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REPORT OF THE  
NUCLEAR SAFETY REVIEW PANEL  
TO THE  
ATOMIC ENERGY COUNCIL

July 8, 1983

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Chairman Chen-Hsing Yen  
Atomic Energy Council  
Executive Yuan  
67 Lane 144 Keelung Rd. Sec. 4  
Taipei, Taiwan 10772

July 8, 1988

Dear Dr. Yen,

We hereby submit the report of the Nuclear Safety Review Panel,  
addressing the questions you asked concerning safety aspects of nuclear  
power plants operated by Taiwan Power Company.

Sincerely,

*Herbert Kouts*  
Herbert J.C. Kouts  
Chairman of NSRP

*Adolf Birkhofer*  
Adolf Birkhofer

*Masao Nozawa*  
Masao Nozawa

*Nunzio J. Palladino*  
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*Norman C. Rasmussen*  
Norman C. Rasmussen

*P. Tanguy*  
Pierre Tanguy

*Long Sun Tong*  
Long Sun Tong

- v - Good | X - Good but need to further monitor
- g - Further strengthening needed
- x - bad

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1. Conduct of the Review

We met with officials and staff of the Atomic Energy Council (AEC) and the Taiwan Power Company (TPC). We visited the three nuclear plants operated by the TPC. In all of these meetings we were provided with detailed information on the nuclear power plants and their operation, with an emphasis on safety. In the course of the presentations and discussions, we asked numerous questions. We believe that this process formed a good basis for the conclusions we have drawn.

We could not perform a complete review of the safety of nuclear power plants in Taiwan; to do so would have required much more time than we had to spend. Instead, we concentrated our attention on a comparison of the safety practices at the Taiwan plants with internationally accepted practices. In the process, we sought to develop answers to the questions on the attached list, sent to us by Dr. Chen-Hsing Yen, Chairman of the Atomic Energy Council. We believe that this report addresses those questions.

Throughout the review we used the document INSAG-3 of the International Atomic Energy Agency, entitled "Basic Safety Principles for Nuclear Power Plants," which indicates current trends that are leading to even further improvement of safety of nuclear power plants everywhere.

We wish to thank the staffs of the Atomic Energy Council and the Taiwan Power Company for their gracious assistance in our review.

## 2. Objectives of TPC Safety Program

The Taiwan Power Company has adopted objectives for the level of safety of its nuclear power plants. We note that these objectives are comparable to those recommended for international use by the International Nuclear Safety Advisory Group in its document INSAG-3. These are very good objectives, which reflect an emphasis on high safety performance. They provide impetus for building a strong safety culture properly starting at the higher levels of management. We discuss safety culture in a more complete way later in this report.

### 3. General Conclusion

The nuclear safety practices at nuclear power plants operated by the Taiwan Power Company fall within the range of performance at similar plants in other parts of the world. In some respects the operations in Taiwan compare well with those in highly rated nuclear plants elsewhere. In some areas the operations in the TPC's plants have not yet caught up with those followed in the best plants of the same types; the TPC is taking steps to improve its practices in most such cases. In this report we recommend some further actions to take care of others.

There is an intensive activity in most of the world to make safety of nuclear power plants even better than the historical record shows it to have been so far. Continued attention and activity by the Atomic Energy Council and the Taiwan Power Company will be needed to keep nuclear plant safety on Taiwan in pace with that elsewhere. We provide below a number of recommendations directed at this objective.

#### 4. Relationship between the AEC and the TPC

The nuclear regulatory structure and activities of the AEC, as well as the AEC's relationship with the TPC, are patterned after those in the United States.

Both the AEC and the TPC have stated their commitment to the overall nuclear safety objective of protecting individuals, society, and the environment, by maintaining an effective in-depth program against radiological hazards from Taiwan's nuclear power plants. We find that they are conscientiously pursuing this goal, and are working together to ensure its achievement.

The AEC's regulatory staff is small compared to the technical staff of the TPC, whereas in the United States the staff of the Nuclear Regulatory Commission is large compared to the technical staff of any single utility. Consequently, it has been necessary for the AEC to rely heavily on the TPC for analyses of proposals for plant improvement. The AEC concentrates on establishing regulatory requirements, reviewing proposals and analyses, and ensuring compliance with safety objectives. This separation of functions between the AEC and the TPC appears to be working well despite occasional problems in communications between the two organizations. We are pleased to note that steps have been taken recently to improve communications between the organizations, for instance by the establishment of monthly meetings of their representatives.

We encourage the AEC to make increased use of the technical support provided by such external organizations as INER and the universities. This can help the AEC to exert its regulatory role efficiently and independently.

