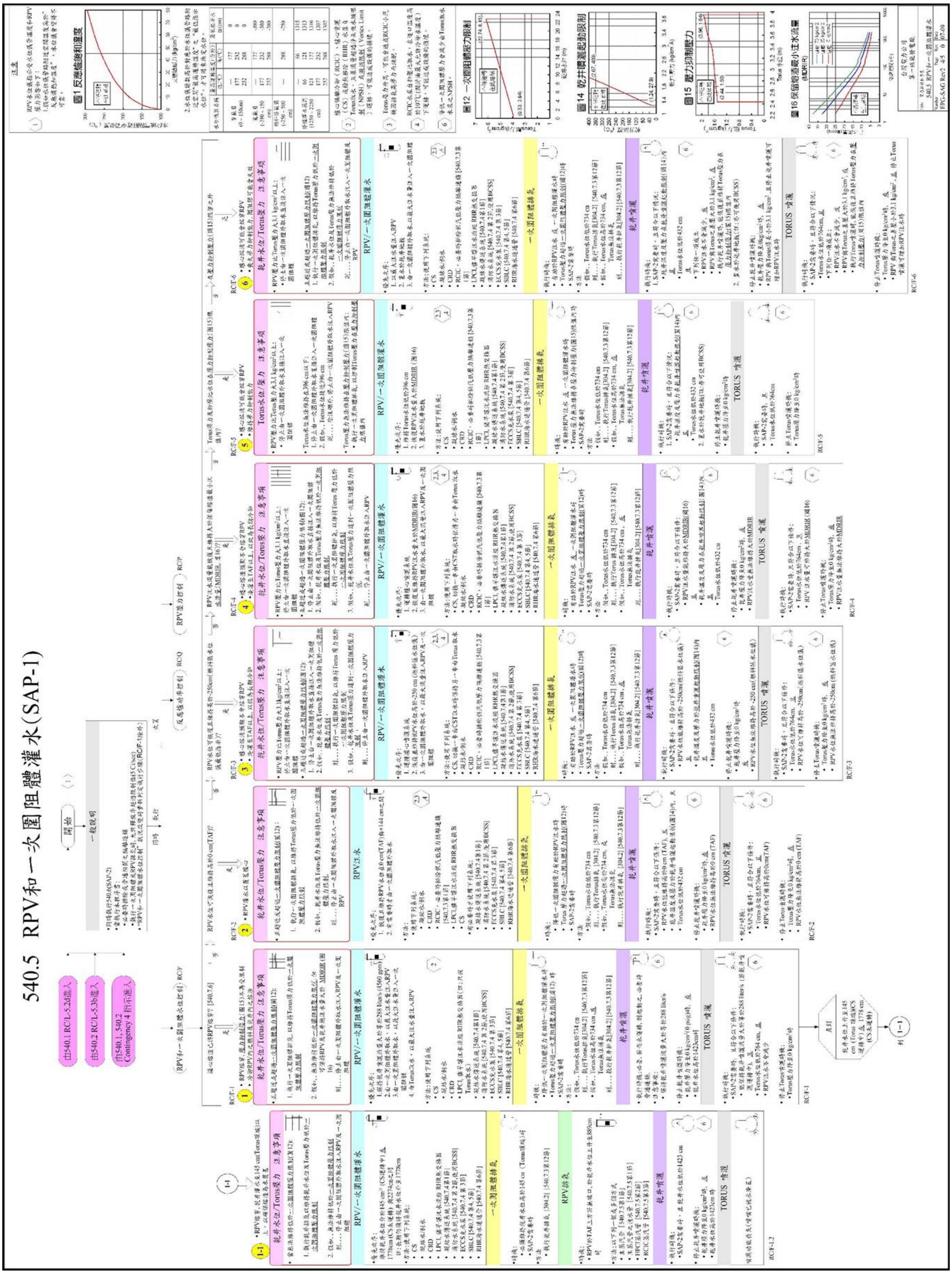


Fig. 6-1 CSNPP SAP-1

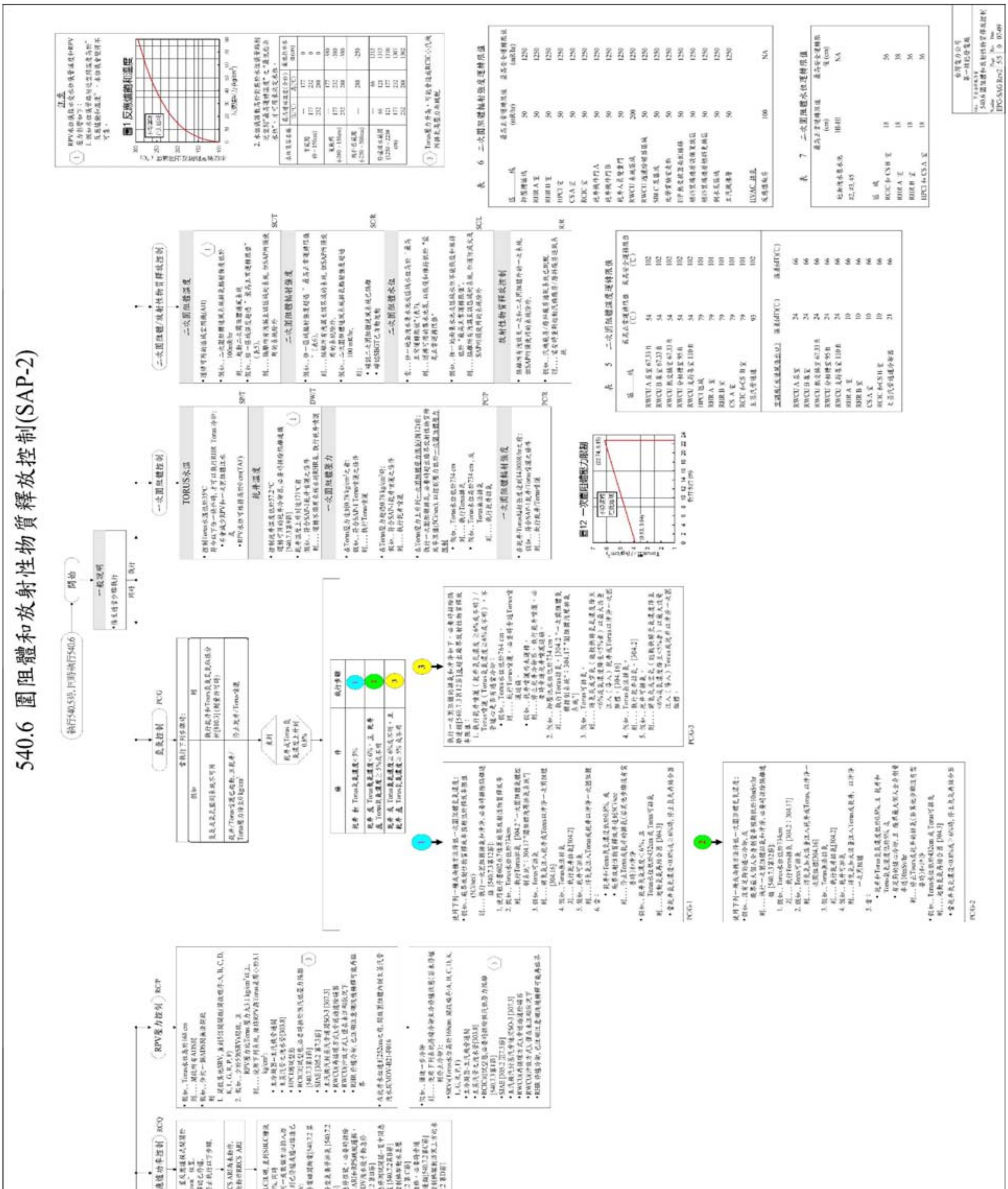


Fig. 6-2 CSNPP SAP-2

