Nuclear Reactor Regulatory Overview

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Outline

- Nuclear Power Plants Safety Performance
- Major Regulatory Activities
- Major Activities Under Planning
- Recent Significant Events in Taiwan
- Concluding Remarks

Nuclear Power Plants Safety Performance

- The overall safety performance of nuclear power plants in Taiwan is continuously maintained at a high level of standards.
- The number of violation, automatic scram, and reportable event report (RER) as shown in Figures 1, 2, and 3.
- Moreover, the performance indicators and the baseline inspection results show all green findings except RCIC system in Chinshan NPP (white) in the area of the reactor safety cornerstones.

Major Regulatory Activities

Various regulatory measures have been taken to closely monitoring nuclear power plants safety performance. The major activities include:

1. Lower the Age of Licensed Operators
2. Underground Cable Performance Monitoring
3. Grid Stability
4. BWR Fuel Channel Bow
5. Fuel Performance
6. Measurement Uncertainty Recapture Power Uprate
7. Lungmen ABWR Construction Inspection

Lower the Age of Licensed Operators(1/7)

- According to a survey, the average age of licensed operators in Taiwan is at least five years higher than that of their counterparts in the US. Among these personnel, approximately 10% are over 55.
- Moreover licensed operators over the age of 45 make up approximately 70% at Chinshan and Kuosheng NPPs. The problem of high average age of licensed operators will become more serious in ten years.
- AEC has requested Taipower to establish a licensed operator recruitment program to accelerate the lowering of the age.
- It is hoped that by lowering the licensed operators' age to below 55, the problem of high average age among licensed operators can be thoroughly solved.

Underground Cable Performance Monitoring(2/7)

- Lessons learned from NRC's Proposed Generic Communication on August 1, 2005, for "Inaccessible or Underground Cable Failures That Disable Accident Mitigation Systems" and NEI 06-05 "Medium Voltage Underground Cable" , AEC conducted a special inspection for the cable's physical protection and functional capability at three NPPs.
- The inspection results showed that part of the cables were immersed in the water environment although the function of the cables was still intact. Besides, part of the underground redundant cables exhibited insufficient physical separation.
- Corrective actions have been enforced which include periodic insulation measurement, periodic cable conduits inspection, installation of pumps at cable man-holes, and risk assessment of the cables.

Grid Stability(3/7)

- The initiating event for the Maanshan unit 1 station blackout incident on March 18, 2001, is the grid instability.
- In addition to the stability improvement of the grid, how to minimize the influences and consequences of the grid instability to the reactor operation is another concern.
- The measures to be taken or under evaluation include communication protocol between grid operator and reactor operator (different department within Taipower) and risk assessment of the transmission system.

BWR Fuel Channel Bow(4/7)

- Operating experience from Susquehanna, Grand gulf, and LaSalle indicates that fuel channel will bow beyond expectation, which could impose safety concerns.
- Chinshan and Kuosheng fuel channel supplier are the same as the aforementioned plants. Therefore, Taipower has been requested to submit a channel bow monitoring program and operators training program regarding increased resistance to control rod movement and control rod indication anomaly.
- Reload analysis for the safety limit MCPR using the updated data bank of the channel bow is also requested.
- Chinshan experienced two control rods slow to settle and then re-channeled 19 suspect assemblies during EOC 22 refueling outage in March 2007.

Fuel Performance(5/7)

- Chinshan Unit 1 and Unit 2 hasn't encountered any fuel failure in 13 and 9 years, respectively.
- During past 5 years, Kuosheng plant has experienced 9 fuel failures. Kuosheng Unit 2 has conducted 3 consecutive mid-cycle outages to replace the failed rods.
- Possible causes of fuel failure are categorized as: debris-induced failure, manufacture problem (missing fuel pellet surface), and PCI (pellet-cladding interaction). The root causes are under laboratory (hot-cell) examination.
- Maanshan plant has encountered three fuel rod failures in 5 years. All of them are debris-induced.

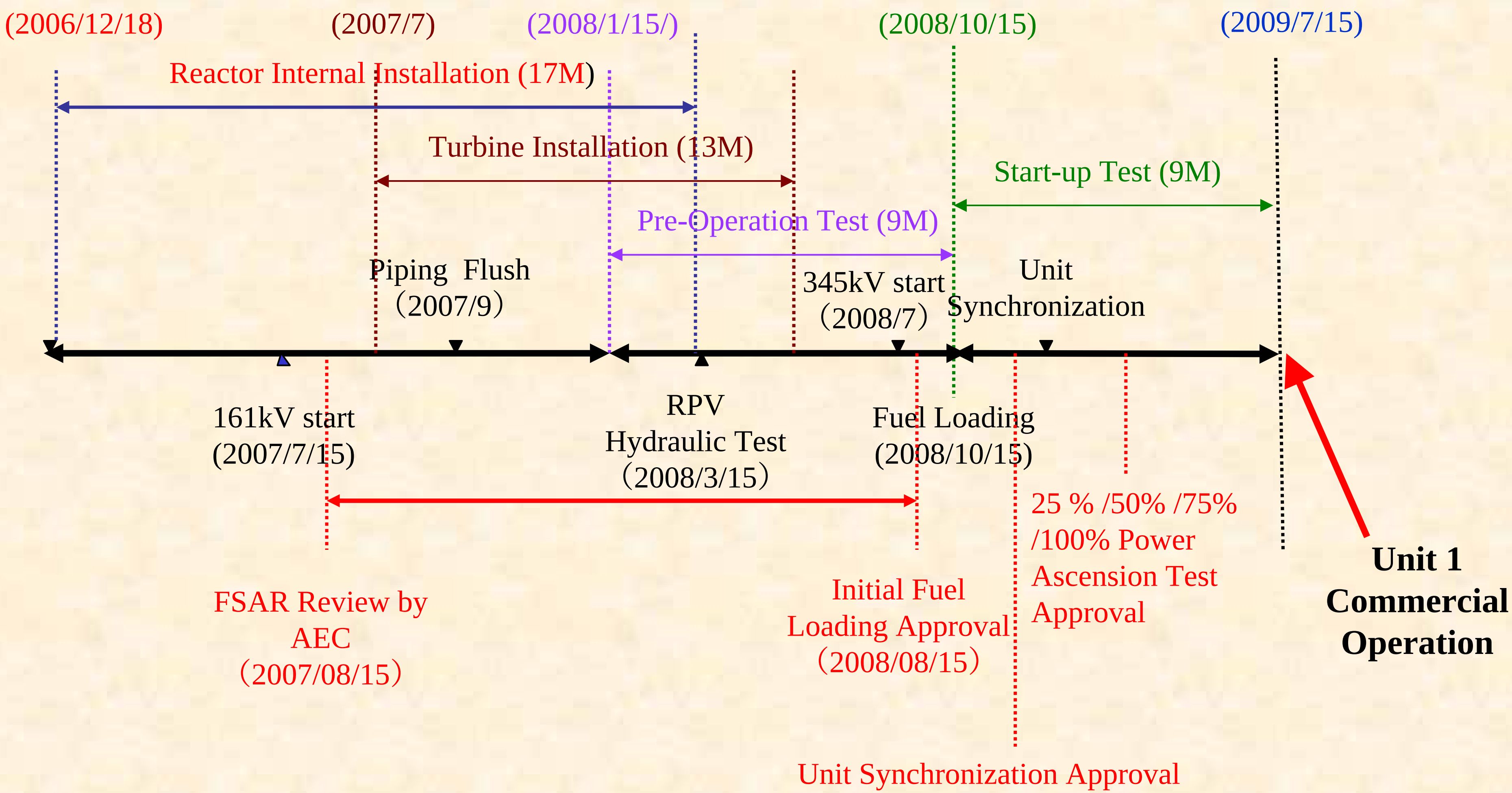
Measurement Uncertainty Recapture Power Uprate(6/7)

