

Summary of Assessment on TPC Nuclear Power Plant Stress Test Program

Robert W. Tsai, 12/12/11

1. Introduction

As a result of the 311 TEPCO Fukushima nuclear power plant incident, the Executive Yuan of Taiwan issued a nuclear safety directive on 4/19/11 to the Taiwan Power Company (TPC). The directive requested TPC to conduct an immediate and complete nuclear safety stress test/assessment for all nuclear plants in Taiwan. The stress test program includes 1) identification of the key differences between the FUKUSHIMA and TPC plants for earthquake/tsunami mitigation, 2) assessment of plant's capability to respond to design basis and beyond design basis accidents by re-evaluating the plant design, safety system, equipment and component and operating procedures and 3) development of near-term and mid-term improvement programs to gain additional safety margin.

With the input and directions from WANO, ROC AEC and US NRC, a near-term nuclear safety program was immediately initiated by TPC. As of 6/30/11, eleven items in the near-term program were completed. These included plant structure seismic margin assessment, plant site sea and land survey and re-evaluation of the original FSAR design basis tsunami event and the state of plant safety systems. By 8/4/11, all of the TPC nuclear power plants have completed the revised procedures and emergency drills based on a hypothetical earthquake/tsunami event. The Stress Test Reports for N1 (GE BWR3/Mark I), N2 (GE BWR6/Mark III) and N3 (W 3-Loop PWR) were completed on 9/30/11 with ROC AEC comments and responses incorporated and N4 (GEH ABWR) report was completed on 11/14/11. Based on these evaluations, additional staff training, plant procedure update and equipment upgrade or additions are being completed and/or planned.

The three-member Stress Test Expert Panel (STEP) was commissioned on November 11, 2011 by the Ministry of Economic Affairs to provide an independent evaluation of the program and the results as of November 2011. The STEP members are Dr. Way Kuo (郭位), President, City University of Hong Kong; Dr. Robert W. Tsai (蔡維綱), Senior Consulting Engineer, Fauske and Associates, and Dr. Rosa Yang (呂鴻薇), Senior Technical Executive, EPRI. This report summarized the inspection results of Dr. Tsai and Dr. Yang only. Dr. Kuo's inspection will be held on 12/13-16/11.

2. Scope and Method of Assessments

- a. Due to complexity of the issues and amount of the information in the stress test reports, the Panel review is limited to overview and programmatic in nature. Limited validation and verification of information is performed.
- b. Review of N1, N2, N3 (dated 9/30/11) and N4 (dated 11/14/11) Stress Test Reports
- c. Plant site visit, walk down and interview with corporate and plant staff
 - i. Monday, 12/5/11 – N4 (Lungmen) plant site, near Taipei
 - ii. Tuesday, 12/6/11 – N1 (Chinshan) plant site, near Taipei
 - iii. Wednesday, 12/7/11 – N2 (Kuosheng) plant site, near Taipei

Summary of Assessment on TPC Nuclear Power Plant Stress Test Program

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- iv. Thursday, 12/8/11 – N3 (Maanshan) plant site, near Kaohsiung at the southern tip of Taiwan
 - v. Friday, 12/9/11 – Final briefing in the offices of the Ministry of Economic Affairs with the Taiwan government officials and the TPC senior leadership
3. Executive Summary
- a. General Observations:
 - i. TPC is aggressive and rigorous on the nuclear safety stress test program. The reports were completed timely with high quality and consistent with the guidelines, suggestions and recommendations provided by WANO, ROC AEC, and US NRC.
 - ii. Other than completing the stress reports, TPC has already completed significant amount of enhancement activities on hardware and training during 2011 to improve safety margin. These include purchase of numerous mobile diesel generators, ultimate heat sink protection, multiple water delivery systems to reactor core and spent fuel pool, and reservoir water reliability enhancement, etc. The emergency operation procedures are updated and emergency exercised were successfully conducted at all sites. TPC's effort and results are recognized and appreciated.
 - iii. The Panel believes firmly that nuclear energy is a must for Taiwan energy future. TPC is reminded to maintain recent outstanding safety and operational performance of N1, N2 and N3 plants. TPC is also encouraged to timely and safely complete N4 construction campaign despite the political uncertainty and nuclear climate in Taiwan.
 - iv. After completing the current campaign of enhancement for typhoon, earthquake, tsunami, flood and landslide, the Panel directs TPC to investigate other vulnerabilities and to develop mitigation strategies.
 - v. The Panel directs TPC not to let the time and resource spent on current earthquake/tsunami campaign to distract the safe operation of the plants.
 - b. Program and Policy
 - i. Need enhanced mitigation strategy on multi-units and multi-site event scenario.
 - ii. Need to develop a well-defined process and mechanism on decision making, especially at early stage of accident. Not clear on roles and responsibilities of corporate organizations and severe accident critical decision mechanism.
 - iii. Need to use tool such as PRA to perform cost/benefit study to develop most effective mitigation and enhancement programs.
 - c. Human Factor and Training
 - i. Need to develop well-defined procedure and continuing training programs
 - ii. Make sure that reactor operators are well trained. Must never put operators in a situation that has not been analyzed previously.
 - d. Ultimate Response Guidelines (Depressurization, Injection and Venting)

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- i. The Panel concurs with TPC URG program with goal of preventing core damage, hydrogen generation and evacuation during emergencies. However, the communication program should be enhanced to avoid the need of final decision by the control room operators and supervisors.
 - ii. The equipment associated with the URG should be clearly marked.
 - e. Communications.
 - i. Use the best of the fleet approach. Exchange ideas between the plants when developing strategies.
 - ii. Communicate actively with BWROG, PWROG and other external organization for strategy development
 - f. Hardware Equipment
 - i. Continue to upgrade the reservoir and associated delivery piping to make sure there will not be flood issues to the plants.
 - ii. Consideration of use of filtered vent or equivalent

4. Conclusions

Based on the activities conducted by the Panel as described in section 2 and TPC's programs on safety system and component enhancements, continuing training and operation procedure upgrade, the Panel concludes that:

- a. The criteria described in the WANO, ROC AEC and USNRC documents are satisfactorily met.
- b. The N1, N2 and N3 plants are designed and constructed with adequate safety margins for normal operation, transients and accident conditions.
- c. Immediate actions taken since 311 Fukushima events so far have added more safety margins, especially in the severe accidents and beyond design basis events.
- d. Timely implementation of the planned enhancement programs will represent additional assurance in maintaining reactor core, containment and spent fuel pool cooling and integrity under the circumstance of severe accident events.
- e. N4 (Lungmen) plant is inherently a safe and well designed plant based on years of design and operating experiences of current operating BWR plants. The stress test report provides good basis to demonstrate that it can be safely operated and be well prepared for emergencies.
- f. However, it is still under construction phase and there is no power testing data and operating experiences that will allow an in-depth assessment of plant capability and readiness for severe and beyond design basis accidents.
- g. N4 plant will require additional effort on governance and oversight on configuration control and management to assure that the entire plant design and construction is adhered to the highest safety criteria and standards for safe start-up and commercial operation.

5. Feedback

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The final briefing meeting was held on 12/9/11 with the senior officials of Taiwan Ministry of Economic Affairs (MOEA) and the senior leadership of TPC. MOEA and TPC accepted the Panel's evaluation summarized above with no exception. TPC will continue to communicate with the Panel members on progress of the enhancement program. TPC further requests the Panel's continued support and guidance in the future.