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2005 ANNUAL REPORT
ATOMIC ENERGY COUNCIL, EXECUTIVE YUAN

ATOMIC ENERGY COUNCIL, EXECUTIVE YUAN

Our Vision

Words from the Minister

The year 2005 has passed. I would like to thank all my colleagues for their effort and devotion during the past year. There is still plenty of room for improvement and it is my hope that all colleagues adhere to our main directives, so that we can move forward together when facing challenges in the future. As the old saying goes, it is as difficult starting a business, as it is carrying it on. Generally speaking, turning from adversity to prosperity might be easy, but from prosperity to superiority requires great effort.

We should always keep in mind that establishing simple and convenient procedures for the public is the primary consideration in streamlining our regulatory tasks. Our main objectives are to improve the quality of service, as well as to alleviate job burdens on our colleagues. Long irrational administrative procedures should be improved from both systematic and regulative aspects. All of the policies and procedures should be readily available for public inspection. The planning process for nuclear emergency exercises should also be transparent to the public. Furthermore, the theme of the exercises should follow the global trend of taking care of peoples' well being, instead of the previous blind belief in the so called 'survival zone'. Public servants, whose duty is to safeguard public safety through professional work, should provide genuine services.

By continuing to build a positive working atmosphere and fostering talents, character and teamwork are the foundation of sustainable development. During recent years, efforts by each coworker have come together to meet the approval of the public. I hope to encourage the consistent pursuit of teamwork as the core value of AEC. Following the principle of constant review and learning, our work in 2006 should focus on handling important matters. All events should be carefully scrutinized and improved. Each time period has its specific historical background. Solutions that seemed appropriate in the past might not apply to current situations. We should always look for a positive side. The implementation of our regulatory programs should reflect a safe, secure and reliable working culture at AEC and show the public our dedication through hard work and diligence.

Ouyang, Min-shen

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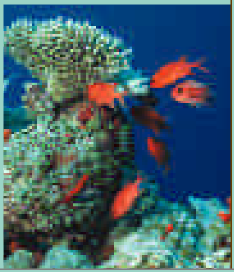
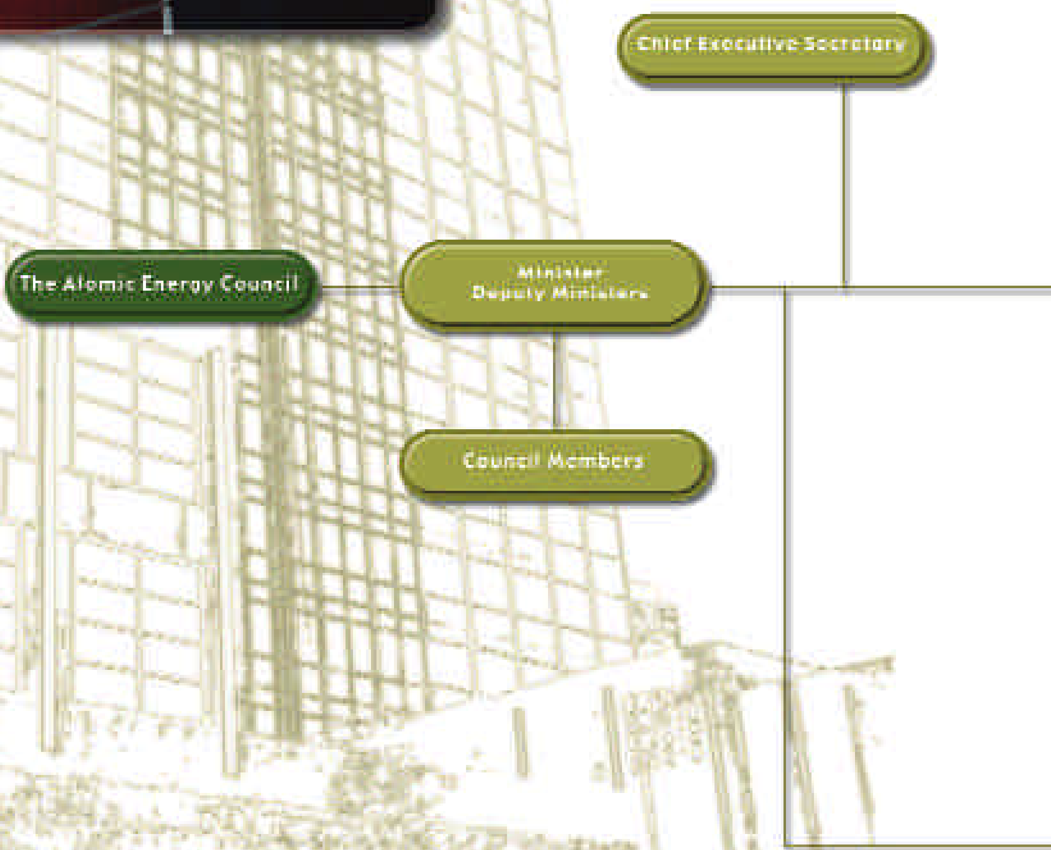


Organizational Structure



- Department of Planning
- Department of Nuclear Regulation
- Department of Radiation Protection
- Department of Nuclear Technology
- Secretariat
- Office of Personnel
- Office of Accounting
- Office of Security

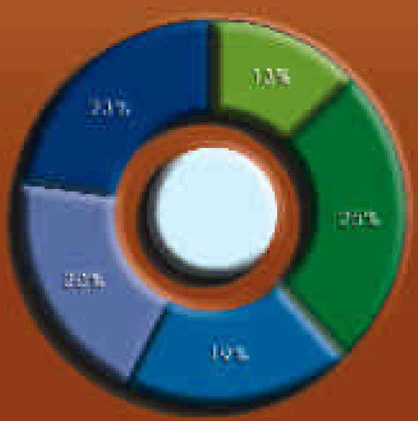
- Institute of Nuclear Energy Research
- Fuel Cycle and Materials Administration
- Radiation Monitoring Center

Advisory Committees

- Advisory Committee on Nuclear Facility Safety
- Advisory Committee on Ionizing Radiation Safety
- Supervising Committee on Nuclear Safety of the Lungmen Station
- Advisory Committee on Nuclear Accident Investigation and Evaluation
- Advisory Committee on Nuclear Legislation

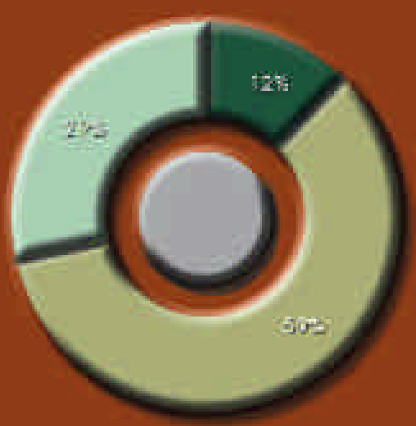
Manpower and Budget

The Atomic Energy Council of the Executive Yuan (AEC)



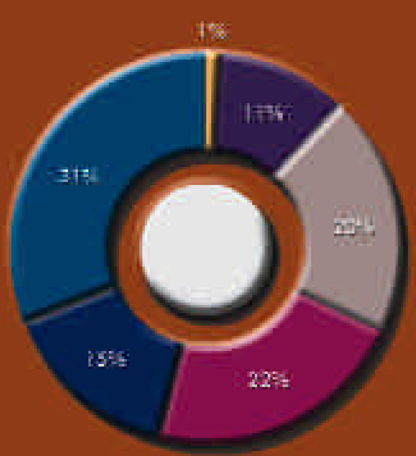
★2005 Human Resources Breakdown

General administration	39	(23%)
Atomic energy science development	34	(20%)
Ionizing radiation protection	33	(19%)
Nuclear installation safety control	44	(25%)
Nuclear technology applications	22	(13%)
Total	172	



★2005 Employee Ranking Breakdown

Selected appointment rank (10-14)	49	(29%)
Recommended appointment rank (6-9)	102	(59%)
Designated appointment rank (1-5)	21	(12%)
Total	172	



★2005 Budget/Expenditure Allocation

(Unit : Thousand NTD)

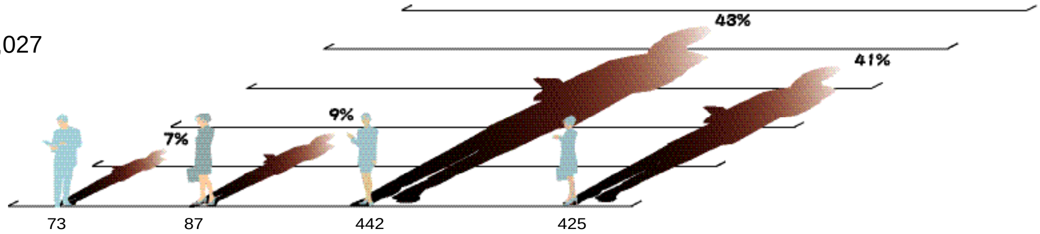
General administration	105,644	(31%)
Atomic energy science development	52,877	(15%)
Ionizing radiation protection	67,116	(20%)
Nuclear installation safety control	75,434	(22%)
Nuclear technology applications	37,271	(11%)
Equipment/facility acquisition	4,465	(1%)
Total expenditure	342,807	

◆ The Institute of Nuclear Energy Research (INER)

★2005 Human Resources Breakdown

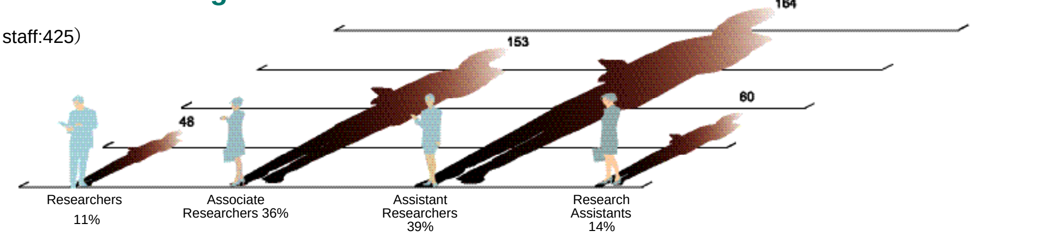
Research staff	425	(41%)	Administrative personnel	87	(9%)
Technicians	442	(43%)	Manual workers	73	(7%)

Total 1,027



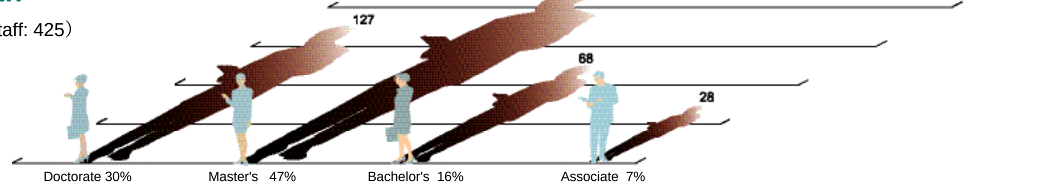
★2005 Research Staff Ranking Breakdown

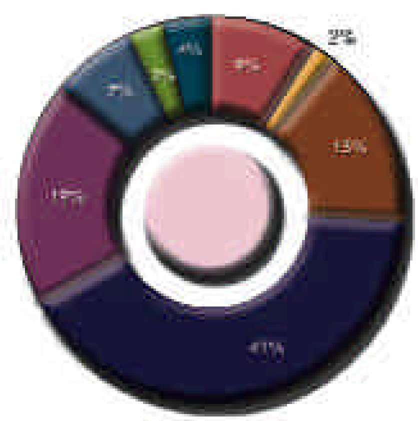
(number of research staff:425)



★2005 Academic Background of Research Staff

(number of research staff: 425)





★ 2005 Budget/Expenditure Allocation

(Unit : Thousand NTD)

General administration	90,902	(4%)
Strategic planning	60,608	(3%)
Facility operation and engineering services	175,101	(7%)
Research in radiation application technology	440,257	(19%)
Research in environment and energy technology	970,256	(41%)
Research in nuclear safety technology	346,656	(15%)
Academic cooperation in atomic energy science	54,042	(2%)
Fostering of nuclear technology applications	210,652	(9%)
Total expenditure	2,350,473	

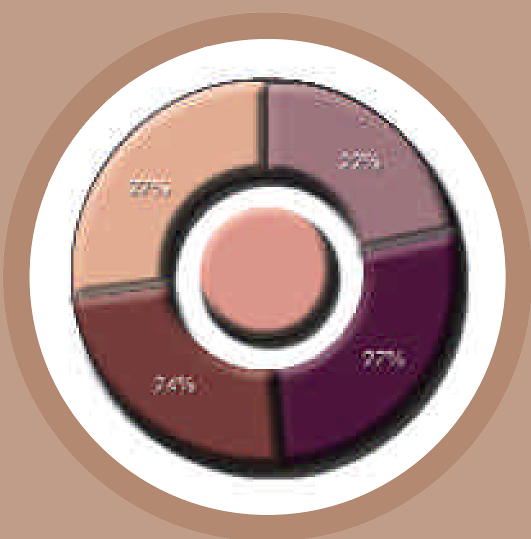
◆ The Fuel Cycle and Materials Administration (FCMA)

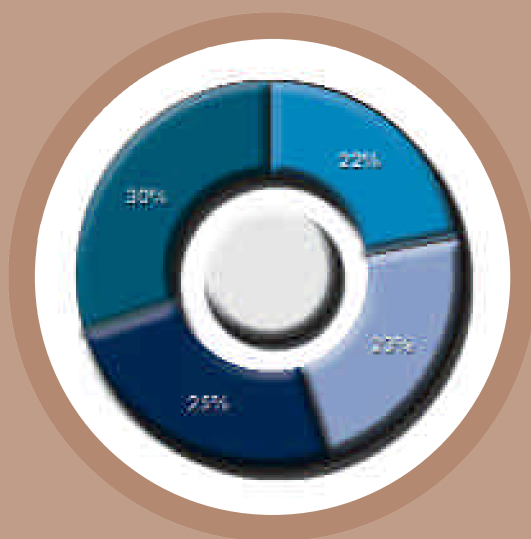
★ 2005 Human Resources Breakdown

General administration	10	(27%)
Radioactive materials administration	9	(24%)
Safety control of radwaste management	10	(27%)
Safety control of nuclear materials and radwaste from small producers	8	(22%)
Total	37	

★ 2005 Budget/Expenditure Allocation

General administration	19,590	(30%)
Radioactive materials administration	16,898	(25%)
Safety control of radwaste management	15,116	(23%)
Safety control of nuclear materials and radwaste from small producers	14,751	(22%)
Total expenditure	66,355	





◆ The Radiation Monitoring Center(RMC)