- Taipower has submitted Measurement Uncertainty Recapture (MUR) power uprate application for Kuosheng plant in July 2006. The proposed power uprating is 1.7% of current rated thermal power.
- Documents accompanied by this submittal include: MUR uprating safety analysis report , ultrasonic flow meter (UFM) technical report, flow uncertainty quantification, design change request (DCR) and list of commitment.
- AEC has recently approved the 1.7% uprating safety analysis report. The actual amount of power uprating needs on-site test result to specify the final uncertainty.
- Chinshan and Maanshan plants will pursuit the MUR uprating in 2007.

Lungmen ABWR Construction Inspection(7/7)

- The total accumulated progress of Lungmen project approach 64.9%
- In addition to the routine inspection activities, AEC also conduct some task forces on special area for this year, including:
  - Reactor internal installation
  - Welding of safety related piping

Mainly Schedule of Lungmen Plant



Bird View of Fourth Nuclear Power Plant

Bird-view of Lungmen Plant

Major Activities Under Planning

In addition to the ongoing regulatory activities, AEC is also preparing the safety review for the foreseeing applications, including:

1. License Renewal （depends on utility's application）

   According to Nuclear Reactor Facilities Regulation Act *Article 6* "..... when there is a need to continue operation after the license is expired, an application for renewing the license thereof shall be filed by the licensee with the competent authorities within the period prescribed by the competent authorities."

   Timeliness of application is from 5 to 15 Years before the expiration of the operating license. The 1st (Chinshan) NPP in Taiwan is now within the time frame to raise License Renewal issues.

Major Activities Under Planning

2. 10-year integrated safety assessment （Summer 2008）

According to Nuclear Reactor Facilities Regulation Act *Article 9* "After nuclear reactor facilities have been formally operated, one integrated safety assessment at least shall be implemented every ten years and then be submitted to the competent authorities for review and approval. "

TPC should submit the third ten-year integrated safety assessment of Chinshan unit 1 in June 2008.

Major Activities Under Planning

3. Maintenance Rule Implementation （starting from 2008）
   - Purpose: To monitor the effectiveness of maintenance activities to minimize the likelihood of failures and events.
   - MR Current Status :
     - The working items of scoping, initiating evaluation, guideline and procedures, database have been completed by Taipower.
     - Now MR on test-run for one year in 2007.

Recent Significant Events in Taiwan

- ✓ CS #2 Reactor Scram Due To Main Turbine-Generator Trip On Nov. 17, 2006
- ✓ MS #1 Reactor Trip Due To loss of CRDM Power On July 28, 2006
- ✓ The Dec. 26 2006 Hengchun Earthquake Effect on MS NPS

CS #2 Reactor Scram Due To Main Turbine-Generator Trip

Event Description

- On November 17, 2006 CSNPS Unit 2 was in 100% power operation.

- At 4:08 a.m. Unit 2 main-generator loss of excitation (loss of field relay actuated).This activated the 86GP lockout relay of the generator, and at the same time tripped the generator output circuit breakers GCB 3540 and 3550, thereby causing the generator and the turbine to trip and the consequent reactor scram.

- Three turbine bypass valves were fully opened and then still kept opened due to DEH turbine throttle pressure signal failure logic actuated (because of inadequate signal validation setpoint); hence, in order to prevent the reactor coolant temperature drop from exceeding the cool down rate limit, at 04:09, operators manually shut off MSIVs. The reactor water level drop caused the RCIC and HPCI start automatically. At 04:12, the reactor water level rose to normal levels and the operators manually stop HPCI/RCIC.

Cause Identification and Correction

- **The cause was due to a malfunctioning V/Hz limiter card of the AVR (Automatic Voltage Regulator). This caused a rapid drop in the excitation voltage and actuated the loss of excitation protection logic.**
- **The malfunctioning limiter card was replaced and AVR was recalibrated & tested according to established procedure.**
- **DEH control transferring to MANUAL mode is because of improper turbine throttle pressure signal setpoint.**

Regulatory Measures(1/2)

The AVR system has been used for nearly 30 years, and V/Hz Limiter card currently being used was purchased in 1996, and some of its spare parts are stored in a Class A warehouse in good condition.