In summary, we believe that the AEC and the TPC are doing an effective job in looking after nuclear safety, but must maintain vigilance to ensure continued attention to safety at all levels of their respective organizations.

## 5. Safety Culture

As is well known, all technologies have both benefits and unavoidable risks. For the technology to be useful, the benefits should exceed the risks. There are many examples of this, such as airplanes, many industrial processes, and of course nuclear power. In all such industries, as in all activities in life, careful attention can reduce the risks, but zero risk can never be achieved.

Experience has shown that those organizations that have been most successful in achieving a high level of safety have developed what is termed a "safety culture" (Paragraphs 28 - 30 of INSAG-3). In such organizations, strict attention to safety permeates all levels of the organization, starting with the highest levels of management. A goal of the entire organization is to continually look for new opportunities to reduce risk and fight the carelessness and complacency that otherwise tend to increase and which can lead to serious errors.

In our opinion, there have been important improvements in safety culture in the TPC in recent years. Among these we note some newly introduced performance indicators related to safety issues, e.g. risk reduction, unplanned safety system actuation, and safety system failures. The proposed new Nuclear Operations and Safety Division (NOSD), which will replace the old Nuclear Operations Division (NOD) in the TPC headquarters, will further emphasize the importance of safety.

It has been suggested that an assistant superintendent for nuclear safety be added at each nuclear plant. We strongly support this as a step highly beneficial to safety.

We have heard of some morale problems among employees of the TPC. These may arise in part from the need for better understanding of the requirements imposed on employees for safety reasons. This is a matter that requires management attention, because it could impede the buildup of a strong safety culture in the company.

## 6. Management

We have several comments concerning possible improvements in the management of safety by the TPC at its headquarters and its nuclear power plants.

During our discussions, we learned of the important changes in the TPC *organizational structure, envisaged to further improve management in safety matters*. We support very much these steps, which are aimed at making the nuclear safety decision process more visible. We have already endorsed in this report the proposed conversion of the Nuclear Operation Department to the Nuclear Operations and Safety Department within the TPC headquarters, and the creation of a position of assistant superintendent for safety at each nuclear power plant.

In addition, we suggest that the TPC carefully review again its management structure to ensure the overall coherence of the responsibilities attached to positions, and in particular to verify that its organization would deal effectively with potential emergencies.

At our meetings, we were told of the betterment program at each plant. Some of the plant modifications in these programs seem to be taking exceptionally long times for their implementation. For those changes with significant safety implications, the schedule should be tightened up. This may require special arrangements for expedited procurement in these cases.

Abnormal events are documented and reported to the AEC, following practices in the United States. We encourage prompt and direct notification of reportable events to the AEC by each plant superintendent, in parallel with any notification of the TPC headquarters.

We took note of the important role played by advisory bodies such as NSC and SORC, by which the TPC seeks to make the best use of in-house and external expertise in safety matters. We stress the point that committees of this kind can only act in an advisory capacity, and do not relieve the management of any of its safety responsibilities.

## 7. Radiation Protection

When human activities, such as operation of nuclear power plants, generate radiation in addition to that which exists naturally, measures are taken to protect against the possibility that the added radiation can be harmful. This is done by ensuring that the added amounts of radiation exposure are very small. Limits have been set by such bodies as the International Committee on Radiation Protection (ICRP) at levels well below those that have been shown to be harmful. In addition, the practice everywhere, including in Taiwan's nuclear power industry, is to make sure that radiation exposures are much lower than the ICRP limits, and are as low as reasonably achievable.

Of course, radiation levels can never be absolutely zero, because of natural sources. There is no scientific evidence that these low levels of radiation from natural sources are harmful, and there is less reason to believe that the smaller amounts of radiation the public may receive from activities at nuclear plants could be harmful. The amount of radiation from radioactive material released from nuclear power plants to the environment throughout the world is very low compared to that from natural sources.

We find that Taiwan's record with respect to release of radioactive material into the environment is very good, because the amounts of radioactive material released from Taiwan's nuclear power plants are very low. We also find that the TPC has programs to reduce these releases even more.

On the other hand, the Institute of Nuclear Power Operations (INPO) has made recommendations concerning means of improving radiation protection measures in the nuclear power plants, which should be strictly followed.

Higher level management should make its dedication to good radiation protection practices in the plants more forceful and more recognizable, especially to the staff of the nuclear power plants. A special position of responsibility for radiation protection should be created in the TPC headquarters in Taipei, with a level of importance high enough to ensure success of the program.

Steps should be taken to achieve a high level of professionalism of the radiation protection staff. Training and qualification should be improved. Consideration should be given to organizing an active Taiwan chapter of the Health Physics Society.