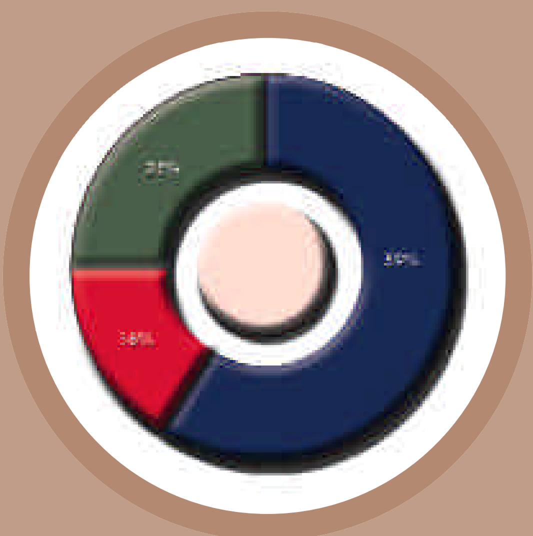
★2005 Human Resources Breakdown

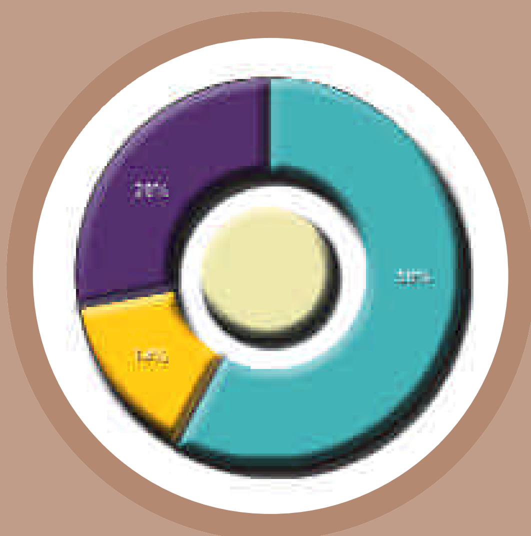
General administration	8	(25%)
Natural ionizing radiation monitoring	5	(16%)
Manmade ionizing radiation monitoring	19	(59%)
Total	32	

★ 2005 Budget/Expenditure Allocation

(Unit : Thousand NTD)

General administration	16,195	(28%)
Natural ionizing radiation monitoring	8,423	(14%)
Manmade ionizing radiation monitoring	34,128	(58%)
Total expenditure	58,746	





Department of Planning

Knowledge Sharing - Building a Diversified Knowledge Management Platform

The main function of the Knowledge Management Platform built by the Department of Planning is to classify internal knowledge of the Department, including knowledge documents that have been officially signed and digitized, such as policy plans, business reports, meeting minutes, SOP and research reports. They are then placed into the platform to be shared with all coworkers. Please refer to Figure 1 for the operational procedure of the platform. To evaluate the performance of the platform, an "online user survey" was conducted starting in September 2005. As of December, most of the respondents were very positive about the platform. By the end of 2005, visits to the platform amounted to over 1,500. Most users responded that the management platform made it easier to share knowledge and experience, and consequently increased the working efficiency of coworkers. The platform realizes the goal of improving administrative efficiency.

The most important assets of an organization are the people and organizational knowledge. The difficulty is managing the organization of knowledge well. The people in the organization are the key to utilizing the information in an effective manner. The information platform alone is not sufficient to do the job adequately. A closer examination of the design and operation of the platform reveals a successful prototype construction. With support from supervisors and cooperation from colleagues, the project target and measurement standard were clearly understood during the planning period, such that the main principles of knowledge management could be integrated with the contents of the platform.

The motivation for building this platform comes from the experience that " integrating knowledge management into an organizational culture is more important than constructing an expensive and strong information system" . It is also believed that knowledge learning in an organization does not stop at individual, instead, an organization that is formed by individuals, needs to enhance competitiveness through knowledge learning. The current knowledge management platform can be viewed as a prototype. In the future, more effort will be required to develop the

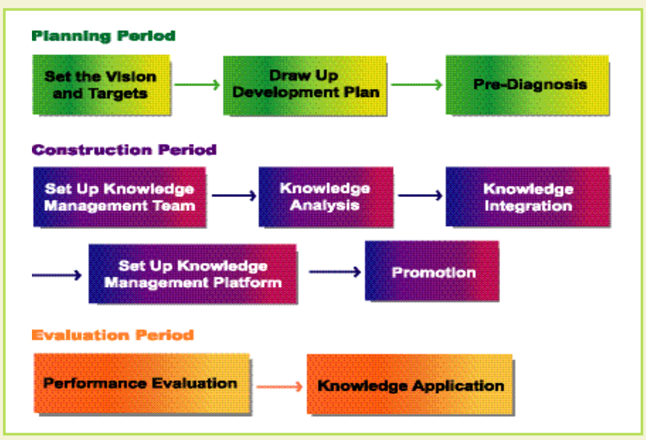


Figure 1 Operational procedure of the platform

platform into a reliable and user friendly system. It is impossible to realize expectations overnight. Success is a gradual and steadily developed process through carefully cultivated working attitudes and serious endeavor.

◆ Review of 2005 AIT-TECRO Conference of Civil Nuclear Cooperation

Since the Joint Standing Committee on Civil Nuclear Cooperation between ROC and the US was established in 1984, conferences held in turn by both sides have been grand annual events. Although the official exchange channel was blocked after the severing of diplomatic ties, the conferences provide a technological communication channel between the nuclear regulation agencies on both sides. The current cooperative fields cover a wide area including nuclear safety, radiation protection, nuclear civil application, nuclear waste storage and disposal, emergency response and information exchange, providing excellent opportunities for direct exchanges among nuclear experts.

The 2005 AIT-TECRO Conference of Civil Nuclear Cooperation was held by AEC during November 1-2, 2005 at the Howard International House of the Civil Service Development Institute. Taiwan's delegation was led by Deputy Minister Shian-Jang Su and the US delegation was led by Mr. Richard J.K. Stratford, Director of Nuclear Energy Affairs Office at the Department of State. About 80 people attended the conference. A total of 10 speeches, mostly introducing recent developments in various nuclear programs on both sides, were presented on the first day's plenary meeting and were followed by 3 parallel discussion sessions. The group discussions continued on the second day and conclusions were reached about a cooperative projects which were summarized at the closing plenary. After the conference, members of the US delegation visited the Lungmen Nuclear Power Construction Site of the Taiwan Power Company.

Figure 2 Deputy Minister Su Shieh-Chung gives an opening address.

Figure 3 Group discussion

Figure 4 Deputy Minister Yang Chao-Yie and Director Richard Stratford of the USDOS cohost the closing meeting.

Department of Nuclear Regulation

Red/Green Color Designation of Safety Significance

To make the operational safety of nuclear power plants more transparent and understandable, AEC has been making a steady effort for a nuclear safety color designation system since 2004. Green, white, yellow and red are used to indicate the performance of safety related systems and equipment in power plants. A green light indicates very low safety significance, a white light indicates low to moderate safety significance, a yellow light indicates substantial safety significance and a red light indicates high safety significance. Based on actual performance, AEC will also adjust its regulatory measures, such as increasing inspection frequency, strengthening control, and stopping the operation of the unit if necessary. The performance indicators have been published on website since 2004. In order to formulate a complete regulatory system, the Department of Nuclear Regulation set up an inspection findings indicators determination procedure for color designation in 2005, referring to the risk informed regulation of the U.S. Nuclear Regulatory Commission. In addition, from September to December, 2005, AEC started pilot inspections of Chinshan, Kuosheng and Maanshan nuclear power plants on three cornerstones of reactor safety: initiating events, mitigating system, and barrier integrity. The inspection findings indicators will be published on the website in 2006 so that the public has an easy access to undertandable information about AEC's nuclear safety inspections.

Lowering the Average Age of Licensed Nuclear Power Plant Operators

Domestic nuclear power operation technology has been matured over the past several decades. However, the average age of the licensed control room operators has increased steadily. The Department of Nuclear Regulation requested that the Taiwan Power Company (Taipower or TPC) review the personnel system and lower the average age of operators. TPC has proposed five options (Figure 5). After discussions between both sides, AEC has basically agreed with the Taipower's proposal for complete personnel system reform, i.e. to lower the average age together with providing training, promotions and job rotation. The Department has asked TPC to draw up implementation measures to carry out the reform carefully and smoothly under the prerequisite of ensuring safe nuclear operation. AEC has also requested TPC to provide an implementation plan as soon as possible. In the future, AEC will review the progress once every year.

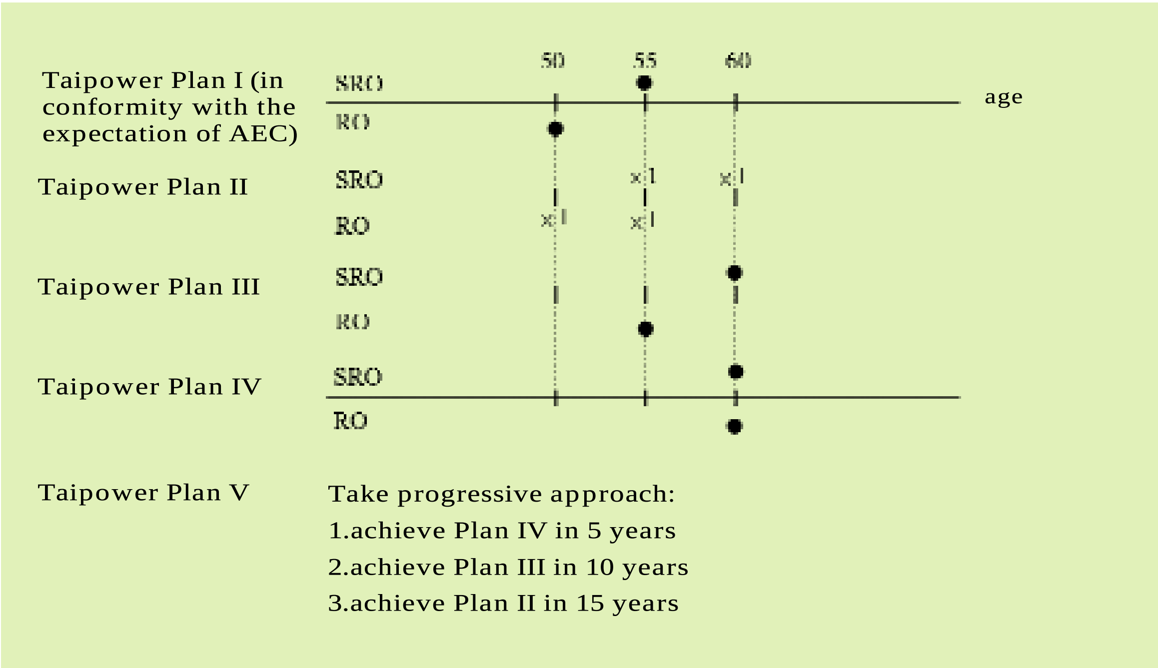


Figure 5 Plans to lower the average age of licensed nuclear power plant reactor operators

◆ Examination Question Databank for Licensed Nuclear Power Plant Operators

The safety of nuclear power plants is closely related to quality of licensed operators. The current examination system has already set a good standard for selecting qualified operators. To make the examination system more complete, transparent and stable, the Department of Nuclear Regulation has looked at past experience and feedback, as well as the practices of other countries, and is actively making an effort to set up an operator's examination question databank so as to make the scope and distribution of the examination questions more systematic. The question databank will also be published on the AEC website such that those willing to become nuclear power plant operators will have the required knowledge and techniques.

After receiving approval from the U.S. Nuclear Regulatory Commission (NRC) in 2005, the Department of Nuclear Regulation has been collecting and translating the 1,600 English examination questions related to boiling water reactor (BWR) used in the U.S.. To ensure the quality of the databank, the Department invited two nuclear training experts from TPC and six experts from the Institute of Nuclear Energy Research (INER) to help with the preliminary review. Final review was undertaken by five BWR examiners within the Department. The whole process lasted for half a year. In addition to email correspondence, four review meetings were held during the period; the entire process was completed smoothly. The databank has both Chinese and English versions, with answer after each question. Besides three volumes of the databank questions which are categorized under components (291 series), reactor theory (292 series) and thermodynamics (293 series), the databank is also published on the AEC website. The website also provides discussion and opinion feedback area for people interested in taking the examination to exchange opinions and be better prepared for the examination.

◆ Professional Training and Classification of Regulatory Staff

Nuclear power generation is a highly specialized area. In addition to front line operators who must possess specialized skills, the regulatory staffs who are in charge of formulating and enforcing nuclear regulations should also receive thorough training. To help the regulatory staff become more knowledgeable, starting in 2005, the Department of Nuclear Regulation invited domestic and overseas experts to hold seminars once every two weeks. The Department also planned a series of training program for inspectors, including basic training, advanced training, quality assurance training, and PRA application training. The total training period lasted for 16 days (96 hours).

It is AEC's duty to ensure safe operation of nuclear power plants thereby preventing the public from radiation exposure. Fulfilling this duty relies on the devotion of quality inspectors. Since the knowledge required for a nuclear power plant is quite diversified, it should be integrated to maximize the effectiveness. Therefore, the Department completed a Classification Procedure of Inspectors in 2005, classifying the inspectors into two levels: inspectors and senior inspectors. For each level, the Department also specifies the required expertise and training (including courses, individual study activities, and on-the-job training). The aim is to equip inspectors with necessary knowledge and skills so that they will be better prepared to do their job. In addition, inspectors showing good performance are endowed with the responsibility of passing on their experiences.

◆ Installation Inspection of Unit 1 Reactor Pressure Vessel (RPV) at Lungmen Nuclear Power Plant

Although the construction process of Lungmen nuclear power plant has been frequently questioned and the project has faced numerous challenges such as specification changes and budget allocation, through efforts of the whole team, the RPV of the Unit 1 was installed in March 2005. This was an important milestone for the over 20-year Lungmen project, signifying the completeness of the preliminary civil engineering process and the beginning of the main mechanical and electrical equipment installation of the project.

Since AEC is responsible for nuclear regulation, based on past inspection experience, AEC set up a special task force before the installation of the RPV to review the installation plan and the implementation process. During the inspection, TPC was requested to immediately correct any mistakes found by the inspection team. In addition, TPC was also requested to prevent making the same mistakes during Unit 2 RPV installation. In general, the installation of the RPV was satisfactory. Some construction techniques used in the RPV installation process, such as hoisting, is definitely outstanding in the world. However, there were still some deficiencies need to be improved. For instance, the installation method adopted by the CTCI Corporation was not in conformity with that stipulated in the construction procedure. AEC has compiled inspection findings and suggestions and asked the Lungmen Construction Office of TPC to take corrective actions. In addition, TPC has also reviewed the RPV installation process. If the experience of this installation can be reflected to the installation of Unit 2, the next RPV installation work is expected to be more smooth and efficient. Figures 6 and 7 show photos of the transportation and hoisting of the Unit 1 RPV at Lungmen.