AEC conducted follow-up work on the related improvement measures:

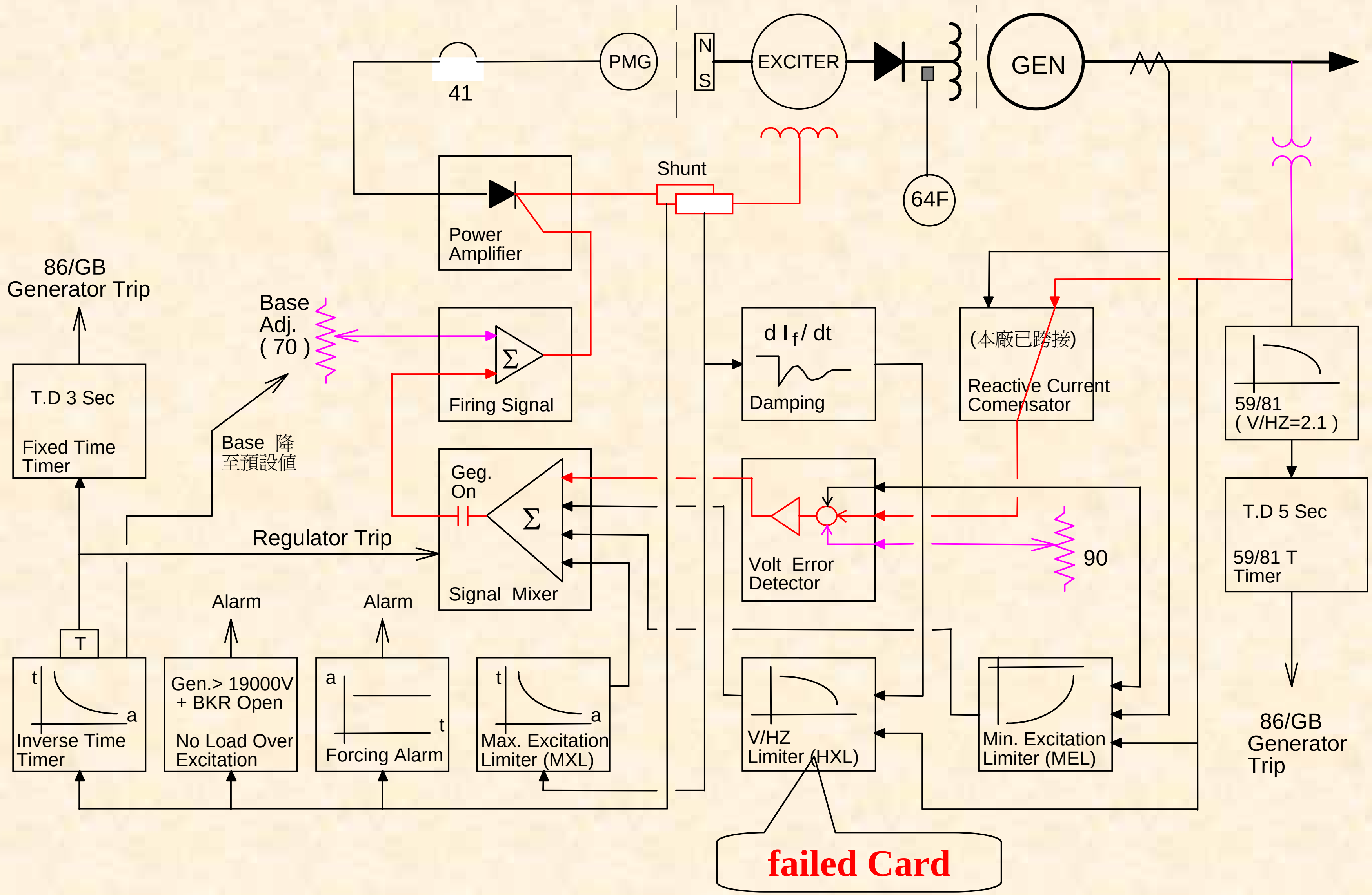
- Ask TPC to Setup maintenance program for each critical component, including the replacement timetable.
- The CSNPS shall speed up the parts replacement program.

Regulatory Measures(2/2)

- **March 2007 AEC found that the DCR of turbine DEH control system in CSNP, which caused DEH control system incapable to fulfill its design function, increased the complexity of reactor trip recovery during the turbine trip transient and challenged the safety of plant operation.**

- **Sep. 2002, CS unit 2 was scrammed due to the same reason. CSNP knew the problem, but did not took corrective action afterward.**

- **Severity level-V violation was Issued by AEC on May 21, 2007.**



AVR(Automatic Voltage Regulator)

MS #1 Reactor Trip Due To loss of CRDM Power

Background

Power to control rod drive mechanisms （CRDM） is supplied by two motor generator sets operating from two separate 480V, three-phase buses. Each generator is the synchronous type and is driven by a 150 hp induction motor. The AC power is distributed to the rod control power cabinets through the two series connected reactor trip breakers.

Event Description

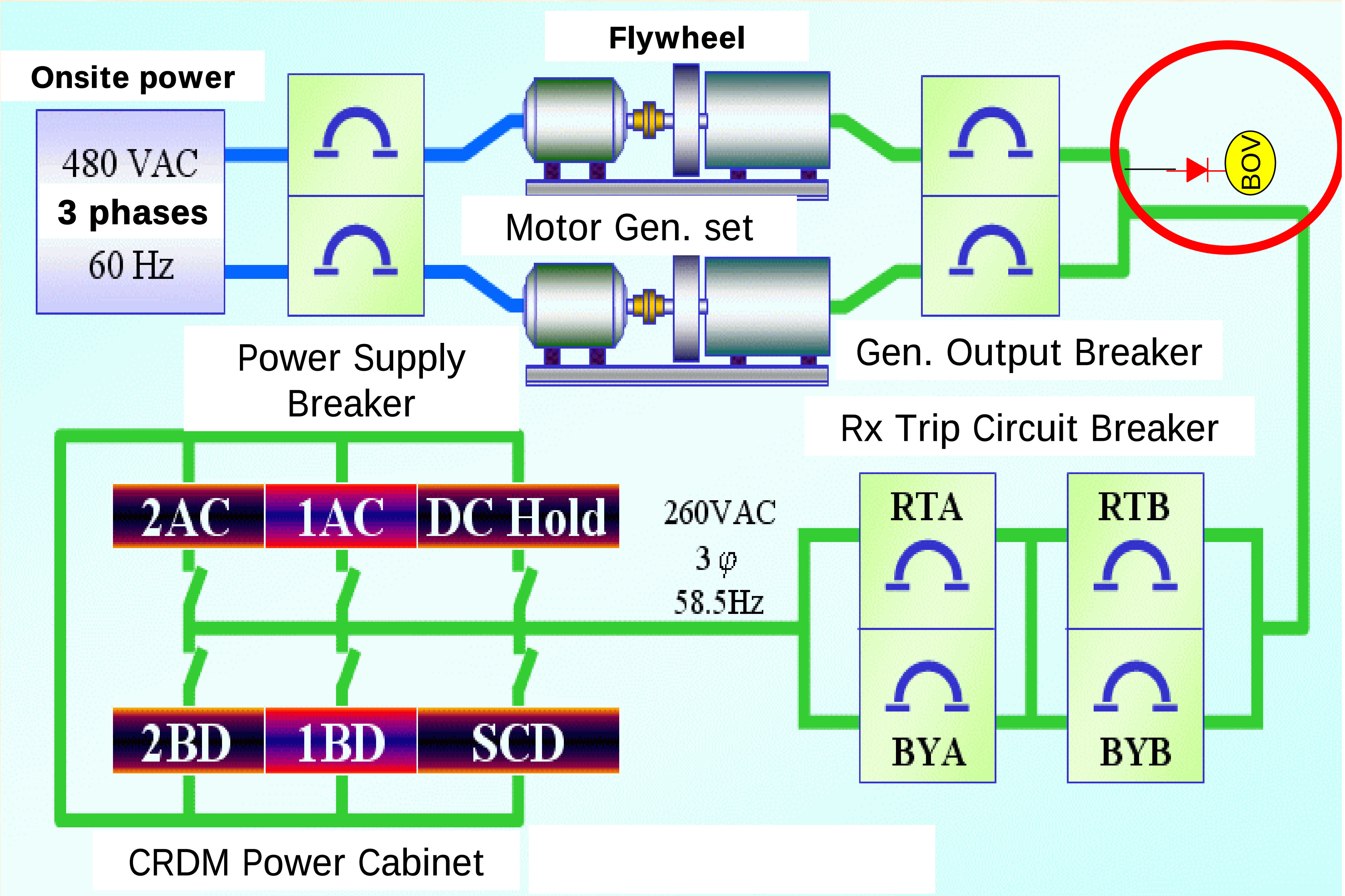
- On July 28, 2006 MS Unit 1 was in 100% power operation.
- At 1:19 a.m. two motor generator sets（M-G sets） output breakers tripped simultaneously. As a result, the control rod drive power was interrupted, and all the control rods fall, by gravity, into the core. Then a reactor trip was initiated by power range high negative neutron flux rate signal.