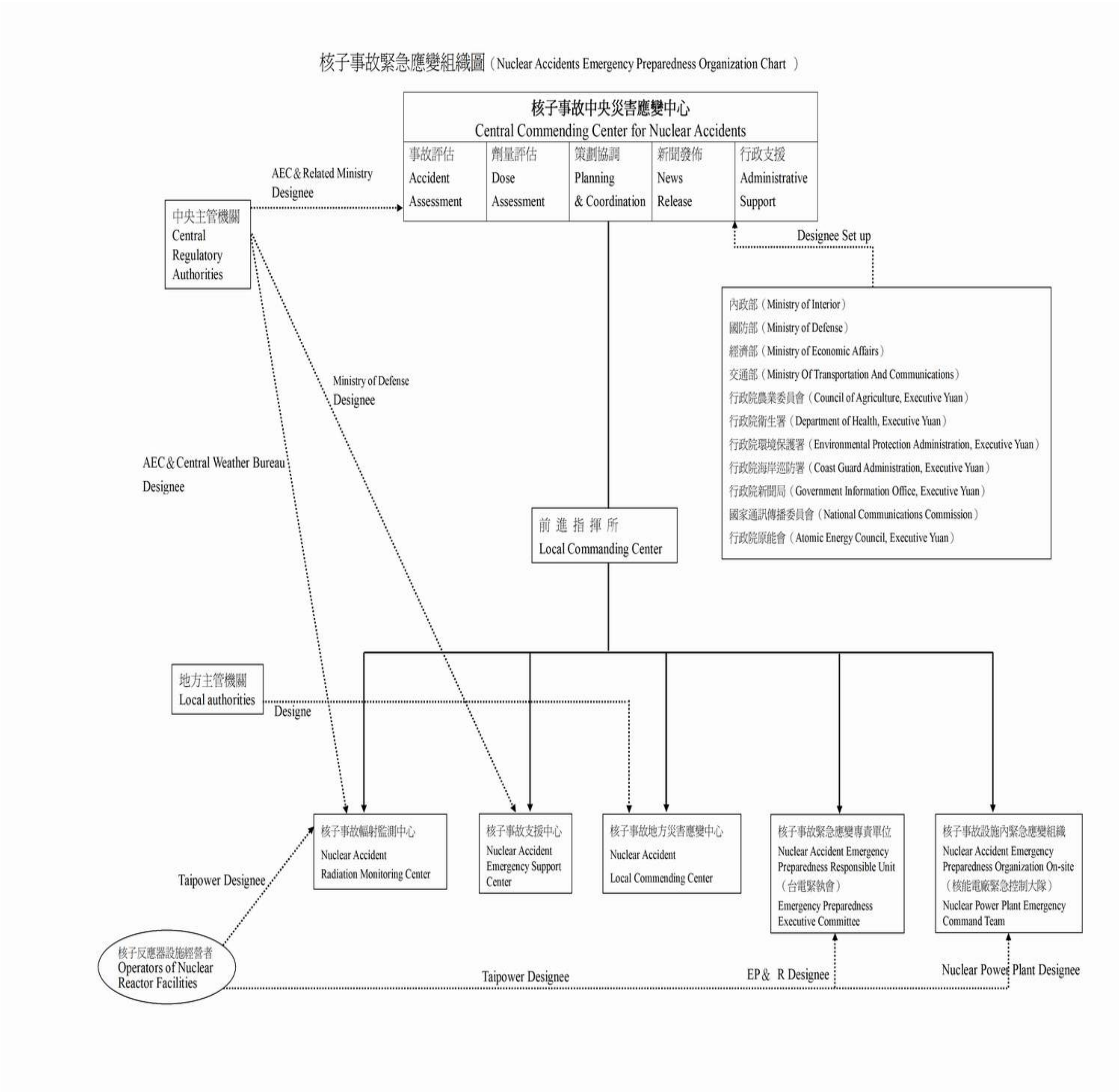


Fig. 6-3 National Nuclear Accidents Emergency Preparedness Organization Chart