Figure 6 RPV transport process

Figure 7 RPV hoisting process

Department of Radiation Protection

Amending Ionizing Radiation Protection Act

At the beginning of 2005, AEC studied the results and effectiveness in the enforcement of Ionizing Radiation Protection Act (IRPA). From both social and economic aspects, AEC acknowledged the trend and necessity to relax legislation. The following are ten issues to be discussed:

- Radioactivity contaminated buildings: an additional clause would grant medical, funeral and demolition-and-migration subsidies to residents living in buildings contaminated by radioactive material.
- Radiation practices and workers: radiation workers and practices are both defined in IRPA. Therefore, they should be taken into consideration when issues on training, badges and physical examination are reviewed.
- Radiation protection plans: simplification in currently submitted radiation protection plans will be examined.
- Administrative penalties: fines imposed over last two years for violations of IRPA are considered to be unbalanced with respect to damage in behavior, amount of fine, social expectations and burden on business owners. Therefore, a decrease in fines is being considered based on the law of proportionality.
- Radiation protection awards: the addition of awards as an incentive will be examined.
- Radiation protection examination: provide legal basis for this examination.
- Suggestions from the International Commission on Radiological Protection (ICRP): The necessity of amending IRPA again after reviewing the time lag among formulating national laws should be considered.
- Targets for inspection: Rules for regulated organizations outside the scope of radiation practice should be reinforced.
- Simplification of procedures: Requirements for documentation and detection certification should be relaxed such that they are kept by the facility operator.
- Entrusting issue: Amendment should be considered to allow implement of the law through entrusting authorizaion with shrinking annual budget and limited human resources.

AEC has established an " IRPA study and amendment working group" to draw up a draft of Amendment to Ionizing Radiation Protection Act. The number of articles expands from previous 57 to current 66 in the draft. The following are the main points of the amendment.

- The clause for radioactivity contaminated buildings is clearly specified according to residents's expectations.

- Radiation protection service providers and dose assessment organizations are included as targets for inspection.
- Violations of administrative procedures are fined based on degrees of damage.
- Specify that sub-laws under AEC's authority should be amended by AEC.
- According to the degree of damage, public expectations and loading of businesses, the amount of administrative fines is reduced to one tenth of the current level.

AEC will continue to solicit comments from various groups on the amendment of IRPA to make the amendment task thorough and complete - to provide better protection of public safety.

◆ Enhancement of Dose Optimization Program (As Low As Reasonably Achievable (ALARA)) of Radiation Protection at Nuclear Power Plants

The primary target for building 21st century radiation protection system is to provide suitable protection standards for people so that they are not excessively restricted from activities that are beneficial but involve radiation exposure. The realization of this target depends on three main principles: legitimization, restriction and optimization. Legitimization requires that the radiation practice should have obvious benefits. Restriction stipulates that the personal dose should not exceed regulatory limits. Optimization takes into consideration social and economic factors, all radiation exposure should be kept at the lowest level that is reasonable and achievable, i.e. the concept of As Low As Reasonably Achievable (ALARA).

ALARA is the basic principle of safety culture, and an essential element for successful radiation protection. Its application and technological advancement are helpful in evaluation and full implementation of measures to decrease doses to the public and radiation workers. The concept of ALARA emphasizes that the acceptable dose limits in radiation operations should be more restrictive than legal dose limits. The procedure for implementation requires full consideration of ALARA during the facility design stage. In addition, various types of suitable equipment, measures, information and management for radiation protection should be utilized during the radiation practice stage to reach the goal of minimizing radiation doses.

To best integrate radiation protection with modern risk management concept, the new international radiation protection trend is to set the " dose constraint " under the optimization principle as the "basic protection standard" with special emphasis on "Stakeholder Involvement" mechanism. Through participation of relavant individuals or groups, more effective and sustainable management decisions can be formulated based on mutual trust, value integration and an aim to settle conflicts. Facing future challenges, our country should

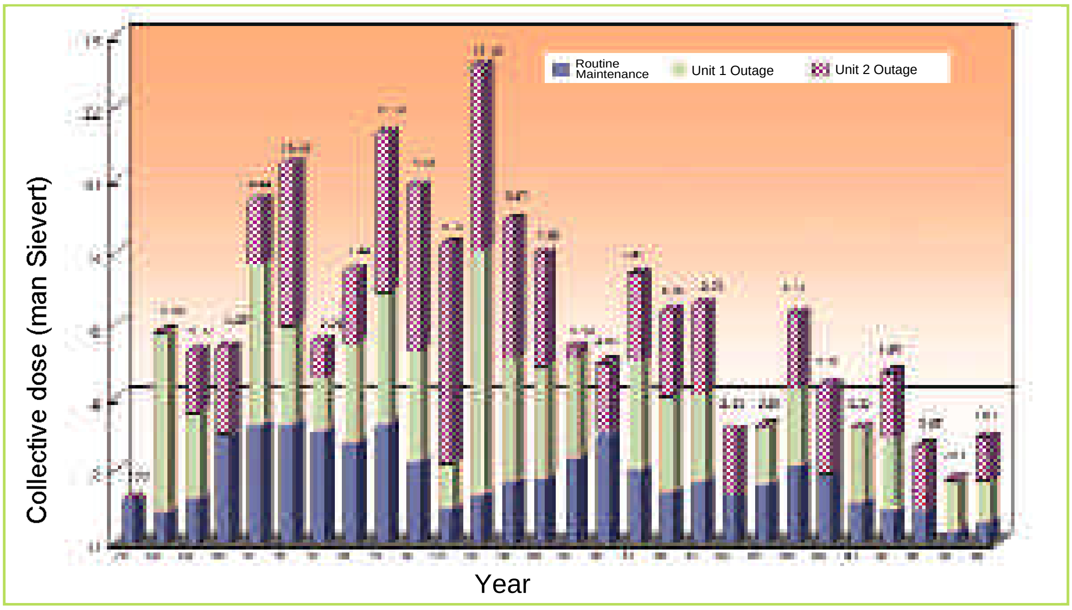


Figure 8 Yearly outage/maintenace personnel's collective dose at 1st nuclear power plant

expand the participation of individuals and entities related to radiation practice and protection, invest actively and consistently in the dose optimization program in radiation protection of nuclear power plants, strengthen safety culture and maintain necessary flexibility in radiation risk management.

Technologies and measures helpful for minimizing radiation doses, such as ensuring fuel integrity, extending fuel cycle, optimizing fuel outage period, implementing online maintenance, improving maintenance quality, chemical water treatment, pipe flushing and decontamination, as well as using low cobalt materials, should also be concertedly planned and implemented by relevant sectors to attain three-win target for nuclear safety, dose minimization and management performance.

◆ Implementing Advice and Inspection on the Task of Radiation Protection and Detection

In recent years, AEC has been actively formulating protective measures for radiation protection and advising private companies to undertake various radiation protection jobs. The aim is to maintain a well functioning radiation protection operation with a trimming-down in government manpower, cultivate private companies with adequate radiation protection and control capability, which serve the public on the frontlines. Since IRPA was enforced in 2003, AEC began drawing up related administrative management rules about radiation protection services to set standards for service quality of the service companies and specify their rights and duties while undertaking radiation protection jobs. By the end of 2005, a total of 39 radiation protection and detection companies received advice from AEC, and set out services to medical, academic, manufacturing, iron and steel, and construction industries, as well as the general public.

Currently, services provided by the radiation protection and detection companies include: 1) radiation protection monitoring of equipment capable of producing ionizing radiation, radioactive materials and related work places; 2) radiation safety assessment of work places with equipment capable of producing ionizing radiation and radioactive materials; 3) relevant radiation protection and detection of transport of radioactive materials; 4) consulting and back-check of the radiation detection practice of iron and steel makers; 5) radiation detection of buildings; 6) radiation detection of steel construction materials; and 7) reporting of abnormal radiation events. AEC inspected the operations of radiation protection and detection companies in 2005 and exchanged opinions with them. It was found that these companies were familiar with radiation protection regulations and detection techniques.

In 2005, the radiation protection and detection companies inspected 5,785 pieces of equipment capable of producing ionizing radiation and 4,461 pieces of radioactive materials. In addition, they surveyed 5,569 buildings and 9,668 tons of steel construction materials, among which 17 buildings were found to have abnormal radiation and 34 cases with abnormal radioactive materials were discovered in steel. AEC requested that buildings with abnormal radiation be listed under control and abnormal radiation materials be recalled and stored properly. Radiation protection and detection companies have demonstrated their ability to detect abnormal radiation levels, and effectively prevent the occurrence of abnormal radiation events. In the future, AEC will continue to assist radiation protection and detection companies to improve their radiation protection capabilities. Furthermore, in order to prevent the recurrence of abnormal radiation events, AEC plans to enhance professional knowledge of radiation protection workers through on-the-job trainings and seminars on new radiation protection knowledge.

Fig. 9 A portal type radiation detector is used to check for radioactivety in scrap metal.

Fig. 10 A radiation detector installed on a scrap metal sucking truck

◆ Promoting Regulatory Control Program for Quality Assurance of Medical Exposure

The focuses of 2005 regulatory control program for quality assurance of medical exposure undertaken by AEC include: 1)discussion of regulations and practical issues with representatives from medical societies; 2)establishing the principle of using review as main control method with inspection as complement; 3)holding meetings to explain and discuss medical exposure quality assurance regulations in Taipei, Taichung, Kaohsiung and Hualien; 4)formulating and announcing guidelines for preparing quality assurance plans for medical organizations to follow; and 5)completing review of quality assurance plans and providing consultation to 55 medical organizations, and further collecting the data and analyzing the results, thereby achieving the goal of assisting medical institutions to establish a medical exposure quality assurance operational system. AEC also held the 2005 Seminar on Medical Exposure Quality Assurance, during which advisory results and experience feedbacks were presented to the relevant medical organizations.

Fig. 11 AEC personnel conducts review of exposure quality assurance operations.

Fig. 12 Deputy Minister Su speaks at the 2005 Seminar on Medical Exposure Quality Assurance.

AEC actively participated in domestic and overseas conferences on medical exposure quality assurance, taking the opportunity to collect the latest information and exchange opinions with domestic and overseas experts. These activities fulfilled the professional training of employees and helped improve their control quality. In addition, AEC completed a policy plan for implementing the medical exposure quality assurance program. In the future, AEC will continue to perfect the medical exposure quality assurance operations from both legislative and systematic aspects. The legislative side covers the overall improvement of the scope and depth of the medical exposure quality assurance program. Radioactive diagnosis and nuclear medicine will be included in the medical exposure quality assurance control program. The systematic side focuses on establishing an advisory and checking platform.

◆ Providing Advisary Services to Sales and Service Providers of Radioactive Sources

■ Source management - improve radiation safety for the public

Sales and service providers of radioactive sources are direct channels for users to get radiation protection information. Equipping sales and service providers with correct knowledge of radiation protection regulations will effectively enhance the radiation safety of users and the public. Sales and service businesses were formally under control after the enforcement of IRPA. As a result, AEC started providing advisory services to sales and service providers in 2005.

Providing active services

AEC offered six courses to business owners and their radiation protection employees on various topics based on approved sales items and types of work places, and issued certificates of continuing education to the persons attending entire courses. On-site advisory services are provided to those businesses owners who have radiation work places, produce or manufacture radiation sources, or sell unsealed radioactive materials. They are required to turn in written documents for review first in order to shorten the whole inspection time.

Enhancing interaction with business representatives

On-site advisory services start with presentations by AEC on relevant regulations, practices of establishing self management and review, and counter service procedures for application of medical radioactive sources. Following the presentations are discussions with business representatives, during which AEC replies to every question. For problems involving legislative amendments or those difficult to implement, AEC follows the amendment procedures to revise the related enforcement rules and simplify administrative operations after the meeting. Good interaction between AEC and businesses create a win-win situation for both sides.

Relaxing legislative restrictions and establishing simple and convenient procedures for the public

AEC will continue with such practices to strengthen professional skills and self management capability of businesses so that they will become the frontline safeguard of radiation safety. AEC will also continue to take comments on regulative amendments from businesses for future legislative and administrative reforms.

Fig. 13 Random check of shipping containers for dangerous objects

Department of Nuclear Technology

◆ The First Domestic Dirty Bomb Field Drill - 2005 Kaohsiung Dirty Bomb Explosion Response and Rescue Exercise

AEC is in charge of responding to radioactive terrorist attacks. On August 18, 2005, AEC and the Kaohsiung City Government held the first dirty bomb field drill at the China Steel Corporation (CSC).

The aim of the field drill was to help local governments bring "radiation emergency response operations" into the current disaster response scheme so that they are better prepared to deal with unpredictable disasters. Peacetime training and field drills were used to enhance the emergency response capabilities of various organizations to minimize the disastrous consequences. The field drill used the CSC site for a mock response to a terrorist bomb threat. The pretend bomb exploded and was found to contain radioactive materials.

The AEC Nuclear Safety Duty Center was alerted and asked to send staff to support with radiation monitoring. According to the allocation of tasks, the Nuclear Safety Duty Center notified the Radiation Monitoring Center to offer support at the accident site. The first stage of the exercise included evacuation of CSC and actions taken by the Kaohsiung City Government Joint Incident Command Post. The second stage exercise featured on-site response, including fire fighting, saving the injured, radiation monitoring and control and cleanup. Organizations which participated in the exercise included CSC, the Kaohsiung City Government, the Reserve Command of Kaohsiung City, Chung-Ho Memorial Hospital (Kaohsiung Medical University), AEC's Radiation Monitoring Center and No. 39 Chemical Group of the National Army. The number of people attending was around 200. Scenes of the field drill were shown in Figures 14 to 17.

This field drill was the first dirty bomb explosion response exercise coordinated by both

Figure 14 Environmental monitoring of the accident site

Figure 15 Establishing control Zone

Figure 16 Saving the injured

Figure 17 Cleanup

central (AEC) and local governments, and also the first experiment to extend the anti terrorist system to areas outside nuclear power plants. Incorporating the experience accumulated by nuclear emergency operations, the dirty bomb joint response scheme between central and local governments was set up to greatly improve anti-terrorist response.

◆ Formal Implementation of the Nuclear Emergency Response Act

Since the Nuclear Emergency Response Plan was approved by the Executive Yuan on November 6, 1981, it has been amended several times based on actual operations. As nuclear emergency response is closely related to public safety, it is greatly expected to be legislated. Considering that the nation has established a set of disaster prevention and relief schemes after the Disaster Prevention and Relief Act was promulagated, to effectively utilize the national resources, AEC incorporated the legislative scheme and spirit of the Disaster Prevention and Relief Act into the draft of the Nuclear Emergency Response Act.