Attention should be given to educating the public about the effects of nuclear radiation, with comparison of radiation levels caused by nuclear plants with actual background radiation levels in Taiwan. Material could be prepared for use in general education courses at high schools and universities.

## 8. Training

Experience has shown that human factors play a major role in the prevention of nuclear accidents, and it is widely accepted that personnel training and retraining are essential components of nuclear power plant safety. This fact has been recognized by the TPC from the beginning of its nuclear program, as demonstrated by the installation of a training simulator at Chinshan before the first fuel-loading. The training program has been endorsed by the AEC through the issuance of operator licenses after adequate examination.

Some shortcomings in the TPC training programs have been identified in the recent past, mainly through INPO visits. These shortcomings have been addressed by the TPC. They have added a sixth shift at two plants in order to make enough time available for retraining operating staff, and intend to do the same at the third plant. They have decided to update the existing simulators, and have started a long-term training improvement program, consistent with the corresponding INPO criteria. These actions should be speeded up and strengthened, by taking advantage of what has been done elsewhere in the world.

We support the endeavors of the TPC to improve all aspects of training. It must be realized that they will require increases in manpower and funding, which are entirely justified by the safety importance of the issue.

There is an urgent need to enlarge training programs for personnel other than control room operators, especially maintenance staff. In a nuclear power plant, no one should be assigned to a task with potential safety implications without appropriate qualification. We recommend for that purpose the increased use of specific aids, such as mock-ups.

There is a shortage of instructors of high quality. We believe that the TPC should make the necessary effort to solve this problem promptly. This may imply raising the salary structure to attract qualified candidates. To help alleviate this shortage, use could also be made of university faculty to teach courses in basic fundamentals.

It is important that the retraining period is used to make sure that the operating personnel have a good knowledge of the plant's technical specifications, i.e. of their rationale and the potential safety consequences of violations. This is an essential component of the safety culture needed in all nuclear activities.

## 9. Probabilistic Safety Assessment

During the last 15 years, a technique called Probabilistic Safety Assessment (PSA) has been developed to give a quantitative measure of risk. Although the calculated risk has a significant uncertainty associated with it, the technique does point to the dominant contributors. This permits the safety analyst to identify system improvements which will be most significant in further reducing risk. PSA's have been performed on the Kuosheng and Maanshan plants, and one is underway on the Chinshan plant. We are pleased to find that the completed PSA's have led the TPC to suggest a number of plant improvements. Some improvements have already been completed, and others are still in the planning stage. Among the most important still in the planning stage is improvement of the emergency power supplies at all sites. This is particularly valuable for external events such as earthquakes and typhoons. We urge early completion of this improvement.

The PSA's provide information valuable for developing an accident management program. Such programs have two major goals. The first is to develop methods for using operational systems to provide core cooling if there were ever an accident in which core melt could be imminent. The second is to develop procedures for reducing the release of radioactivity if severe core damage were to occur (e.g. hydrogen control). It should be noted that the TPC betterment program already includes several projects that will improve accident management capability. In addition to the proposed improvement of reliability of electric power, other changes are envisaged. In the area of hydrogen control, projects are underway to inert the containments at Chinshan and to add igniters to containments at Kuosheng.

In general, we strongly encourage the TPC to cooperate in international programs that are developing accident management equipment and procedures, and to implement them when they become available. 12

We have not been able to verify the extensive calculations of the PSA's that have been done. However, in our review we have found that the methodology that has been used follows currently accepted practice. The inclusion of external events typical to Taiwan (earthquakes and typhoons) turned out to be particularly important since some of these were found to be significant contributors to the risk.

## 10. Betterment-Maintenance

We endorse establishment of the newly formed Onsite Engineering Group at each of the three nuclear power plants. This group is composed of individuals dispatched from the Nuclear Engineering Department at the TPC headquarters, and it maintains technical contact with its parent Department in Taipei. However, it is under the administrative supervision of the plant superintendent, so that the superintendent can establish close cooperation between the Group and his Betterment Division. This arrangement ensures that the superintendent has approval authority for design changes of his plant under the betterment program.

In a nuclear power plant, scheduled preventive maintenance should ensure that structures, components and systems continue to operate as intended, with their capability to meet the design objectives undiminished by ageing, wear, or other deterioration. We note that the TPC has engaged in a preventive maintenance program, which makes use of modern information systems. We endorse this program. Its results should be carefully followed and evaluated. Results on component reliability should be used for any revision of the PSA's.