Cause Identification and Correction

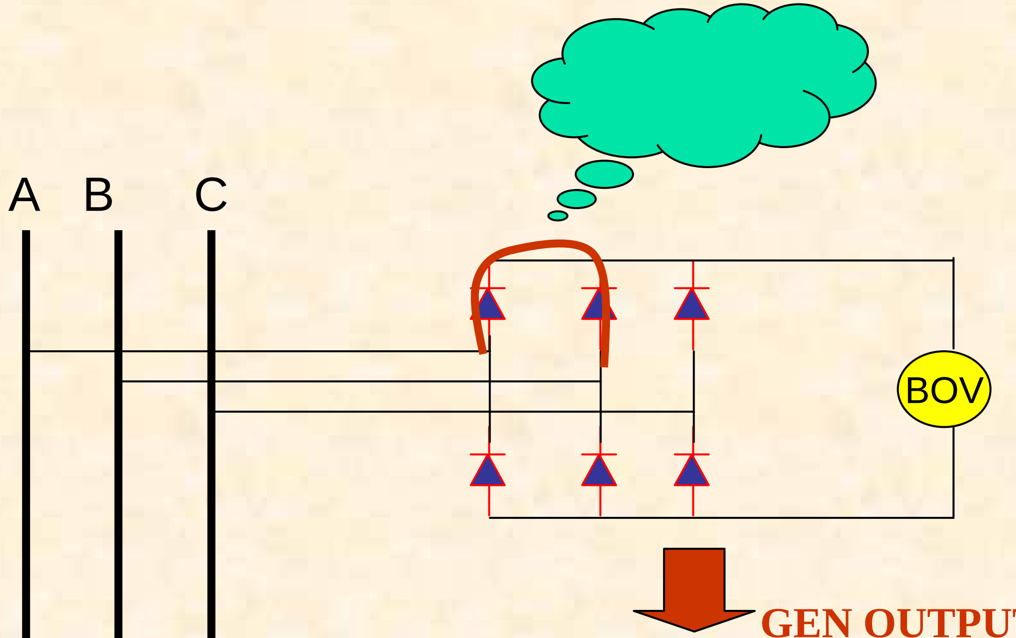
- Six diodes which were located at a rectifier of M-G sets output bus over voltage relay(BOV) were burned-out. Abnormal current between damaged diodes caused Two M-G sets output breakers tripped by short circuit protection.
- Screening process which was performed in 1994 failed to identify those diodes as critical component whose failure could cause a reactor scram, so there is no PM of those diodes conducted before.
- Install an indicating fast-acting fuse on each phase of BOV to prevent same problem from happening again.
- Periodic check of diodes temperature is also scheduled.

Regulatory Measures

- **AEC has requested the MS to re-review the critical components screening results to ensure there is no missing again.**
- **TPC should assess the lifetime of critical electronic components, and establish a maintenance program and/or a monitoring program to ensure the reliability of those critical electronic components.**



Onsite power
480 VAC
3 phases
60 Hz
Flywheel
Motor Gen. set
Power Supply Breaker
Gen. Output Breaker
BOV
Rx Trip Circuit Breaker
2AC
1AC
DC Hold
2BD
1BD
SCD
260VAC
3 φ
58.5Hz
RTA
RTB
BYA
BYB
CRDM Power Cabinet