The Act was approved by the Legislative Yuan and announced by the President on December 24, 2003. It cnatins 7 chapters, including General Principles, Organizations and Responsibilities, Preparedness Measures, Response Measures, Recovery Measures, Penal Provisions and Supplementary Provisions, with a total of 45 articles. The main points of the act are listed below:

- At the time of emergency, AEC shall establish a National Nuclear Emergency Response Center to organize and command, under which are the Radiation Monitoring and Dose Assessment Center activated by AEC, the Nuclear Emergency Support Center activated by the Ministry of National Defense and the Regional Nuclear Emergency Response Center activated by local governments;
- Establishing a nuclear emergency command system. The central authority is responsible for issuing orders for public protection actions, the local governments are to act in accordance with the commands;
- Specifying the duties of nuclear reactor facility operators and penalties for violating the regulations; and
- Setting up a Nuclear Emergency Response Fund to deal with expenditures of emergency responses.

Since January 2004, AEC started inviting relevant ministries, local governments and TPC to discuss releted regulations and rules. Enforcement Rules of the Nuclear Emergency Response Act were approved by the Executive Yuan on April 15, 2005 and formally entered into force on July 1, 2005.

◆ Attitudes and Views - the 2005 Nuclear Emergency Exercise

The 2005 nuclear emergency exercise was held at three locations - Shi Men Village, Chinshan Nuclear Power Plant, and San Chih Village in Taipei County from July 18 to August 12, 2005. The following are special features of the exercise.

■ The exercise was practically and carefully designed, accomplishing four tasks:

- It verified the completeness of the response procedure after the Nuclear Emergency Response Act was implemented;
- In accordance with the Local Government Act and Disaster Prevention and Relief Act, some parts of the exercise were led by the local governments;
- It was the first exercise to seperately issue news releases, testing the staff's capability to deal with an accident and emergency news; and
- It was the first exercise that required a nuclear power plant to practice for a severe nuclear emergency procedure to strengthen its emergency response capability.

■ The exercise provided training for officials and communication with the public.

The first week of the exercise was scheduled for public communication and responder training. Representatives from the participating organizations were interviewed by broadcasting company "BCC" to explain features and focuses of the 2005 Nuclear Emergency Exercise. The nuclear emergency exercise was advertised more than a hundred times (30 seconds each) on BCC. Staff members from San Chih, Shi Men and Chin San township offices and village leaders were invited to attend workshops on nuclear emergency to explain radiation protection measures and emergency response plans, with on-site display of radiation assessment apparatuses. A total of 310 people showed up in the workshops. In addition, the nuclear emergency response and narrator training was held twice during the year to provide a communication platform for different organizations and personnel. The participants used the opportunity to test their familiarity with different tasks and review the response operations. Nearly 70 people attended the training sessions.

■ The exercise was a full scale mobilization and test of response capabilities.

The on-site plant response exercise was held at Chinshan Nuclear Power Plant during the second week. The exercise included emergency response, anti-terrorist and fire fighting and severe nuclear accident response. It provided the participants from AEC, TPC, the NPP and other organizations an opportunity to become familiar with emergency notification and handling procedures. A total of 810 people participated in the exercise.

The third week included facility and equipment auditing and a mobilization exercise. The auditing work focused on the operational facility of the Radiation Monitoring Center (North Taiwan), radiation monitoring apparatuses, sampling and analysis equipment and public warning system, to ensure the reliability of their functions. The auditing also included the emergency accommodation facilities of the Taipei County Nuclear Emergency Center and San Chih township office to verify their accommodation ability at the time of emergency. In addition, through coordination by the Department of Health of the Executive Yuan, the auditing team went to the Taipei Veterans General Hospital to observe the processing procedure for radioactive injuries, and related equipment and facilities.

Notification and mobilization exercises involved notifying team members according to a preset schedule, after each emergency response center received an emergency report. This exercise examined the coordination between different centers and within each organization, and practiced the procedures of notification and mobilization. A total of 297 people were mobilized.

The exercise consisted of several well-designed field drills.

Field drills were conducted in the fourth week. On the morning of August 10, the radiation monitoring center was the first to conduct a field drill. In addition to going through the procedures under varying situations, the drill included environmental monitoring, sampling and analysis, and dose assessment. The aim of the drill was to familiarize the participants with related procedures and actual operations so they would be able to take appropriate response measures at the time of an emergency. A total of 96 people attended the drill.

On the morning of August 11, the Keelung Army Brigade conducted a response field drill under various situations (such as setting up facilities, taking shields, taking iodine tablets, treating radiation injuries, evacuation, and dismissing centers) and held video conference discussions. A total of 91 people attended. The drill in the afternoon simulated rescue procedures for car accident injuries during evacuation of a nuclear emergency at the Chinshan NPP. A medical station was set up at San Chih Public Junior Middle School to deal with inspection and decontamination, injury classification, injury rescue and injury transfer. The handling procedure for transferred injuries was practiced at the Tamshui Branch of Mackay Memorial Hospital. This field drill allowed the participants a chance to become familiar with response procedures and set up a close support scheme between different organizations. A total of 186 people attended.

At 9:00 -10:00 on the morning of August 12, staff from the Taipei county government and

Shi Men township office set up a command post at the Shi Men emergency response center. The procedural drill also included alarm notification, vehicle broadcasting, and an indoor sheltering exercise for the public. A total of 56 people attended.

The procedural drill of the joint incident command post of the National Nuclear Emergency Response Center was conducted at 10:00 -12:00 on the morning of August 12. The drill simulated a discussion between commander in chief about condition reports for the accident with representatives from other participating organizations and made final decisions on response measures. The command post was instantaneously connected with the nuclear power plant and the command posts of all the emergency centers through video conference system. In addition, to maximize the effect of training and promotion, films about the actual operations were shown during the drill to let the drill participants have a real feeling for the actual operations. A total of 50 people attended.

■ The exercise achieved desired outcomes.

The 2005 Nuclear Emergency Exercise held by AEC's Department of Nuclear Technology, joined by participants from other departments of AEC, the National Nuclear Emergency Response Center, local nuclear emergency response centers, support centers, the radiation monitoring center, hospitals assigned to deal with radiation emergencies and the Taiwan Power Company, was successfully closed. The total participation was 1,622 person-times. In addition, the emergency response staff from different organizations, local public, public representatives and teachers attended the public statements held before and after the exercise, totaled 653 person-times.

The 2005 Nuclear Emergency Exercise was the first one after the Nuclear Emergency Response Act came into effect. Although disturbed by two typhoons, it was still successfully completed through quick coordination and close cooperation of all participating entities. The nuclear emergency exercise platform achieved its aim to improve communication with the public about radiation protection knowledge. Figures 18 to 21 are photos of the exercise.

Figure 18 Joint incident command post drill.

Figure 19 Injury rescue drill

Figure 20 Workshop

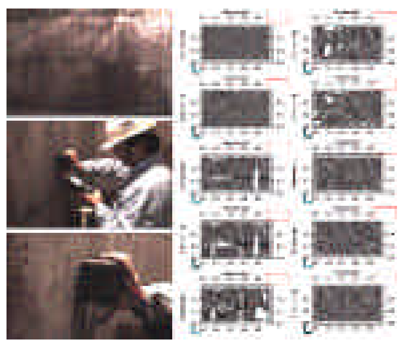
Figure 21 Local emergency response center drill

Institute of Nuclear Energy Research

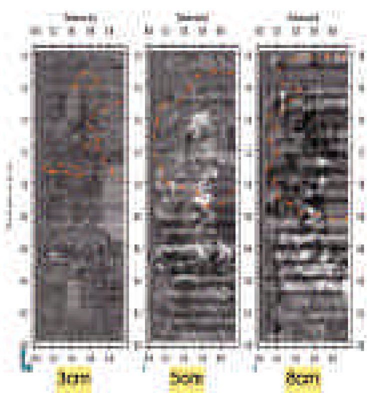
The Development of O&M Technology for Nuclear Power

As the leader in domestic nuclear technology research, the Institute of Nuclear Energy Research (INER) has established international credibility in the areas of fuel damage root cause analysis, safety analysis of digital instrumentation, risk monitoring system and severe accident analysis. INER is also competitive in the areas of reactor core loading design, safety analysis, thermal performance analysis and monitoring, fuel inspection, nuclear grade item verification, non-destructive testing and simulator upgrade. The strong international competitiveness prevents a technological and commercial monopoly by foreign companies. In addition, INER has set up regulation technology that provides service to AEC directly. The strategic plan of INER's Nuclear Safety Technology Center is to provide self-developed technology with imported ones and seek strategic technology alliances with both overseas and domestic organizations. After setting up technological capabilities, the Center will actively serve the domestic nuclear community, including TPC and AEC for the short term. In the long run, the Center plans to

Use DPC sensor to detect the damage of broken reinforced concrete plate



Integrity evaluation for the concrete of the spent fuel pool in Maanshan Nuclear Power Plant, using C-scan tomography to display the sectional graphs of different depths



Use DPC sensor to B-scan a pre-cracked 40cm-thick reinforced concrete board and produce sectional profiles (e.g. the following three graphs). The position of the internal horizontal cracks can be seen in the graph (yellow dotted line)

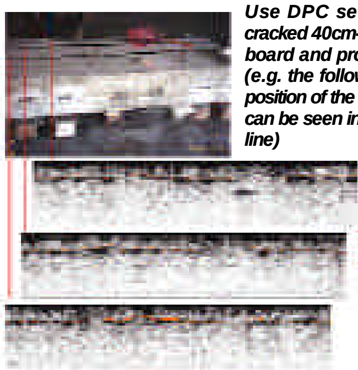


Figure 22

provide technical services in the form of incubation, authorization or technical transfer depending on market demand and scope. The following gives a detailed introduction of reactor core management and safety analysis, inspection, instrumentation upgrade and safety, as well as PRA application and national radiation standards.

Concrete ultrasonic computer tomography

Non-destructive testing refers to examination of the quality of a test object without damaging its original features or usability. Nowadays, the public is paying more attention to the quality and safety of public construction and building structures. To test the strength and internal defects of the structure for safety assessment and maintenance, INER has developed several complementary concrete non-destructive testing technologies, which have been successfully applied in the quality control of new constructions and aging and deterioration diagnosis of existing buildings. The development of these technologies is significant to enhance the quality control of domestic constructions and to maintain public safety.

Risk significance evaluation of nuclear power plants

Risk informed regulation has been gradually adopted by international nuclear power plant regulatory agencies. It emphasizes incorporating results from risk analysis into the traditional regulatory philosophy of in-depth defense and safety margin as the decision making basis for regulatory affairs. Under the prerequisite of maintaining safety, the aim of risk informed regulation is to allocate regulatory resources to the most important issues about safety in order to maximize the regulatory effect and alleviate unnecessary burdens laid on the regulatory agencies and the operators. Risk informed regulation uses Probabilistic Risk Assessment (PRA), also known as Safety Assessment to quantify risk. This assessment tool can be summarized under three questions: "What can go wrong?", "How likely is it?" and "What are the consequences?" It also requires a thorough understanding of the system characteristics to propose a reasonable risk assessment result that conforms to the real situation. Although this evaluation tool uses probability as its analytic language, the analytic process is based on actual events and statistical data. It is also able to combine expert opinions, thus providing a wide scope of information to decision makers.

Figure 23 PRA Model Based Risk Significance Evaluation (PRiSE)

Technology and application development of the nuclear digital instrumentation system

Digital instrumentation, combined with information technology, is used in automatic or manual operation of nuclear power generation and plays a key role in economic development.

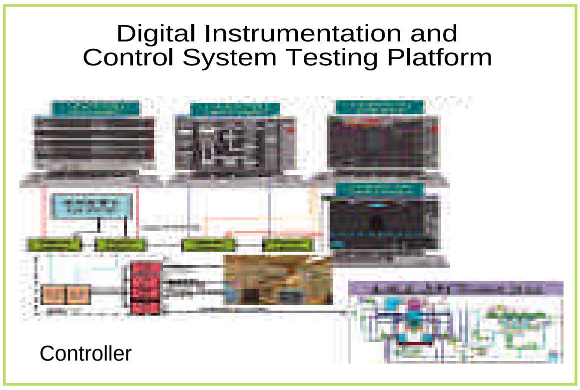


Figure 24 Simulation analysis of digital feedwater control system

• *Application for testing platform*

The advantages of digital instrumentation include easy collection of information, flexible design, as well as meeting the requirement of coping with diverse environmental changes. In a nuclear power plant, a testing platform, composed of such hardware equipment as a control processor, workstation and network switch, is set up to performs sensor and equipment (pump and valve) operational environment simulation, control tactical simulation (Figure 24), software installation and verification, and operational procedure analysis and verification.

• *Application achievements and future research direction*

The nuclear safety analysis software received international recognition at the Computer Based Systems Important to Safety Conference (COMPSIS) held by the Nuclear Energy Agency under the OECD. To further enhance the software quality, risk assessment technology will be used to identify and remove bugs hidden in the software design. As a result the operational reliability and safety of nuclear power plant will be improved.

Nuclear fuel management and safety analysis

Reactor core management and safety analysis is closely related to safety, economics and operational flexibility of nuclear power generation. Furthermore, it involves the interaction between regulatory agencies, power companies and nuclear fuel suppliers. INER has created independent analytic tool to examine and verify suppliers' designs, provide analysis of power plant operational supports and clarify safety issues. Use of these tools can ensure nuclear safety and improve operational benefits.

• *Reactor core operation technology*

Major analytic tools used include CASMO-3,CASMO-4,SIMULATE-3,SIMULATE-3K,XIMAGE/SIMAN and other self-developed auxiliary interface programs. INER has successfully developed a set of pressurized water and boiling water reactor core analyses. The applications include: independent verification of fuel designs of different suppliers, power coast down analysis of the pressurized water reactor, parallel design and verification of nuclear power plant reactor core design.

• ***Safety analysis***

Major analytic tools used are RETRAN, RELAP and VIPRE. INER has completed the development of system safety analytic modes and methods for four local nuclear power plants and the application for AEC certificates is underway.