Attachment 1: Chinshan pla

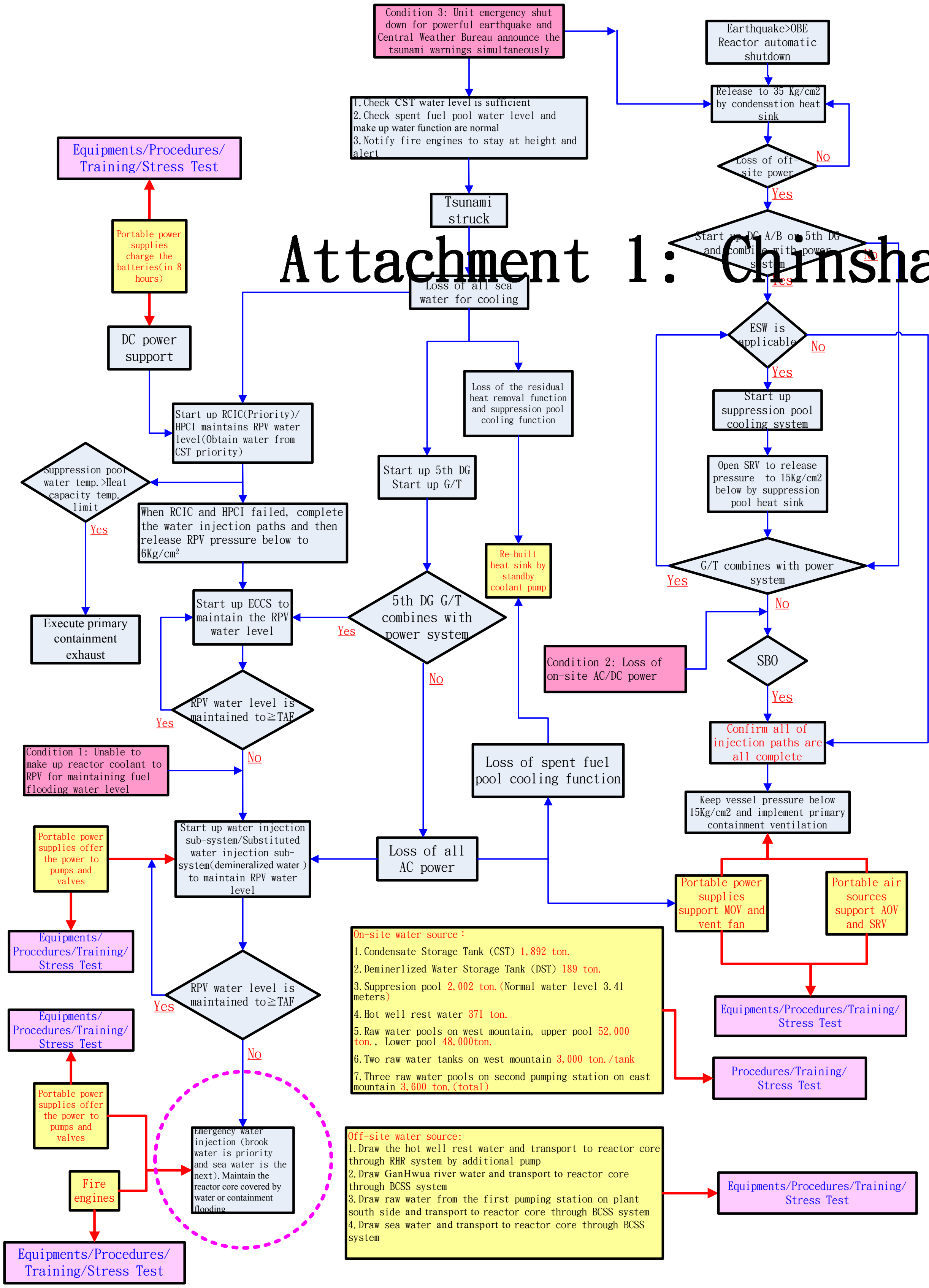


Fig. 6-4

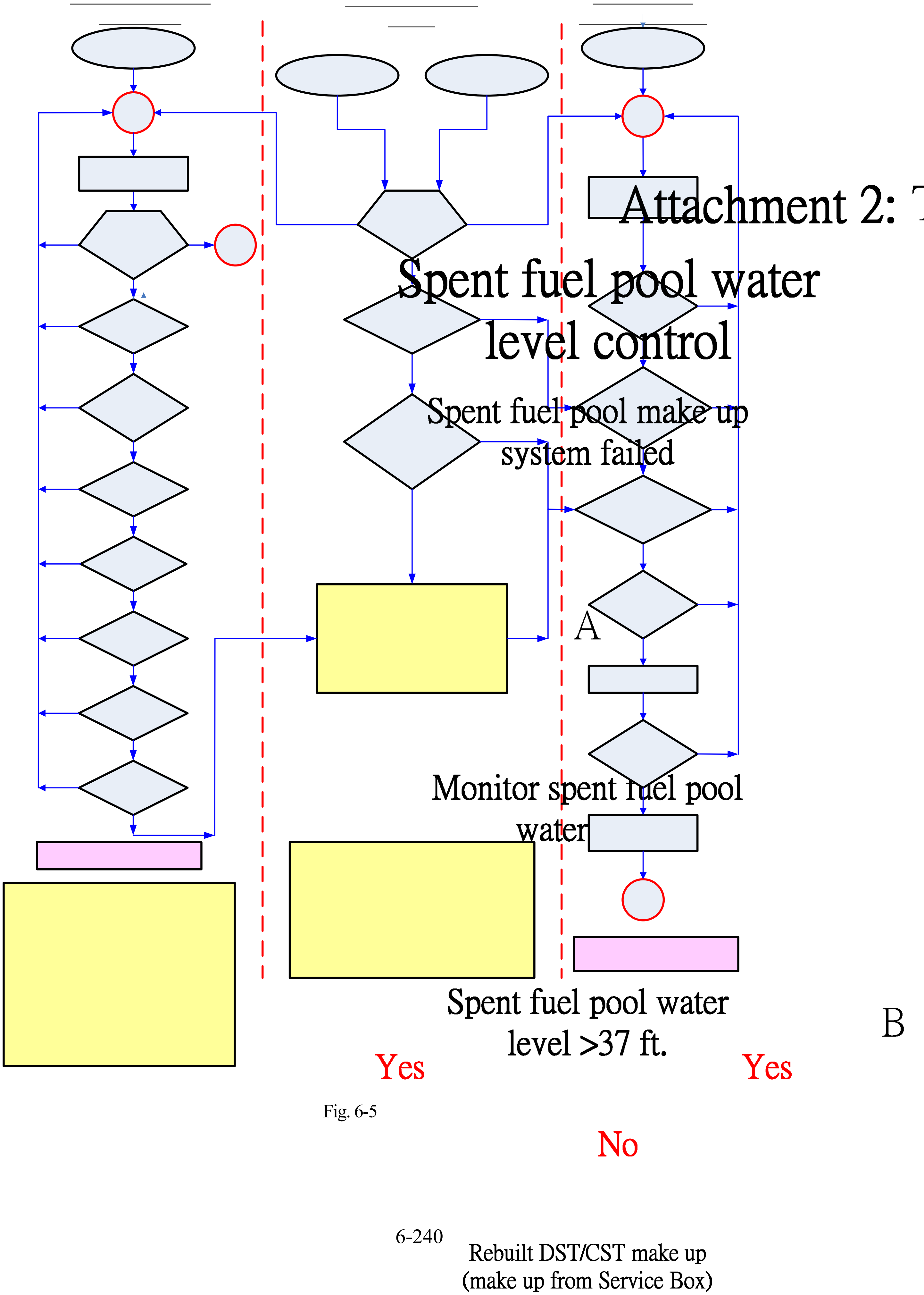

Attachment 2: T
Spent fuel pool water
level control
Spent fuel pool make up
system failed
A
Monitor spent fuel pool
water
Spent fuel pool water
level >37 ft.
B
Yes
Yes
No
Rebuilt DST/CST make up
(make up from Service Box)