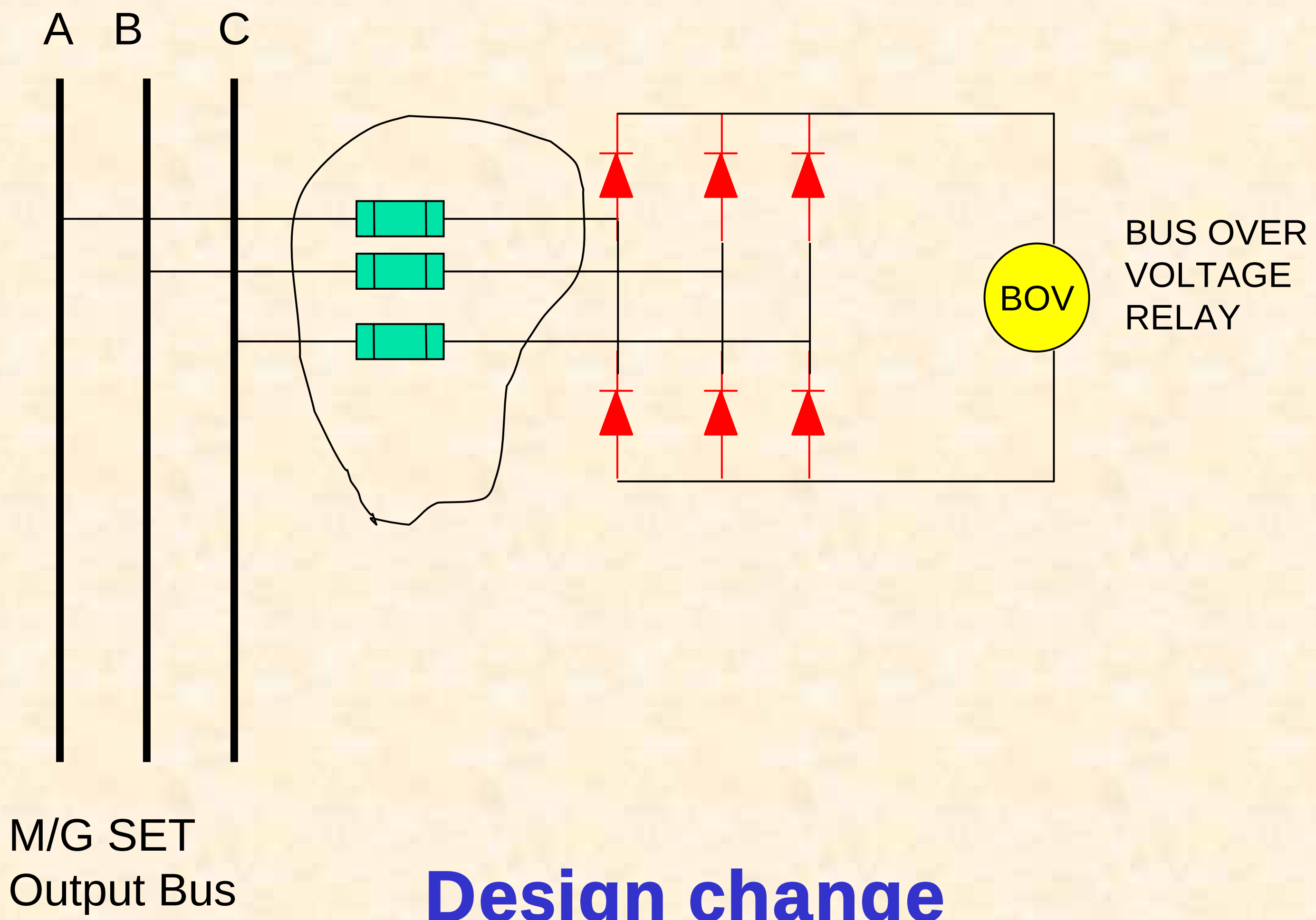
BUS OVER VOLTAGE RELAY

GEN OUTPUT BKR

M/G SET

Output Bus

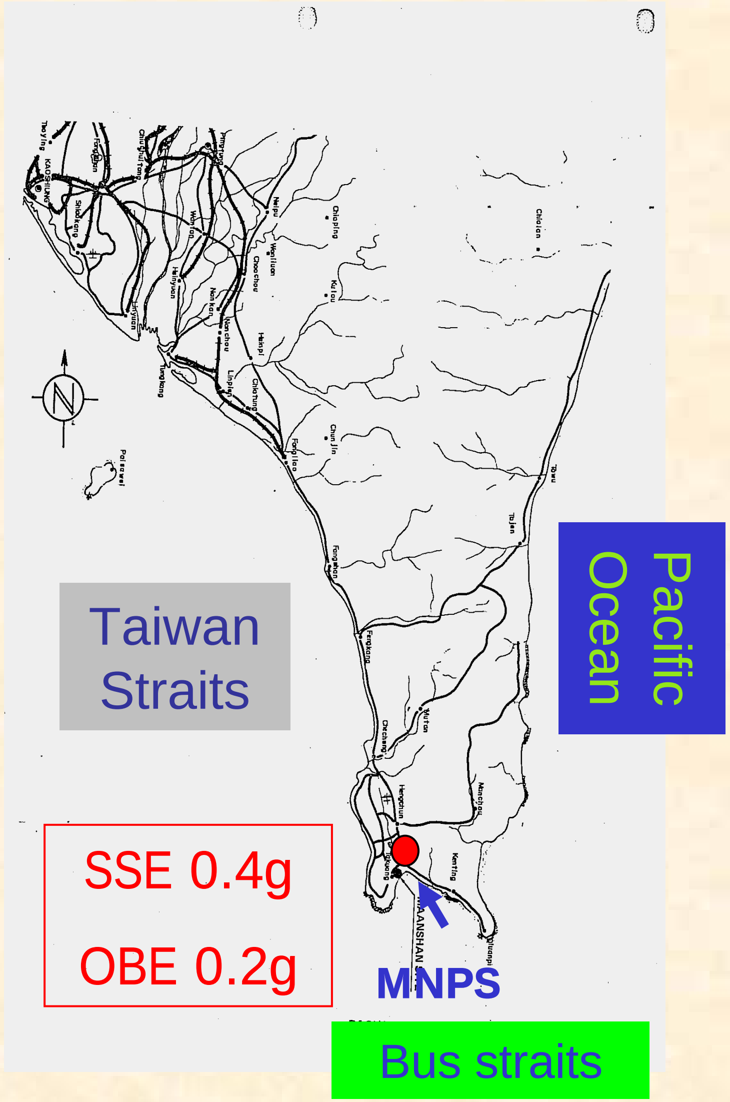
Short Circuit Actuated



Design change

The Dec. 26 2006 Hengchun Earthquake Effect on Maanshan NPS

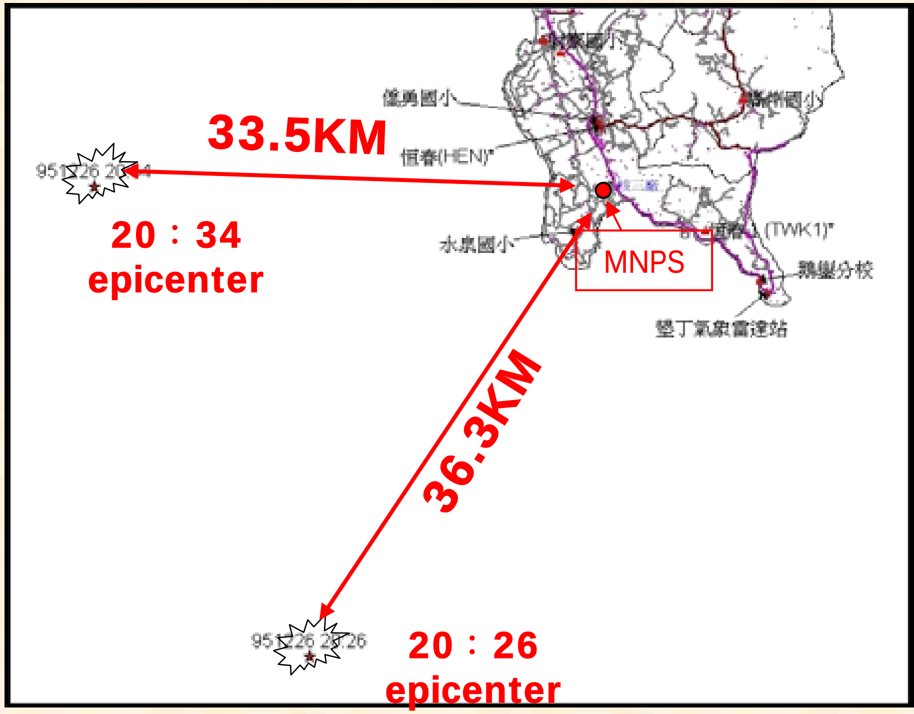
Seismic design basis of MNPS



- The design basis earthquake is assumed that the largest known earthquake which occurred offshore east of Taiwan (the magnitude 8.3 event of June 5, 1920) might occur on the closest approach to the site of this nearest known fault which is about 35 kilometers away from MNPS site
- Under these assumptions, the maximum ground accelerations at MNPS site is slightly less than 0.4g

Hengchun Earthquake Data

- From 20:26 December 26, 2006, a series of earthquakes occurred near Hengchun where MNPS located. The epicenter, depth and magnitude of two main earthquakes are as follows:



	time	epicenter	depth (KM)	magnitude
1	2006/12/26 20:26	21°67 ºN 120°56' ºE	44.1	7.0
2	2006/12/26 20:34	21°97 ºN 120°42' ºE	50.2	7.0


2006/12/27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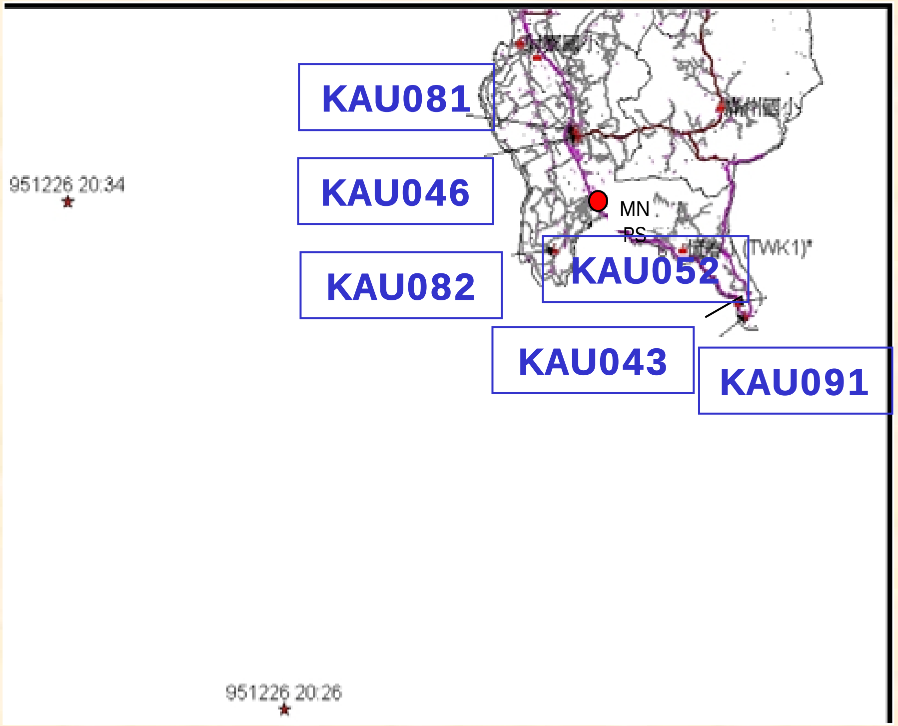
Local seismic monitoring stations

- **list of seismic monitoring stations of Central Weather Bureau in Hengchun area**



Station code	Station name	North latitude	East longitude
HEN	Hengchun weather station	22.00	120.75
KAU 043	Eluan branch school	21.91	120.85
KAU 046	Hengchun weather station	22.00	120.75
KAU 052	Hengchun1 (Research institute)	21.94	120.81