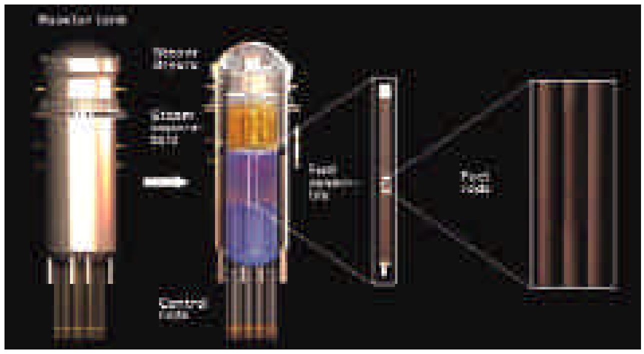


Figure 25 Cross-sectional view of nuclear power reactor core fuel

National standards of ionizing radiation

In 1992, INER was authorized by the Bureau of Standards, Metrology and Inspection to set up a National Ionizing Radiation Standard Laboratory. The main task was to establish and maintain the highest national radiation measurement standards, and provide a calibration standard for radioactive diagnosis, radioactive treatment, nuclear medicine, radiation safety, lab certification (capability test) and international comparison through mutual recognition arrangements. To date INER has established 12 national standards on physical quantity and 3 radioactivity standards on radiation sources. Out of the total established standards, 7 were self developed and the other 5 came

Figure 26 National Ionizing Radiation Standard Laboratory

Table 1 List of established measurement standards and application areas

Standard \ Application	Radiation Diagnosis	Radiation Diagnosis	Nuclear Medicine	Nuclear Medicine	Proficiency Testing	Mutual Recognition Arrangement
10-50 kV X-ray air kerma rate (primary)	V			V	V	V
50-250 kV X-ray air kerma rate (primary)	V	V		V	V	V
^{137}Cs γ-ray air kerma rate (primary)				V	V	V
^{60}Co γ-ray air kerma rate (primary)		V		V		V
^{60}Co γ-ray absorbed dose to water (primary)		V				V
^{90}Sr / ^{90}Y absorbed dose to tissue				V	V	
^{252}Cf ambient / personal dose equivalent				V	V	
^{241}Am-Be ambient / personal dose equivalent				V		
4πβ−γabsolute activity measurement system (primary)			V	V		V
4πγionization chamber			V	V		V
2πα/β proportional counting system (primary)				V	V	V
^{192}Ir reference air kerma rate		V				

Table 2

International Comparison	Future Prospects
After several years of hard work, INER has become a formal member to the Asia Pacific Metrology Programme(APMP) and the International Committee of Radionuclide Metrology (ICRM). INER is also an associate member of General Conference on Weights and Measures(CGPM). Joining the above organizations will help NRSL's participation in international comparison activities and the recognition from other national metrology institutes for its measurement capabilities and calibration reports.	NRSL will make economy- and civil-application-oriented plans for future development to improve the quality and safety of people's lives. And NRSL will strengthen the cooperation with universities and industries for personnel trainings and enhance research capabilities for measurement technology and calibration standards to produce comprehensive benefits.

from the national standards of other countries. In addition, the Lab passed the assessment of the Taiwan Accreditation Foundation in 2001, and because the first national standard laboratory in the Asia Pacific region to pass ISO 17025.

Real-time environmental radiation monitoring

Environmental monitoring, which involves collection of on-site environmental information to help with decision making and communication, is vital for environmental protection. INER uses PDAs to incorporate on-site monitoring results, digital images and GPS to obtain real-time positioning information. These data are transmitted to the administrative center through GPRS wireless transfer, and combined with GIS to provide a real-time display of environmental radiation monitoring results and on-site images. The image record improves the understanding of on-site situation, and also increases transparency of the monitoring process and credibility of the monitoring results. It is believed that the new system will become a standard environmental monitoring tool as the information technology becomes more common and mature.

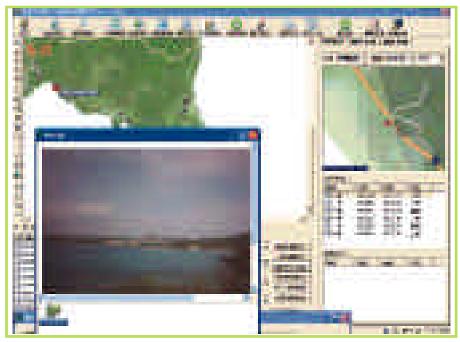


Figure 27 PDA image feedback from environment contamination investigation

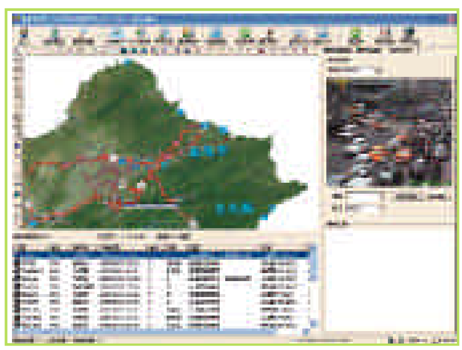


Figure 28 Real-time display of image and position

Radioactive Waste Disposal and Nuclear Facility Decommissioning Technology

To develop nuclear energy applications, it is also necessary to decommission nuclear facilities and dispose of nuclear waste. Within 20 years, domestic nuclear power plants might have to face this technological challenge. Therefore, INER invests in technological development of radioactive waste disposal and nuclear facility decommissioning. The aim is to establish advanced and reliable decontamination and decommissioning technology of unused facilities and accumulate relevant experience vital for ensuring environmental protection and public safety. Based on this target, INER carried out the following 6 projects in 2005:

Decontamination equipment set up for radioactivity contaminated metal waste

INER has set up decontamination equipment for radioactivity contaminated metal waste at a previous reactor building to deal with low level radioactivity contaminated metal produced during decommissioning. The target of the decontamination is to meet the cleanness standard established by radioactive waste regulations, or to change the classification level of radioactive waste to reach the goal of waste reduction and resource recycling. In 2005, INER first installed and tested the functionality of mechanical decontamination equipment and detergent solidification equipment. It was followed by a procurement process, detailed planning and design, and manufacturing installation and functional test of the above processing equipment. The cleanness measurement after decontamination was performed by the activity measurement system developed by the nuclear instrumentation staff of INER and installed at the end of the chemical decontamination process. After decontamination, washing and drying, the object enters into the cleanness measurement system for initial measurement Objects that pass the measurement are sent to cleanness measurement center for further verification. Objects that fail the measurement need to be decontaminated again or sent to a warehouse for storage.

Dismantling of the Uranium Conversion Test Pilot Plant

In accordance with the Radioactive Materials Management Act, INER carried out the

Figure 29 Sandblasting, polishing and mechanical decontamination equipment in quarantine

Figure 30 Chemical and electrochemical decontamination equipment

Uranium Conversion Test Pilot Plant (UCTPP) dismantling project in 2004. The project was completed in December 2005. Major achievements of the project include:

- Mastering the application and approval procedure for the nuclear facility dismantling (decommissioning) project and implementing the UCTPP equipment dismantling project according to law;
- Drew up 16 SOP documents for the UCTPP equipment dismantling operation;
- Completed the equipment dismantling of the UCTPP main building (036A) and related areas (036W, 036U, 036E and 036G). Approximately 1,500 m2 in building areas have been converted from "low radiation and low contamination controlled area" to "zero radiation and zero contamination area (monitoring area)";
- Effectively decreased the amount of radioactive waste. A total of 150,324 tons of waste (mainly steel) were dismantled, of which low radioactive materials accounted for 24,277 tons, or 16.15 wt% of the total; and
- Nuclear materials stored at UCTPP were safety relocated, satisfying IAEA's nuclear protection and prevention requirement.

Figure 31 Facility condition before dismantling

Figure 32 036A-100&200 area after dismantling

Research on free release characterization methodology of decommissioning waste

Following international practices, INER has set up a release characterization laboratory for decommissioning waste to solve the problem of very low level radioactive waste management. The laboratory has installed important assay system and established an inspection and verification procedure. It adopts multi-inspection procedures, and the concept of different detection modes, and screens out higher contamination to eusure that the activity concentration of standby clearance waste meet regulatory standards. In this way, the environment and public safety shall be assured, resource can also be effectively reused and the environmental burden will finally be relieved.

Major achievements in 2005 include:

- Detection procedure planning and proposed release plan: The comprehensive monitoring and inspection procedures and proposed release plan for dismantling large

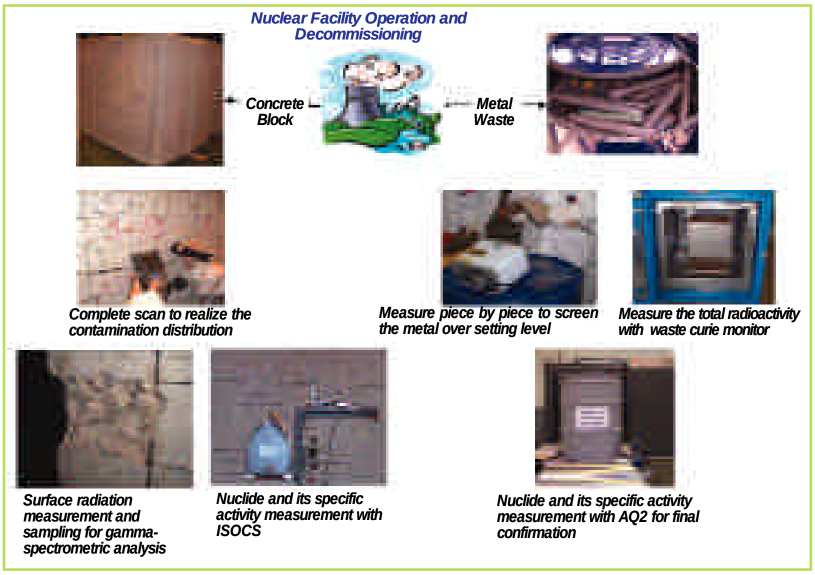


Figure 33 Free release characterization procedure for decommissioning waste

concrete blocks and drum packed scrap waste have been completed; and

- Total waste inspection system: The clearance assay system, in-situ gamma spectrometry and conveyor-type contamination screening system were set up for total waste inspection system. The accuracy and sensitivity has met regulatory requirements for inspection and verification of specific wastes.

Launching of the high-efficiency volume reduction and solidification system for wet waste treatment in Kuosheng NPP

To reduce the volume and improve the quality of solidified waste produced by boiling water reactor (BWR) nuclear power plants, INER's Chemical Engineering Division has developed BWR waste high-efficiency solidification technology (BWRHEST). By taking advantage of waste characteristics, the technology adopts a strategy - "using waste to solidify waste", to significantly reduce solidified waste in BWR nuclear power plants. The technology has not just received patents from a number of countries such as Taiwan, U.S. and EU but has a pending patent from Japan. It also won the Silver Medal from National Inventions and Creations of Taiwan in 2004.

After successful demonstration of the pilot system, Kuosheng NPP decided to build a high-efficiency volume reduction and solidification system in December 2002. System installation and the pilot test run were completed by the end of 2005. In addition to waste volume reduction, application of this system will further enhance the safety and reliability of the

Figure 34 High-efficiency volume reduction and solidification system for wet waste treatment in Kuosheng NPP

Figure 35Solid produced by pilot run of the high-efficiency volume reduction and solidification system waste solidification process. It is estimated that with this technology, the original volume of solidified waste in Kuosheng NPP will be reduced by at least 60%. INER solidification technology team, following the unprecedented and excellent volume reduction performance at Maanshan NPP, set another world record of volume reduction achievement for nuclear waste treatment.

Recycled water treatment technology

Figure 36 Recycled waste water treatment demonstration system

Figure 37 Waste water before treatment

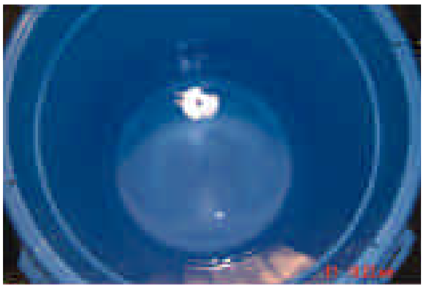


Figure 38 Waste water after treatment

Removal of total organic carbon (TOC) is important for saving water and reaching the target of zero waste water discharge as well as being helpful in improving long term operational security and reliability of the nuclear power plant. INER has successfully developed new TOC degradation technology, which has a special effect on removing organic contamination from waste water. After power plant simulation and testing with waste water, the technology has been verified to reduce the TOC concentration in water to less than 150 ppb. Water quality after using this technology is better than the TOC 200 ppb standard required by the EPRI 2000 version of the U.S.

Besides dealing with recycled water from the nuclear power plant, this technology also has very good effect on removing TOC of waste water produced by other industries. Water after treatment conforms to the regulatory waste water discharge standard (BOD<30 ppm, COD<100 ppm). The cost of the technology is also lower than that of the traditional methods, without secondary waste production.

Dry storage facility for spent fuel

INER was entrusted by TPC in July 2005 to purchase and install a dry storage facility for spent fuel at Chinshan NPP. Considering this being the first time for a Taiwanese organization to install a dry storage facility with severe time constraint, INER decided to transfer the technology from overseas and build the facility itself. The project is scheduled to last 6.5 years, ending in February 2012. Major tasks include:

- Obtain the technology from an overseas dry storage facility manufacturer, and transfer part of the technology to TPC;
- Conduct dry storage facility design and safety analysis, and assist TPC to apply for construction and operation licenses;
- Provide concrete foundation, civil construction and surrounding facilities necessary for installing a dry storage facility;
- Provide related equipment (including transportable storage canister, fuel basket, transfer cask, and vertical concrete cask) necessary for installing a dry storage facility;
- Load, transport and store spent fuel, as well as provide related equipment; and
- Provide software and hardware necessary for a dry storage facility.

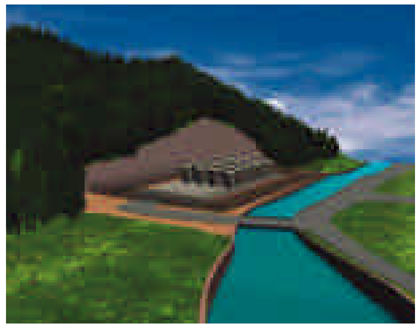


Figure 39 Bird's eye view of the future dry storage facility

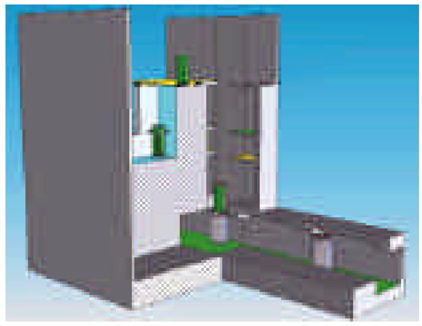


Figure 40 Future on-site operational diagram

Based on past experience and capability, INER-designated team can competently accomplish all tasks.

◆ Development and Application of New Energy Technology

In addition to exploring nuclear energy technology, INER also explores new applications and development of renewable energy. New energy technology is aimed at making contributions to the national energy structure for future CO_2 emission regulations and self produced energy challenges. During 2005, INER made great efforts to establishing key technologies and systematic displays, as well as setting up national renewable energy and new energy technological development centers, including a fuel cell research lab, solar cell research lab, new lighting source research lab, and renewable energy system integration testing equipment.