Fig. 6-5

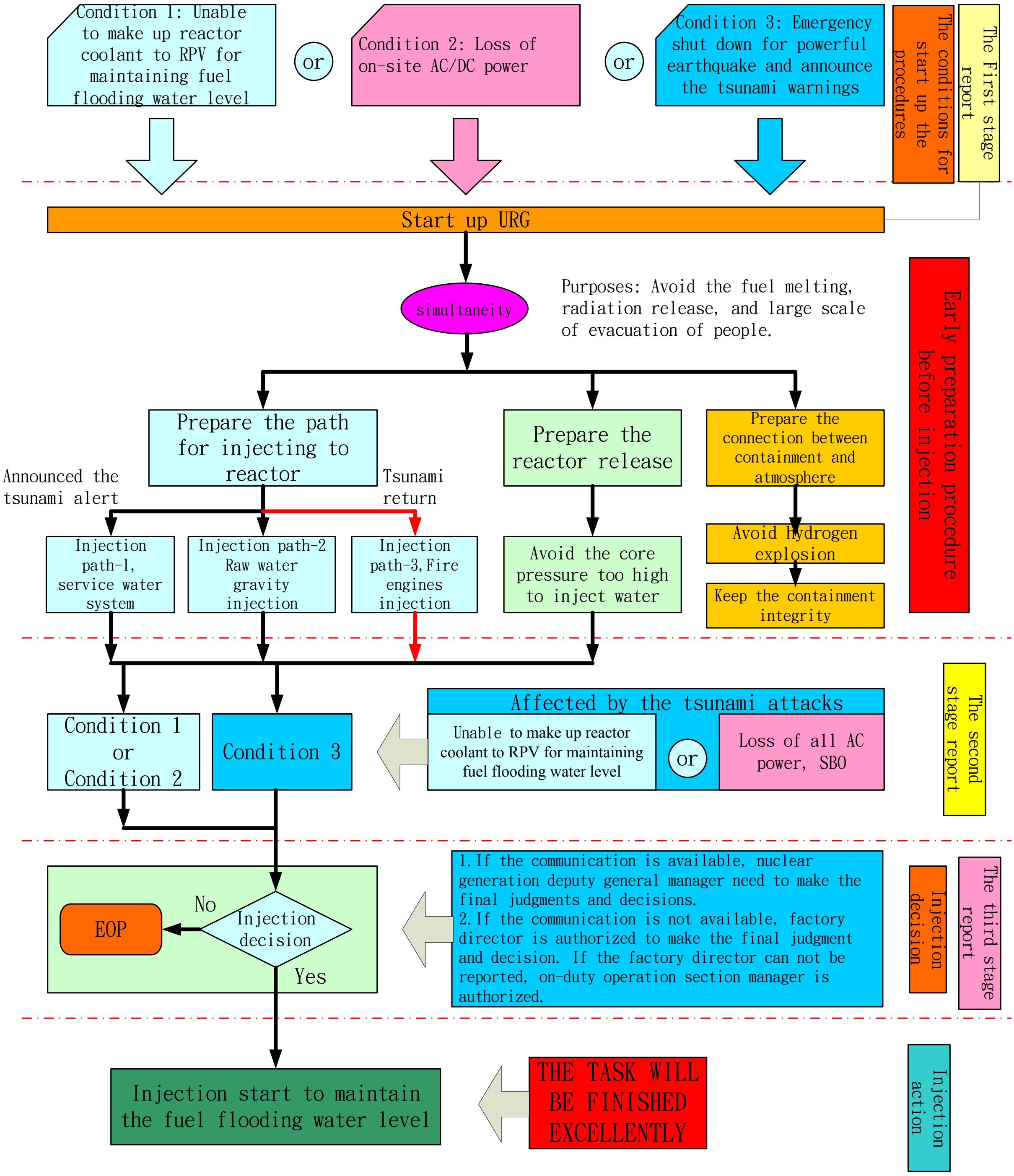


Fig. 6-6 CSNPP URG Execution Condition and Report Timing

Attachment 1

Analysis and simulation on CSNPP different RCIC survival times (0-24 hrs)

1.Abstract

For BWR with MARK-I containment, RCIC is a major core cooling equipment for SBO event. Standard design operation time was 8 hours, however in the 311 event, RCIC ran 30-70 hours in unit 1 and unit 3, and it showed that RCIC can be operated much longer than designed mission time. By assumptions of RCIC running 0-24 hours, this analysis studied its effect on plant major parameters.