KAU 081	Ciaoyong elementary school	22.01	120.75
KAU 082	Shueicyuan elementary school	21.94	120.73
KAU 091	Kending weather radar station	21.91	120.86

Peak ground acceleration data during earthquakes

time：2006/12/26 20:26

Unit: gal=1cm/sec^2

station / direction	MNPS Free field (E)	MNPS Free field (H)	Shueicyuan elementary school (KAU082)	Ciaoyong elementary school (KAU081)	Kending weather radar station (TWK1)
vertical	72.37	73.91	78.03	57.31	70.28
N-S	138.40	137.69	240.3	181.64	125.61
E-W	159.96	156.55	217.87	191.92	159.88
Approx. Distance from epicenter (km)	~36.3	~36.3	~33.2	~40.3	~38.8

Peak ground acceleration data during earthquakes(continued)

time ：2006/12/26 20:34 Unit: gal=1cm/sec^2

station / direction	MNPS Free Field (E)	MNPS Free Field (H)	Shueicyuan elementary school (KAU082)	Ciaoyong elementary school (KAU081)	Hengchun weather station (KAU046)
vertical	71.97	74.06	82.1	59.58	69.97
N-S	160.86	162.12	176.14	250.89	254.16
E-W	139.88	140.85	182.47	195.56	172.38
Approx. Distance from epicenter (km)	~33.5	~33.5	~31.4	~33	~33

The status of the units after the earthquake

- During the earthquake, operators in both units had experienced of violent shock, and noticed the RCP and main turbine high vibration alarms.
- The unit #2 operators trip Rx manually.
- However, when unit #1 operators decided to took the same action, the earthquake had been slowed down and the high vibration alarms could be reset, so they kept unit #1 in operation.