Important achievements of the year include: carbon nanotube (CNT) hydrogen storage, flat element solid oxide fuel cell (SOFC) development, processing technology of direct methanol fuel cell membrane electrode assembly (DMFC MEA), assembly and testing of fuel cell stack and its application in 3C electronic products, a wind power generation system, high efficiency III-V family solar cell, concentrator solar energy system, and a biomass energy conversion system.

CNT production and hydrogen storage research

Hydrogen is the best source of clean energy. It is the most abundant element in the universe. Its high specific energy content at 33.3 KWh/Kg is almost three times that of gasoline or diesel. However, hydrogen storage still cannot meet the application requirements with respect to efficiency, size, weight, price or safety.

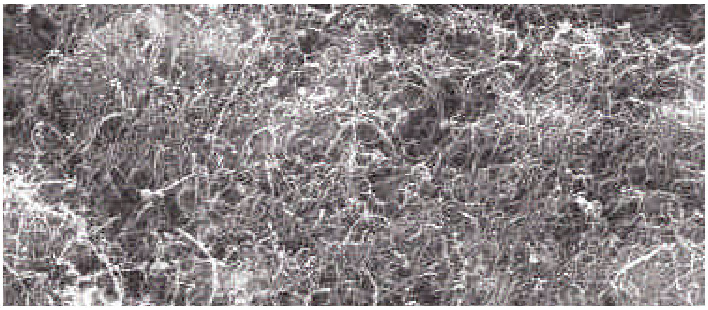


Figure 41 CNT growth using thermal CVD method

Figure 42 INER's high pressure TGA system

INER has established a distinguishing CNT synthesis and purification procedure. The highest hydrogen absorption amount can be as high as 3.3 wt%. To measure the hydrogen absorption amount, INER has set up the Sievert system based on volume, the thermal gravity analysis (TGA) system based on gravity, and the temperature programmed desorption (TPD) system based on desorption amount. It is expected that through a comparison of measurement results and establishment of SOP, INER will be able to set up a national standard lab that can measure hydrogen absorption for micro hydrogen absorbing substances and provide a domestic measurement comparison standard for hydrogen energy research.

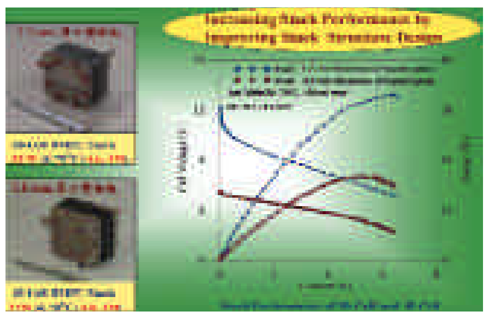


Figure 43 DMFC stack design, assembly and testing

DMFC System

The DMFC system uses methanol as its fuel. It is favored for its low contamination, low cost and easy transportation. INER has gone one step further to replace the stack electron panel's stainless steel with titanium to make the stack lighter, and reduce the thickness of graphite

Figure 44 INER 15W DMFC portable system

bipolar plate from 3mm to 1.7mm. The fuel leakage problem and stack stress have both been remedied. The DMFC stack effect has been greatly improved after design changes, with a power density increasing from 60W/L to 100W/L and an output power increase from 17W to 33W. Currently, this DMFC stack is intended for use as a power supply module for the DMFC power pack. In addition, INER is planning to develop a 15W DMFC power pack, including DMFC stack, BOP, fuel storage, transportation system and methanol sensorless control technique, to meet the requirements of 3C electronics products.

Wind power generation system

Figure 45 Wind turbine developed by INER

Taiwan is scheduled to have 2.16GW of wind power generation by 2010. By the end of 2005, generators with total installed capacity of 24MW were in operation. Approximately 600MW is planned or currently under construction. Wind turbines however, are all imported. Domestic manufacturers only provide towers and some small components. The aim of the 25kW wind power demonstration system project undertaken by INER in 2005 was to integrate the capabilities of industrial, academic and research institutes to design, manufacture and install a high-efficiency wind power demonstration system. The system will appear similar to a large wind turbine, incorporating tilt angle of the blade, a yawing mechanism, a safety brake and a maximum power point tracker (MPPT). The prototype will be completed within 8 months to display the feasibility of integrating domestic wind turbine technology.

Wind power generation has seen rapid development in European countries, such as Germany, Denmark and Spain. The technology promises to mature quickly. The U.S. and India are also catching upon establishing their own wind power industries. There is still ample room for growth in terms of wind turbine efficiency, cost, wind farm real-time forecast, stability of parallel connections with a network of electricity, development of offshore wind and engineering, and applications of wind power energy. The wind power industry has great development potential and deserves investment from domestic technology institutes and industry.

High concentration III-V family solar power generation system

The effective use of solar power has always been very important in the research and development of renewable energy. In recent years, solar power generation technology has received more attention. However, due to the shortage of polysilicon raw materials, the price of the traditional silicon solar cell continues to rise. A high concentration solar power generation system uses inexpensive condenser lenses to focus the sunlight onto small size high-efficiency GaAs solar cell to generate power (Figure 46). This system can effectively reduce the price of solar power generation system and improve its power generation efficiency.

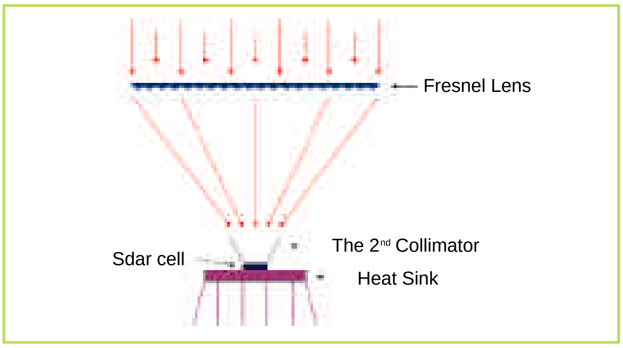


Figure 46 Structural diagram of concentration-type solar cell module

Figure 47 INER's 1kW high concentration solar power generation verification system

In December 2005, INER completed development of a 1kW high concentration solar power generation verification system (Figure 47). This is the second kW-class verification system using a condenser lens and III-V family high-efficiency solar cell worldwide, after the one installed by Concentric Solar GmbH of Germany in July 2005. The verification system has a concentration ratio of 100 times, and an energy conversion rate higher than 20%, which is better than the conversion rate of 10-14% of traditional silicon solar power generation systems. Several domestic LED and microwave manufacturers have expressed their willingness to participate in the research and manufacture of high concentration solar power generation systems. INER will work together with the local companies to establish domestic III-V family solar power generation industry.

High temperature SOFC power generation system

The advantages of high pressure SOFC are relatively high energy density, low pollution, and diversified fuel uses. The SOFC power generation systems designed by INER include: fuel and air supply systems of alcohol reformation for hydrogen production, SOFC battery stacks and high pressure heat exchangers. Figure 48 is a schematic diagram for the system procedure of the 1kW SOFC under development.

INER utilizes coating-sintering and plasma spraying methods to produce cell units. The present power rate per unit area is 80mW/cm^2. INER also tested cells produced by the foreign company InDEC and domestic company Leatec. The power rate per unit area is above 300mW/cm^2 (Figure 49).

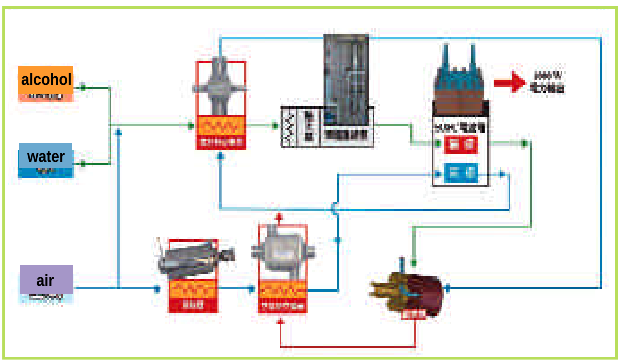


Figure 48 System procedure of the 1kW SOFC

INER has developed the first generation alcohol catalytic reformer, which is characterized by its small size, portability and easy operation. The

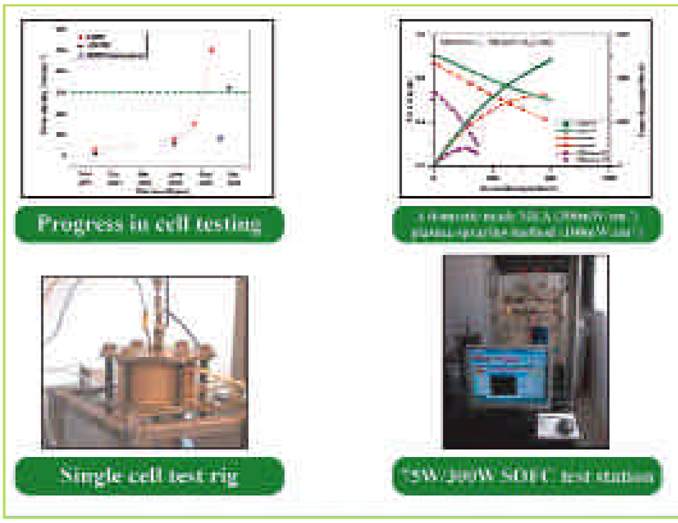


Figure 49 SOFC battery effect testing

Figure 50 Alcohol catalytic reformer system for hydrogen production

design principle uses alcohol, water and oxygen in a self-heating reformation reaction on the surface of the catalyst. When using dry matter, hydrogen production rates reach 30%. At present, the amount of hydrogen produced by alcohol catalytic reformers is enough to support SOFC to generate power of 1kW. (Figure 50)

Biomass energy conversion system

Biomass is the fourth type of energy used worldwide following petroleum, coal and natural gas. It provides about 14% of primary energy demand. Biomass materials can be converted to biofuel or biopower through bioconversion or a thermo-chemical process. INER's research on biomass energy focuses on seaweed aquaculture, conversion of cellulose to alcohol, hydrogen production from bioalcohol, and biomass plasma gasification technology.

Major achievements include: 1) development of novel genes engineering, which changes yeast by hydrolysis and fermentation to convert cellulose to bioalcohol; and 2) development of a 20kW vapor plasma torch (Figure 51) to be used in plasma gasification of biowaste. Future research will focus on setting up a demonstration system capable of disposing of 100kg/h of biowaste and developing a high temperature synthesized gas purification system to satisfy the gas inlet requirement of the power generation system.

Figure 51 20kW vapor plasma torch system

◆ Development and Promotion of Plasma Technology

Since 2004, INER has been fully devoted to the development and promotion of plasma technology. It has finished the construction of the following four facilities: the high power plasma torch testing center, the plasma melting process development center, the plasma slag resources center, and the plasma melting technology industrialization platform. Research achievements in the year of 2005 are illustrated by the following six major projects.

■ Establishment of the high power DC plasma torch testing center

After erecting the factory building, the AC/DC power supply system and the high pressure air supply system in 2004, the work completed in 2005 includes primary/secondary water cooling systems, a test chamber, and cooling and ventilation systems. The primary water cooling system includes an RO pure water production and storage system, an EDI ultra high pure water production and storage system, a 10kg/cm^2 middle voltage inverter type cooling/circulation system, a 30kg/cm^2 inverter type cooling/circulation system and a vibration monitoring system. The secondary water cooling system includes a cooling tower, a water filtration system and a chemical feed water treatment system. Water goes through a thermal exchange system to be cooled. All equipment within the system was installed on a three-story steel platform (Figure 52).

For the 3MW torch development, INER designed and fabricated two DC plasma torches, one the transferred type and the other the non-transferred type (Figure 53). After refurbishing the optical lab, the old SPEX 1404 spectrometer was used to measure the spectral characteristics of a 100kW steam torch.

Figure 52 Primary/secondary cooling systems for the high-power torch

Figure 53 3MW DC plasma torch

■ Establishment of DMFC System at the plasma melting process development center

In order to expand the application of plasma technology in environmental protection, INER has been developing procedures for hazardous waste treatment and spent past two years establishing the plasma melting process development center. The center has set up a process system that can handle waste of 2 tons per day. The kinds of waste include organic waste, inorganic waste, mixed waste and liquid waste.

Figure 54 Experimental facilities of the plasma melting process development center

The entire facility includes one plasma melting furnace and one plasma gasification furnace. Each has one 100kW non-transferred plasma torch. Public utilities, the secondary combustion chamber, the off-gas purification system, the central control system and the continuous emission monitoring system (CEMS) are shared by both plasma furnaces. The system design focuses on high flexibility and multi-functionality, so as to test the capability of the treatment processes for various kinds of incineration ash, organic solid waste and liquid waste. The system design has also incorporated environmental protection and energy saving measures by taking issues such as off-gas purification (dust, SOx, NOx, Dioxin,), waste heat recovering and zero waste water discharge into consideration. Functional tests of the units and the whole system have been completed. Melting and incineration tests of simulated mixed wastes such as soil, incineration ash and organic resin waste produced good results, with a volume reduction ratio of about 3.5 and weight reduction ratio of about 1.3. The CEMS monitoring result also shows the off-gas purification system is capable of reducing the concentration of controlled substances in the off-gas to a level far below the limit value set by the environmental protection regulations.

■ Plasma slag resource development and application demonstration

Aggregates produced through the screening of slag can be used as roadbed materials. Mixing slag with asphalt creates asphalt concrete. In 2005, INER built a 1.8m wide, 50m long sidewalk with permeable bricks made of quenched slag. Figure 55 shows the sidewalk. Figure 56 shows the use of quenched slag in a road pavement. Quenched slag can be used to make high-value products.

Figure 55 Sidewalk paved with permeable bricks

Figure 56 Road paved with quenched slag

Foaming agents (e.g. dolomite, sodium sulfate), flux (e.g. SiO2), and foaming stabilizer (e.g. sodium phosphate) can be added into plasma slag to make foam glass. A coloring treatment offers different colors to improve quality and value of the products. Man-made stones can be formed by mixing unsaturated polyester alkyd and a small amount of natural rock powder with plasma slag, then shaped in a mold. The characteristics and functions of the man made stones are equal to stones made by natural rock powder.