We are pleased that the nuclear plants have been adopting computerized maintenance tracking systems. These systems have a semi-monthly print-out of incomplete items for the QC Division. This allows the requesting division to track the progress of the work.

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## 11. Operation

At all TPC plants, operating procedures and administrative control programs are set up to ensure safe operation. We find that certain practices are very good, such as the shift turnover procedure. However, it was not possible for us to make a detailed review in the short time available. We note that the TPC has invited INPO to visit periodically its nuclear power plants and to make appropriate recommendations. Past recommendations are being addressed by an action plan that the TPC is presently drafting. We believe that these visits should be systematically programmed, at least for the next few years, with the objective of covering all operational aspects in each plant. x

For the future, we believe that the TPC should implement an internal capability of organizing plant visits which would give to the management an internal independent evaluation of the quality of plant operation and of its safety level. External consultants could assist the TPC in the implementation. In the longer term, the visiting teams could consist of personnel coming from other TPC plants as well as representatives of the TPC headquarters. x

## 12. Operational Experience Feedback

We note that all of TPC's nuclear power plant superintendents realize the importance of implementing an efficient system for collection and interpretation of operational experience, to the end that no safety event goes undetected and that corrections are made to prevent recurrence of abnormal events.

We believe that a high priority should be given to the continuous evaluation of the effectiveness of this system. For instance, it should be verified that no unnoticed technical specification violation occurs, which would indicate that plant personnel are not appropriately trained. The analysis of significant incidents should be reviewed to ensure that the corresponding root causes have been properly identified.

The feedback system may require the assistance of the NOSD within the TPC headquarters, especially to assess the generic significance of incidents. For instance, we believe that the safety implications of the flooding which occurred in 1987 at Kuosheng during a typhoon deserved a more in-depth analysis.

We have the impression that the nuclear power plant staffs do not get enough benefit from operational experience abroad. This is not an uncommon situation, and it has been observed elsewhere. Nevertheless it should be improved. Improvements may imply the designation in each nuclear power plant of a staff member responsible for the practical implementation of such feedback. But we think that the NOSD also has a key role to play, by analyzing the events reported through INPO or from other sources, and presenting the staffs of nuclear power plants with the corresponding lessons to be learned, taking into account each plant's specific characteristics.

### 13. Emergency Planning and Emergency Communications

We note that an emergency plan has been developed by the TPC for each of the three nuclear power plants. The organization and technical support provided by this plan are quite consistent with international practice. It is anticipated that assistance from sources in United States might be requested if an accident ever occurred. It would be useful to investigate whether cooperative arrangements with neighboring utilities or vendors might also provide help.

The TPC has installed a comprehensive emergency communication system which includes an onsite Technical Support Center and a near site Emergency Operation Center at each plant, and the Central Emergency Control Center at the head office in Taipei. We strongly endorse this effective emergency communication system between the plants and headquarters which the TPC has developed. The installation of computer terminals at headquarters linked to the plant-specific SPDS systems plays an important role in this communication net.

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Attachment

Panel's Evaluation and Comments on the  
Following Specific Issues Are Solicited

A. Safety Issues Related with the Management at Taipower Headquarters

1. Evaluate the corporate culture in view of safety relevancy.
2. Comment on the suggested Taipower organization structure changes to improve accountability and functional responsibility in the plant safety and in the headquarters' support to plant safety. The changes are:
  - (a) Creation of a Nuclear Safety Department under the VP for nuclear power, and creation of a Nuclear Safety Deputy Superintendent at each plant.
  - (b) Redirect three plants under the ~~suspicious~~ of Nuclear Operation Department. *Group*
  - (c) Reassignment of responsibility of the repair and improvement project at plants.
3. Comment on the argument that the airborne within limit, per se, is not a significant safety concern, rather it reflects the culture and the deficiency in management control. This argument means to prevent any confusion of Taipower's attention to the operational safety by an over emphasis of airborne event.

B. Safety Issues Related with Safety Operation and Maintenance at Plants

1. Evaluate the adequacy of the maintenance policy and training as a key function of the nuclear operation department at corporate headquarters.
2. Evaluate the adequacy of procedure adherence and question attitude at the plants.

3. Assess the ACTUAL implementation of ALARA principle.
4. Assess the effectiveness of radioactive material control program.
5. Evaluate the application of operation experience feedback.

C. Safety Issues Related with Modification of Plant Facilities and Equipment

1. Assess the effectiveness of the repair and improvement programs at plants.
2. Assess the planned modifications in view of peculiar situation at Taiwan, like seismic events, typhoon, and small grid.
3. Compare the bases of the approaches for mitigating the consequence of severe accidents; and for a case study, assess the suggested modifications at No.1 NPP.