The status of the units after the earthquake(continued)

- After the earthquake, plant staffs followed the procedure 582.1 “checklist of significant equipment after shutdown due to strong earthquake” to examine the integrity of SSCs of both units（except inaccessible areas of unit #1) .
- The result showed that there is no major damage on all SSCs of two units .Minor damages are as following items:
  1. some RCP C/T cable ducts connection are loose(unit #2)
  2. some water and oil spilt from Spent fuel pool and EDG fuel oil storage tank.
- Lots of dust accumulated inside ventilation pipe floated down from top ceiling of main control room during & after the earthquake.

Ventilation outlet

LESSONS LEARNED

- Re-review & standardize the procedures dealing with earthquake for all operating NPPs.
- Routine inspection records and digital images of major SSCs are essential information for checking activities after earthquake . it is important to gather & update those information during routine inspection tours by plant staffs periodically.
- Organize a plan to clean the dust accumulated inside ventilation pipe of main control room periodically.
- Study the possibility to incorporate a seismic shaking table experience course into the operator on-job-training.
- Study the ways (radiation level, humidity, temperature, etc.) to monitor the status of inaccessible areas after earthquakes.

Concluding Remarks

- The goal of the reactor regulation is not only to assure the safety of the NPPs in order to protect the public health and environment but also to maintain the stable/reliable operation.
- The overall safety performance of nuclear power plants in Taiwan is continuously maintained at a high level of standards.