Establishment of the incineration ash plasma melting pilot plant

In cooperation with the Environmental Protection Administration, INER carried out a plasma melting project to treat ash left over from city garbage incineration. Its major mission was to ascertain the characteristics and benefits of city garbage incineration ash treated with plasma melting, and to set up a prototype system. INER has completed composition analysis, dioxin content and heavy metal leaching test analyses for ashes from five incinerators (Beitou, Neihu, Shulin, Hsinchu City and Kaohsiung City) and determined parameters of melting operation. Pilot runs of total 1,000 hours and a single-batch 7-day continuous run have been completed. A total of 66 tons of incineration ash were melted, producing 47 tons of quenched slag, for a weight reduction ratio of 1.40 and volume reduction ratio of 3.0 (i.e. the volume of the quenched slag is one third that of the incineration ash). The TCLP leaching test of the quenched slag shows that the contents of heavy metals such as Pb,Cd,Hg,Cr,As and Se were in conformity with those set in environmental protection regulations. The content of dioxin is lower than 5.00×10^{-6} ng -TEQ/g, and the dioxin removal rate is over 99.98%. Quenched slag can also be used to make permeable bricks, micro- crystalline materials and glass ware. The treatment cost of plasma melting is approximately NT$ 8.9/ton. If converted to permeable bricks, there will be 6 million NT profit each month.

Figure 57 Plasma furnace at the incineration ash plasma melting pilot plant

Surface modifications of fabrics with atmospheric pressure plasmas

To develop a green manufacturing process for fabrics and improve their wash durability at INER, a laboratory-developed atmospheric pressure plasma was used to activate polyester fabric and subsequently graft chitosan, to attain fast absorption and evaporation of sweat

(Figure 58). Even 390 days after the treatment, no aging effect was observed in this excellent hydrophilicity. Furthermore, the wash durability for a 15-s plasma treated PET fabric has been greatly enhanced to more than 50 times for fabrics with its original wash durability of less than 5 times (Figure 59). It was demonstrated that sustainability and wash durability can both be significantly improved in its hydrophilicity obtained from surface modifications with atmospheric pressure plasmas. The results are also in conformity with the requirements of the textile industry, for which green manufacturing is the future.

Development and application of PFCs plasma treatment technology for semiconductor plants

The Kyoto Protocol passed in 1997 by UNFCCC sets restriction for emissions of six major greenhouse gases, of which PFCs are mainly used in semiconductor manufacturing. On February 16, 2005, the Kyoto Protocol came into effect. To help the domestic semiconductor industry reduce the economic impact of this protocol, INER developed a thermal plasma technology to remove semiconductor PFCs. It uses high temperature plasma produced by a low power (5~15 kW) DC torch (Figure 60) to remove PFCs, with a removal rate above 99%. The technology can effectively decrease emissions of PFCs and help the

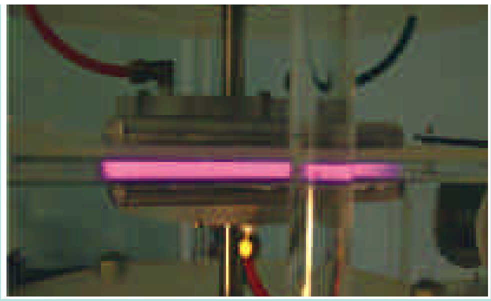


Figure 58 Atmospheric pressure plasma developed by INER

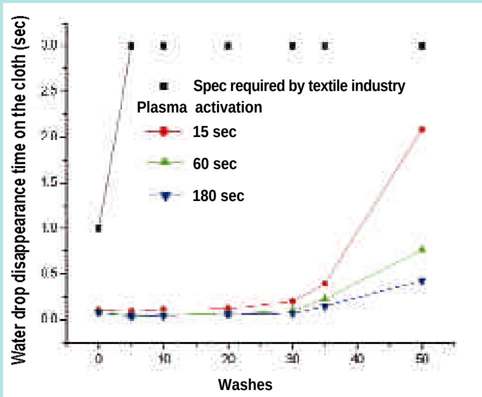


Figure 59 Comparison of wash durability of polyester clothes

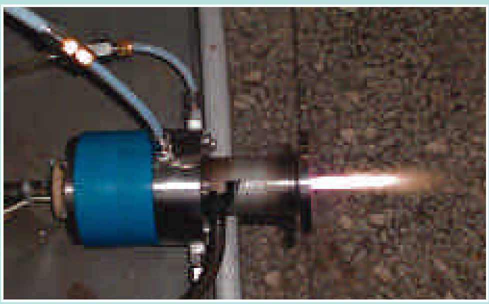


Figure 60 Low power (5~15kW) non-transferred DC plasma torch

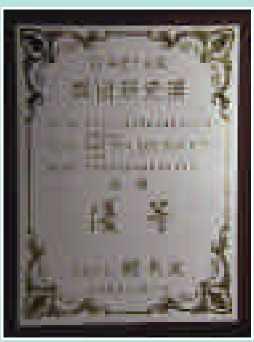


Figure 61 2004 Outstanding Research Award of the Executive Yuan domestic semiconductor industry reach the PFC reduction target of 0.66MMTCE in 2010. INER has transferred this technology to local companies. Equipment using this technology has been set up in several semiconductor factories for on-site testing, which have achieved favorable results. This technology has received an ROC patent and the 2004 Outstanding Research Award of the Executive Yuan (Figure 61).

R&D and Application of Radiopharmaceuticals

Medical tomography is a technique that applies radioactive substances in human body to trace various physical and biochemical reactions. It also uses a flashing video camera to shoot the distribution and metabolic condition of the radioactive substances as basis for disease diagnosis. The radionuclides in clinical used radioactive substances are classified into two groups: single photon radionuclides which emit gamma rays of different energy levels during the metamorphosis process and is tomographied by single photon emission computed tomograpy (SPECT); the other is a positron emission nuclide which emits positrons during the metamorphosis process. Positrons collide with electrons, resulting in an annihilation reaction that emits two 511 KeV photons in opposite directions. This kind of nuclide is tomographied by positron emission tomography (PET).

Undertaking the mission of using nuclear energy to serve the public, INER's Nuclear Medicine Center is actively developing biomedical applications for nuclear energy. It currently has 12 medicinal certificates and is the only domestic radiopharmaceutical factory that has passed the third level cGMP audit by the Department of Health.

The INER In-111-Pentetreotide Injection and the INER TRODAT-1 received medicinal certificates from the Department of Health in 2005 and were awarded a Bronze and a Gold Medals, respectively, in the Medicine Technology R&D Competition coorganized by the Ministry of Economic Affairs and the Department of Health.

INER TRODAT-1 Kit

Parkinson's disease is a nervous system disorder that consistently damages dopamine which is in charge of coordinating movements in the brain. It is also a severe central nervous system disease which is a concern in an aging society. The illness rate significantly increases as the age group increases. Its major symptoms are shaking, muscle rigidness and slow movement. Patients in the early stages may have uncontrolled shaking of part of the body, but the symptoms might be caused by light apoplexy. It is estimated that there are 280,000 people with Parkinson's symptoms and 40,000 with Parkinson's disease in Taiwan. Currently there is no sufficient diagnosis tool for Parkinson's disease; doctors diagnose only through examining the symptoms. Therefore, about one fourth of the patients do not receive the correct diagnosis and treatment. Since a decrease rate of dopamine transporters is directly proportional to the death rate of substantia nigra, specific labeling drugs for dopamine transporter has been used in medical tomography to assess the abnormal situation of dopamine transporter distribution density in the patient's brain recently. The information is very important for clinical diagnosis of Parkinson's disease.

Tc-99m-TRODAT-1 is a derivative of cocaine (Figure 62). It selectively combines with the dopamine transporter protein and can be developed into a radiopharmaceutical used for dopamine transporter SPECT. In available publications, a multiple-bottle method is usually used to make Tc-99m-TRODAT-1, which requires 7 drawing and mixing processes. The complex procedure cannot meet the demand of clinical examinations. The new INER TRODAT-1 kit developed by INER only requires adding Tc-99m eluates, and then heating. The patient only needs to take an intravenous injection 4 hours before tomography; the image of brain dopamine transporter will be displayed by SPECT. The amount of Tc-99m-TRODAT-1 in a Parkinson's patient's brain is significantly lower in that of normal people (Figure 64). The sensitivity and specificity of the image are both above 90%.

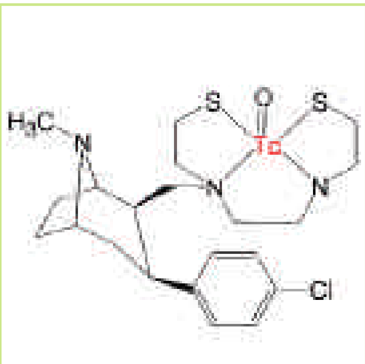


Figure 62 Tc-99m-TRODAT-1 structure

Figure 63 INER TRODAT-1 kit

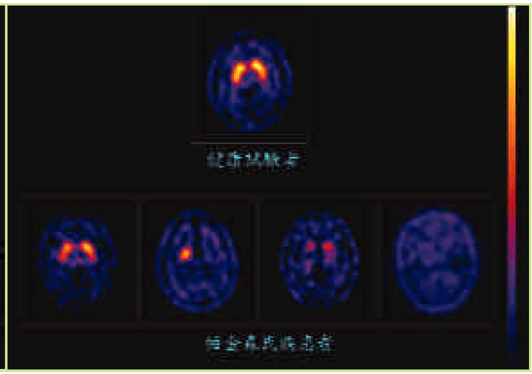


Figure 64 Brain tomographies of normal people and Parkinson's patients

The INER TRODAT-1 kit is the first available Tc-99m labeling radiopharmaceutical agent for dopamine transporter tomography in the world. It is used to display the image of dopamine transporters at striatum synapse of nerve endings. The INER TRODAT-1 kit has received two ROC invention patents, one for its formula and processing, the other for quick analysis method of the product. The quality control examinations of both raw materials and product are also in the application stage for new invention patents in the ROC, U.S. and Brazil. The product has been under clinical trial in many domestic and foreign (Chile, Germany and Brazil) medical centers. It has been used for the brain tomography of cranial nerve dyskinetic disease with Parkinson's symptoms, attention deficit hyperactivity disorder, and schizophrenia. The researchers at INER have published about 60 papers in well known journals and conferences of nuclear medicine, with research results acknowledged by respected experts in the field.

Compared with DaTSCAN (Iodine-123 labeling radiopharmaceutical agent), the only dopamine transporter tomography medicine available on the overseas market, the price of DaTSCAN is about six to eight times that of Tc-99m-TRODAT-1, and DaTSCAN has a half life limitation of 13.2 hours. Therefore, Tc-99m-TRODAT-1 is very competitive in terms of convenience and price for clinical use. After this new medicine goes on market, Parkinson's patients will be able to get correct diagnosis and therapeutic control. Furthermore, high risk populations of Parkinson's patients might be able to get early diagnosis. This research achievement will also help establish a local radiopharmaceutical industry and exalt the international position of Taiwan's medical research.

INER In-111-Pentetreotide injection

The neuroendocrine system refers to a kind of special cell originating from the neuroectoderm, which is widely distributed around human body. Neuroectodermal cells are found in the gastrointestinal, pancreas, lung, thyroid, adrenal gland and skin. They can produce peptides and amides to be used as hormones and neurotransmitters. Cancers originating from these cells include small cell carcinoma, MTC, carcinoid, neuroendocrine tumors and cancers of the pancreas and digestive tracts.

Neuroendocrine tumors, composed of small but uniform, round or polygonal cells, have round and clear cell neucleus and eosinophilic cytoplasm, which are hard to identify as benign or malignant. Neuroendocrine tumors in the early stage are very small and hard to find. The best treatment opportunity will be missed when the cancer cells become larger and are confirmed. Even if neuroendocrine tumors are cured, the conditions of patients are usually very poor and the tumors can possibly transfer to other sites including the bone marrow.

There are large numbers of somatostatin receptors distributed on the surface of neuroendocrine tumors. Octreotide is a peptide with 8 amino acids, which are structured like somatostatin. It has better stability than somatostatin in the blood. In-111-Pentetreotide injection is produced by using octreotide conjugated with dual functional DTPA group and a special formulation, labeled as medicinal class In-111 liquid (Figure 65). This nuclear medicine was issued a medicinal certificate (R000024) by the Department of Health on June 21, 2005, and formally appeared on the market (Figure 66).

Figure 65 INER In-111-Pentetreotide injection


行政院衛生署藥品許可證

Figure 66 Medicinal certificate

Figure 67 Body tomography

Until now, In-111-Pentetreotide injection did not have any known contraindication and mutations. Among 538 patients in clinical trial examinations, only less than 1% has temporary side effects such as lethargy, fever, headache, low blood pressure, liver enzymes changes, arthralgia, and nausea. According to clinical statistics, in terms of sensitivity, concentration and correctness, In-111-Pentetreotide is better than the traditional CT and MRI. The clinical statistics of its diagnostic sensitivity on neuroendocrine tumors is higher than 80% (Table 3).

In-111-Pentetreotide injection is the first peptide radiopharmaceutical cerified by the Department of Health. It is produced in the only radiopharmaceutical factory that has passed the three stage cGMP audit by the Department of Health. After strict comparison of chemical equivalence with the one made by the original factory, the quality and effect of the medicine produced by INER are same as that produced by the foreign medical company. A high sensitive and specific diagnostic radiopharmaceutical In-111-Pentetreotide injection will be available for patients with neuroendocrine tumors at a reasonable price in the near future.

Table 3 Comparison of sensitivity , specificity and accuracy

	In-111-Pentetreotide	CT/MRI
Sensitivity	83％	82％
Specificity	93％	86％
Accuracy	87％	84％

Fuel Cycle and Materials Administration

◆ Dry Storage of Spent Nuclear Fuel Ready to Launch

Spent nuclear fuel

Nuclear fuel used for a period of time must be replaced due to decreased efficiency. Irradiated fuel withdrawn from the reactor with no further use is called " spent nuclear fuel ". Spent nuclear fuel just taken out of the reactor has very high radioactivity and heat, and needs to be stored in the spent nuclear fuel pool for decay and cooling prior to successive process of disposal or reprocessing. Because the reprocessing is strictly restricted by international treaties and a spent fuel disposal facility is not yet available at the present time, nuclear power plants usually select interim storage to solve the spent nuclear fuel pool capacity problem.