2. Scenario of simulated accident

After SBO, reactor scrammed, decay heat is 3% of the rated power and will decay with time, shown in figure 1. Operation of RCIC kept reactor water level between L-3 (low-low level to scram) and L-8 (normal water level), water in RPV was vaporized to become steam, steam was pass to suppression pool via SRV, and RPV water level was decreasing.

As long as water level dropped to TAF, fuel temperature increased rapidly, cladding reacted with steam, therefore, Hydrogen was formed and released to suppression pool via SRV.

If SBO was not repaired, the plant had no ultimate heat sink, decay heat eventually accumulated in suppression pool, when temperature of suppression pool reached saturated temperature, suppression pool lost its designed function.

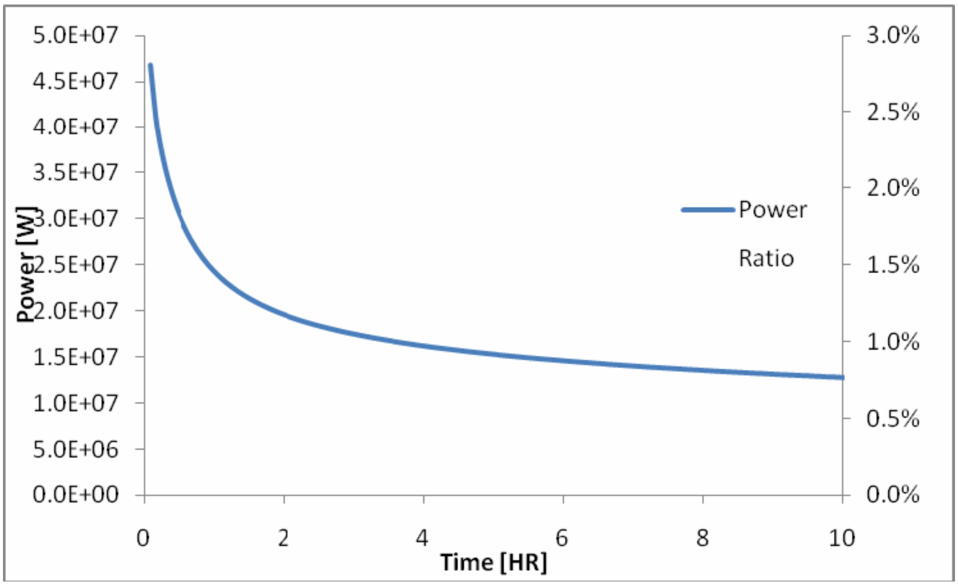


Figure 1. Reactor Power Histogram

3. Influence of plant response time

If RCIC ran 8 hours after accidents, the time for water level dropping to TAF is 11.19 hours, at 12.42 Hours after the SBO, core temperature could reached to 2200 F, fuel damage started.

Considering the most severe case, assumed that HPCI/RCIC failed at the same time of SBO. The time for water level to drop lower than TAF is 0.73 hours, and the core temperature reached to 2200 F at 1.33 Hours after the SBO, core damage started.

In the real case of Fukushima 311 event, Tsunami reached the plant 1 hour after earthquake, RCIC/HPCI was still operable for more than 30 hours (Fukushima Unit 3)
Therefore RCIC operable time is important, the table list below showed 0-24 hours of assumed RCIC operating time and simulation result of important plant parameters by MAAP5.
Another difference from Fukushima Plant, CSNPP has raw water reservoirs built at high elevation and could provide water source for the core injection via gravity power. Attachment (1) of this analysis shows the feasibility and details.