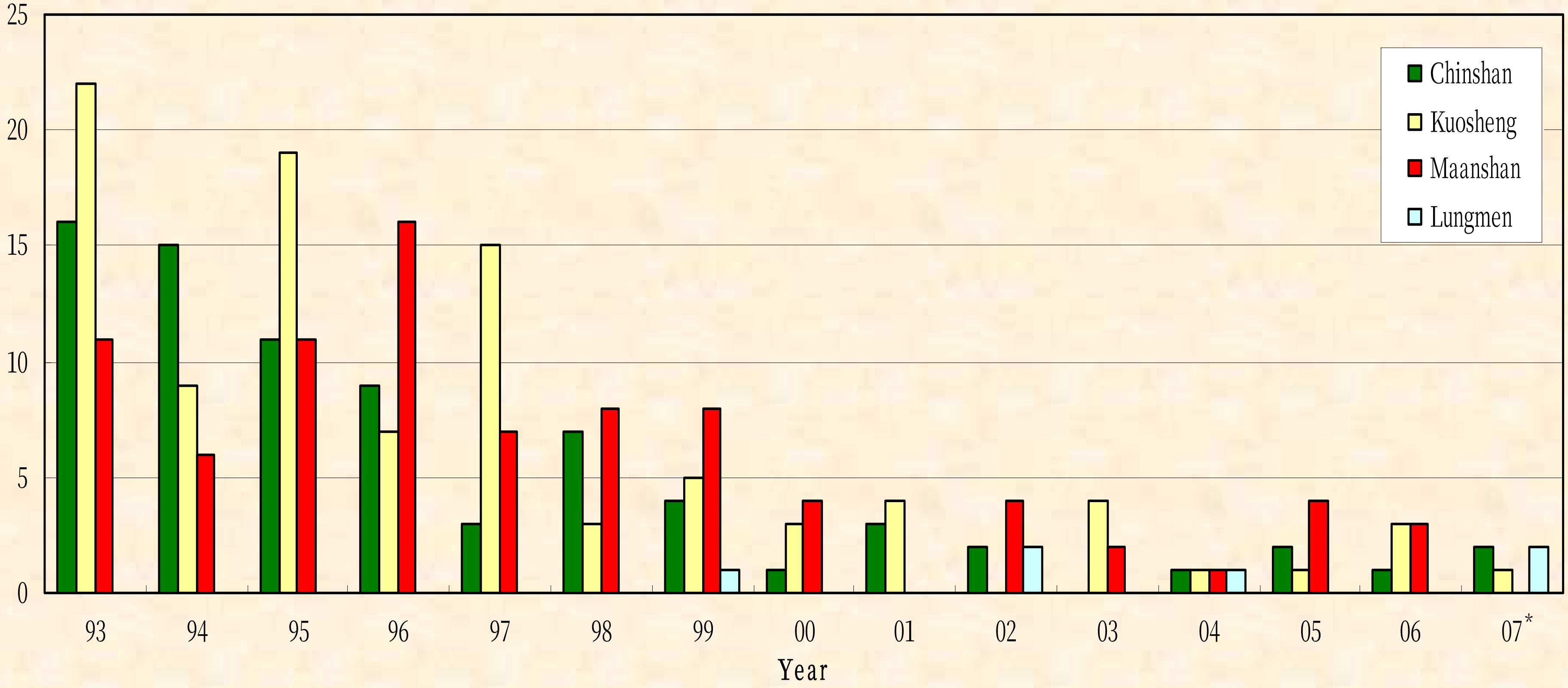


Figure 1 Number of Violations for Each Plant

（*：Data up to May 2007）

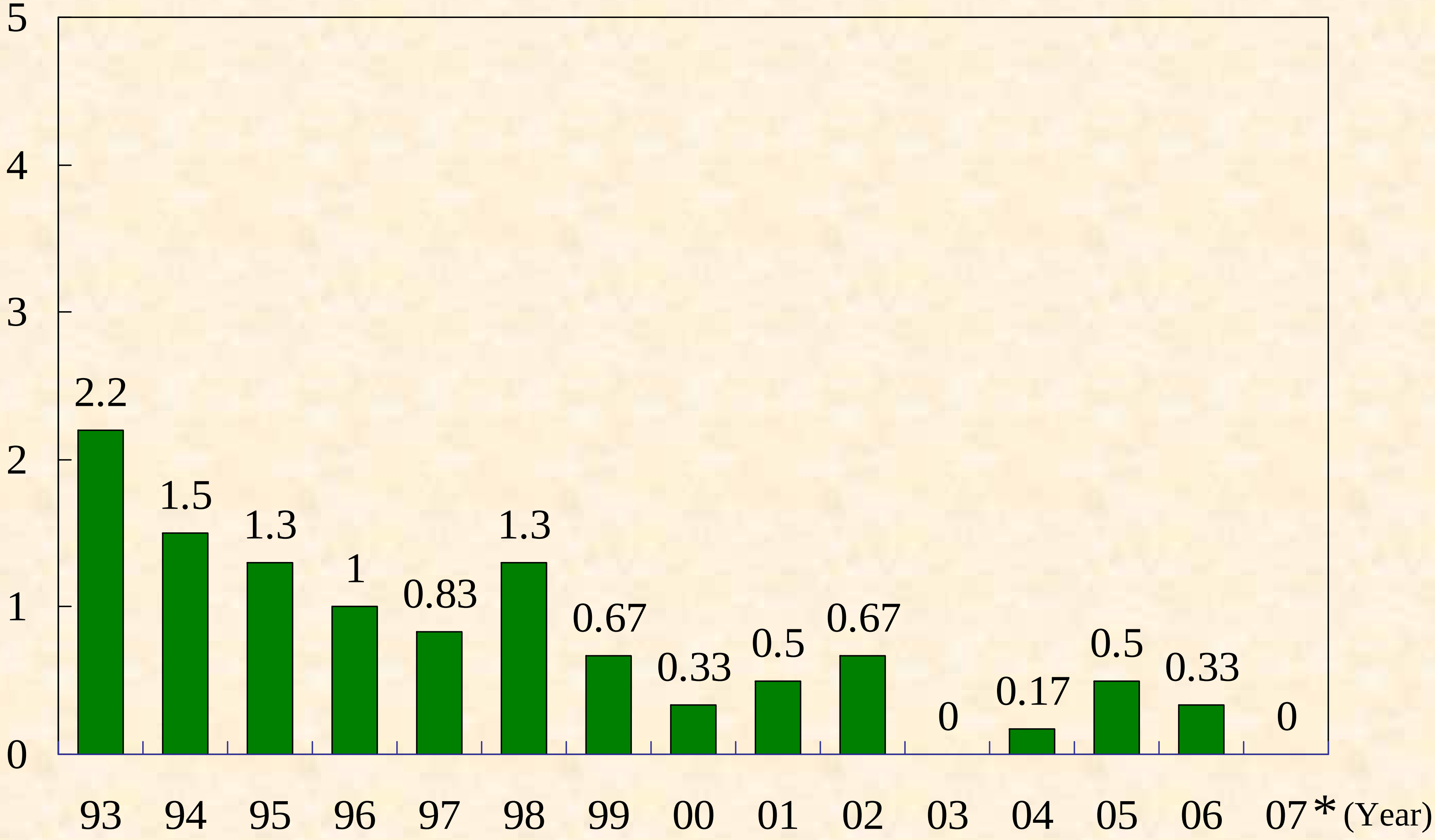


Figure 2 Average Number of Scram per Unit

（*：Data up to May 2007）

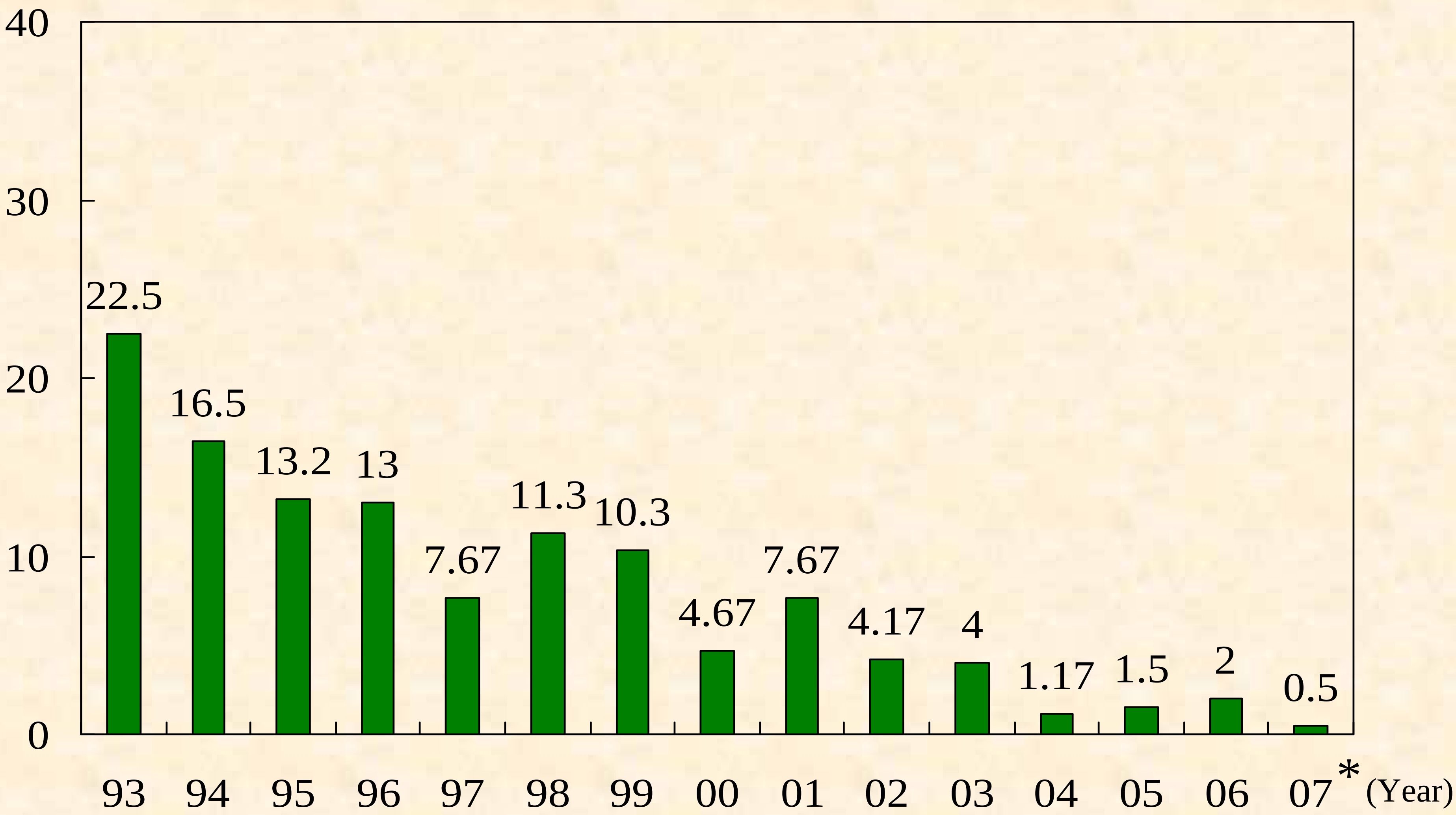


Figure 3 Average Number of RER per Unit

（*：Data up to May 2007）

第四核能發電廠空照圖


生活區
進水口防波堤
施工處辦公室區
#2機廠房
開關場
排氣塔
抽水機房
廢料廠房
輔助燃料廠房
電廠行政區
排水隧道
#1反應器廠房
#1控制廠房
#1汽機廠房