4. Simulation Case Result

Table 1, scenario of RCIC ran 0-24 hours

Event	RCIC 0 hr	RCIC 1 hr	RCIC 2 hr	RCIC 3 hr	RCIC 4 hr	RCIC 5 hr	RCIC 6 hr	RCIC 7 hr	RCIC 8 hr
TAF	0.73	2.68	4.47	5.50	6.53	7.63	8.77	9.96	11.19
PCT=2200°F	1.33	3.58	5.50	6.50	7.59	8.76	9.92	11.17	12.42
CDF > 0	1.41	3.67	5.50	6.59	7.67	8.84	10.01	11.26	12.51
BAF	2.00	4.75	6.67	7.76	8.92	10.09	11.26	12.59	13.84
RPV failed	5.37	8.35	10.80	11.99	13.40	14.73	16.26	17.43	19.25
SP temperature > 100℃	N/A	N/A	13.68	13.18	12.66	12.17	12.09	11.89	11.26
Containment Pressure > design pressure (62 psig=0.528 MPa)	5.42	11.59	13.34	14.01	14.35	14.76	16.35	17.51	19.26
Containment Failure(184.7 psig=1.27 MPa)	11.36	32.32	31.79	32.59	29.24	27.05	27.76	26.17	29.26

Event	RCIC 10 hr	RCIC 12 hr	RCIC 14 hr	RCIC 16 hr	RCIC 18 hr	RCIC 20 hr	RCIC 22 hr	RCIC 24 hr
TAF	13.41	15.65	17.85	20.49	22.35	24.08	25.91	27.94
PCT=2200°F	14.68	16.94	19.19	21.94	23.86	25.61	27.51	29.53
CDF > 0	14.85	17.19	19.36	22.11	24.03	25.86	27.78	29.87
BAF	17.68	19.43	22.22	24.51	26.65	27.42	31.28	33.41
RPV failed	19.93	22.29	25.07	27.73	29.62	31.70	34.33	35.09
SP temperature > 100℃	12.10	13.01	12.93	12.93	12.93	12.93	12.93	12.93
Containment Pressure > design pressure (62 psig=0.528 MPa)	19.60	22.36	25.11	28.03	29.70	31.79	32.27	33.78
Containment Failure(184.7 psig=1.27 MPa)	34.14	37.35	38.02	40.52	44.22	46.57	47.12	48.56

Attachment (1) , URG timing analysis

Chin Shan SBO timing

Sequence	t=0 min	Reactor Scrammed
		RCIC on
	t=20 min	Tsunami
		Loss of RCIC
	t=60 min	Emergency Depressurization (ADS open)
		Raw water system on
		RPV water level maintain at L-3
		Containment venting

After reactor scrammed, water make up to the core must be kept to absorb the decay heat, however, decay heat decreased with time, amount of water needed for the core cooling also decreased.

CASE 1A : It is assumed that water from raw water reservoirs had been injected to the core at a rate of 225 gpm, 60 minutes after reactor scram and depressurization. RPV water level had experienced a lower level than TAF, but still higher than MSCRWL .(Minimum Steam Cooling Reactor Water Level)

If injection rate was only 75% (170 gpm), core water had experienced a lower level than MSCRWL, but it could be raised to TAF pretty soon, no Zr-water reaction would occur.

If injection rate was 60% (153 gpm), core water level had experienced a lower level than MSCRWL, even it was restored to TAF pretty soon, cladding temperature would be raised high enough to trigger Zr-water reaction.

	CASE 1A	CASE 1B raw water 75% rate	CASE 1C raw water 60% rate
Raw water injection rate	255gpm	170gpm	153gpm
Transient minimum core water level	1.191 meter below TAF (higher than MSCRWL)	2.251 meter below TAF (lower than MSCRWL)	3.361 meter below TAF (lower than MSCRWL)
Maximum core temperature	315℃ lower than 1500 F	519℃ lower than 1500 F	780℃ near 1500 F

1500F: initiation temperature of Zr-water reaction.