Chinshan and Kuosheng NPPs have been in operation for almost 30 years. While the spent nuclear fuel pools have been re-racked 2 to 3 times to increase storage capacity, they

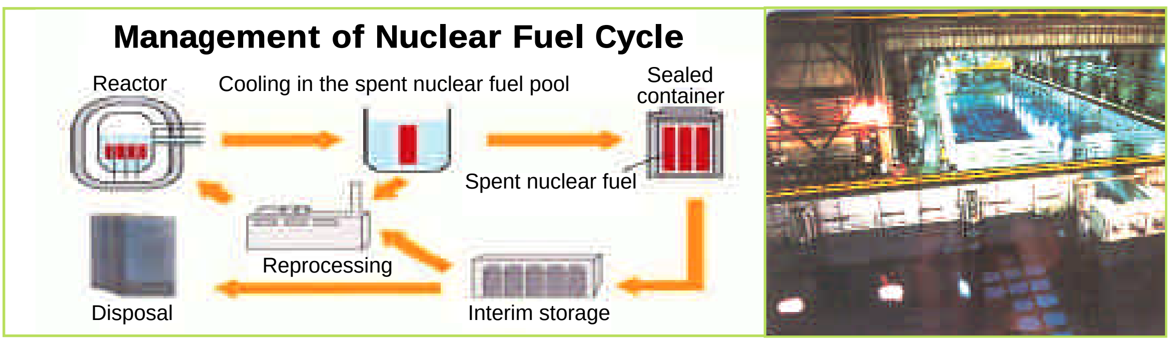


Figure 68 Spent nuclear fuel pool

are close to their maximum capacity. TPC conducted the technological feasibility and storage safety analyses with consideration of social, economic and environmental impacts, and concluded that dry storage is the most suitable storage method. After a number of open but failed biddings, INER was finally entrusted by TPC in August 2005 to set up a spent fuel dry storage facility at the Chinshan plant. Key milestones of this project are: July 2006 - apply for construction license; November 2008 - apply for test run permission; February to May 2009 - test run of two storage casks; and September 2009 - apply for operation license .

Dry storage

Dry storage is a method of storing spent nuclear fuel. The fuel is surrounded by inert gas inside a sealed metal container, and cooled down by the air outside the container. There

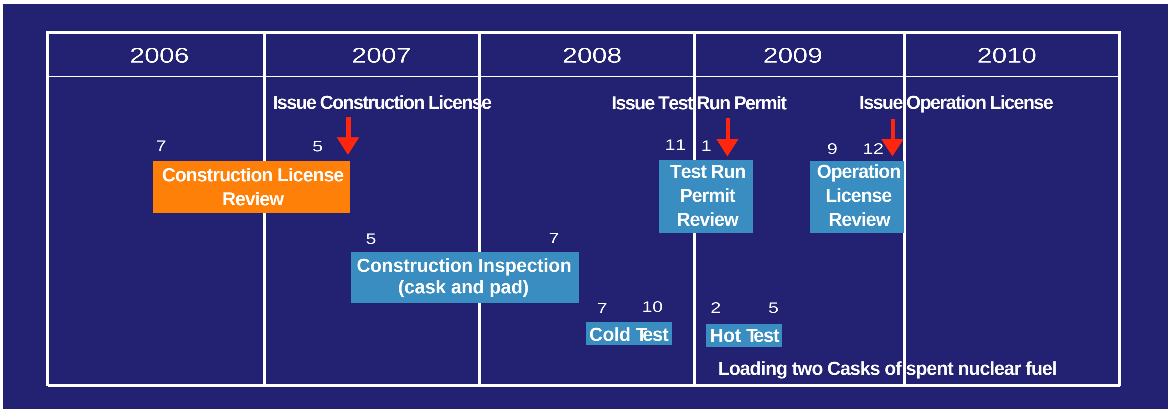


Figure 69 Review schedule for the dry storage facility of spent nuclear fuel at Chinushan NPP

are several types of dry storage concept. One of them is called concrete cask. The metal container is embraced by a thick concrete shield to protect the inside container as well as to decrease the irradiating radioactivity to the environment. Dry storage has many merits such as easy operation and maintenance, low operational cost, few corrosion problems, less secondary waste and radioactivity release to the environment (Figure 70). Therefore, it has been widely used at the nuclear power plants.

Domestic fabrication

INER has devoted to a great deal of efforts and resources to nuclear energy research. Several research achievements have been successfully used in domestic nuclear power plants. INER also built an experimental nuclear fuel dry storage cask in 1997, and

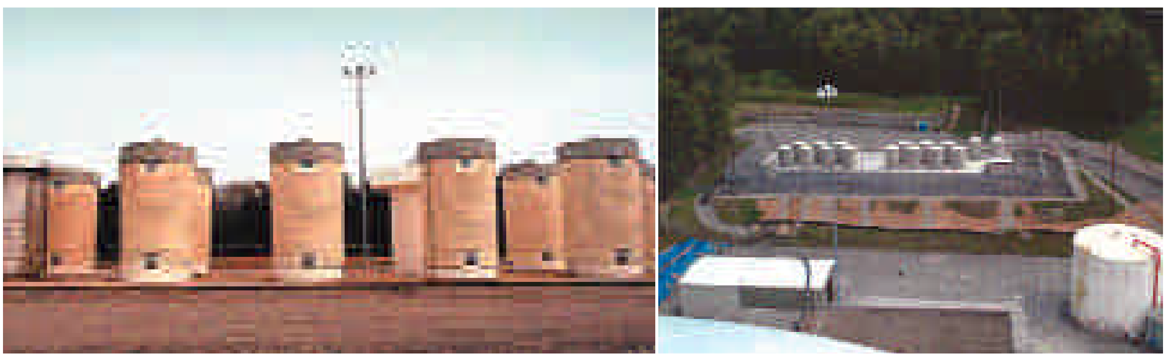


Figure 70 A concrete cask storage facility for spent nuclear fuel at the Yankee Rowe NPP in U.S.A.

transported the research nuclear fuel back to the United States in 1999. Moreover, INER has conducted nuclear fuel inspections of the three nuclear power plants in Taiwan on numerous occasions. The institute has had lots of fuel handling and heavy loading experiences such as evaluation technologies of structure, nuclear criticality, heat transfer, as well as radiation protection management and shielding design, and therefore, has the capability to carry out the dry storage project. Because the schedule is too tight for development of a research program, INER will transfer technology of the well known NAC-UMS storage cask system from abroad, and bring in the administrative system for modifying design and fabricating the storage casks. To cope with the domestic environmental conditions, INER will make some design changes and handling equipment modifications. It will also cooperate with qualified domestic steel companies and manufacturers to build the storage casks.

Safety control

AEC is responsible for review and issuance of construction and operation licenses for the dry storage project. Since the 1990s, AEC has entrusted domestic academic institutes, research organizations and engineering companies to conduct research on regulatory policies, regulations, safety review, safety evaluation technolog, operation monitoring and quality assurance programs for spent fuel dry storage. The aim is to formulate a complete regulatory system and set up a review team as well as an experienced inspection group to ensure construction and operational safety of the facility.

Formulating a robust regulatory system

The Nuclear Materials and Radioactive Waste Management Act, its enforcement rules, and a whole suite of daughter regulations have been in places to ensure public safety and health, and to maintain environmental quality. To conduct effective regulatory control and administration of the storage facility, AEC also specifies requirements for applicant qualifications and conditions, contents of the application forms, and review procedures. The owner/operator of the storage facility should also abide by the regulations stipulated in the Atomic Energy Act, the Ionizing Radiation Protection Act, the Nuclear Reactor Facilities Regulation Act, and the Nuclear Emergency Response Act. All of these detailed regulatory rules should effectively facilitate ensurance the safety of dry storage facilities.

To provide guidelines for applications, AEC issued Guidelines to Safety Analysis Report for Application of Installing a Dry Storage Facility of Spent Nuclear Fuel . The Guidelines encompass analysis items from the safety analysis report ,and can be used as a reference when preparing application documents.

Information transparency and public opinions

In recent years, a focus on democracy has made public opinions increasingly important. Information disclosure is a cornerstone of government policy. As stipulated in the Nuclear Materials and Radioactive Materials Waste Act and its daughter regulations that within 30 days of receiving an application from the applicant, AEC must issue a public notice and make the application documents available for public review for 60 days. AEC will also hold a public hearing to solicit public comments.

Two-stage review system - construction license and operation license

After receiving the application for installing a dry storage facility at Chinshan NPP , AEC will review carefully to ensure public health and safety. To issue a construction license, AEC will also examine impacts of the project on the environment and technological, administrative and financial capabilities of the applicant. During the construction period, AEC will send staff for on-site investigation to ensure construction quality and future operational safety. After completion of the installation with a successful test run, the applicant is required to provide the test run report, technical specifications, the latest safety analysis report and an emergency response plan to apply for an operation license. The storage operation is allowed only after the operation license is issued. During the storage period, AEC will also send inspectors to the site to conduct various inspection to ensure safe operation of the facility.

Review team and inspection group

To ensure the design, construction and operational safety of the dry storage facility, AEC will invite domestic experts to form a review team and an inspection group during different

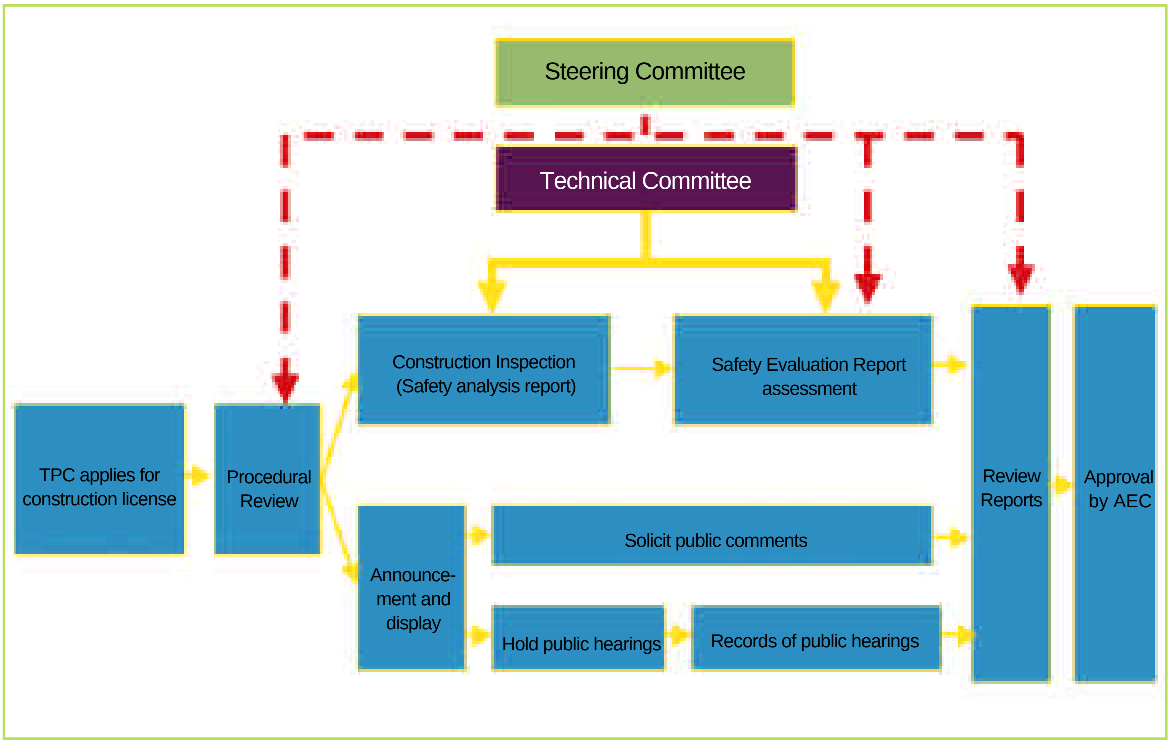


Figure 71 License review procedure

stages of the project. For the construction license application, the focus will be on safety assessment. The review team includes experts in geology, earthquake, structure, material, shield design, nuclear criticality, radiation safety and heat transfer. In addition, a steering committee will be formed to guide the review process of this project. Committee members will include delegates of technical experts listed above as well as legal, financial, social communications and public health experts. The aim through multistage examinations is to have the facility conform with environmental and safety regulations (Figure 71). During the construction period, AEC will also invite quality assurance, welding and nondestructive testing experts to carry out facility and equipment inspections.

Improving inspection technology to ensure safety

To improve inspection technology, AEC has already established research on key assessment technologies of dry storage and sent staff to training at the U.S. Nuclear Regulatory Commission (USNRC). In recent years, AEC's research has focused on earthquake effects on the facility, and has invited domestic overseas experts to hold seminars on the subject. In 2005, AEC invited two experts from the USNRC to hold a one-week seminar. Experts from the Central Research Institute of Electric Power Industry and the Tokyo Power Company of Japan were also invited to deliver special lectures.

Furthermore, AEC entrusted the National Tsing Hua University and the National Synchrotron Radiation Research Center to carry out examination and assessment projects. After TPC decided the type of storage cask, AEC sent staff to NAC in the U.S. for technical transfer training. Eight examination groups of 30 people were set up propmtly to conduct advance examinations for a safety analysis report of the NAC-UMS storage cask. Group members include professors from leading national universities, as well as experts from the Taiwan High Speed Rail and National Synchrotron Radiation Research Center. To ensure fair and independent appraisals, the review team members must not take part in any project related research activity financed by either TPC or INER.

Conclusion

The dry storage facility of Chinshan NPP is the first one to be installed in this country. The storage cask will be built domestically. It is the first project that requires holding of a public hearing . Although there is no prior experience, it is believed that with diligence, devotion and cooperation of all parties, we will be able to achieve a great success.

Radiation Monitoring Center

How Radioactive Are Porcelain Tiles?

Porcelain tiles are widely used in home decor, for decorating floors and walls of living rooms, bathrooms and kitchens. But does porcelain tile contain any kind of radiation? First we must take a look at its manufacturing process. The manufacturing process of porcelain tiles includes three stages: raw material handling, high pressure pressing, and glazing. Porcelain tiles are mainly composed of feldspars and clays, which are natural raw materials. Feldspars usually contain natural radioactive elements such as uranium, radium, thorium and potassium, the amount of which decides the radioactive intensity of feldspars. But in most situations, it is the glazing process that causes the concentration of natural radioactive materials to increase in porcelain tiles. So radiation does exist in porcelain tiles. What we are concerned about is to decide the amount of natural radioactive nuclides contained in porcelain tiles and analyze the causes of formation.

To know about the levels of radioactivity of porcelain tiles sold in the market, the Radiation Monitoring Center used gamma-spectrometer analytic technology to measure the radioactivity of both domestically manufactured and imported porcelain tiles. The measuring procedure is shown in Figure 72. Since raw materials of porcelain tiles are of powder or particle shape, they were first sifted to remove the larger particles. Then they were packed into a plastic sample can, 5cm in diameter and 1cm high. To reduce the escape of radon gas, silicone high-vacuum grease was placed around the inside edge of the lid when sealing the can. After putting it aside for one month, a pure germanium detector with lead shielding was used to analyze the radioactive nuclides. The results are shown in Table 4.

To measure the radioactivity of porcelain tiles, samples were first modified to have the same size as the calibrating radiation source, i.e. 15cm long, 15cm wide, and 2cm thick. They were then measured by gamma-spectrometer analysis. A total of 55 samples of 7 types were analyzed. The measuring results were grouped into the 7 types and shown in Figures 73, 74 and 75.

The measuring results listed in Table 4 show that the specific activities of uranium

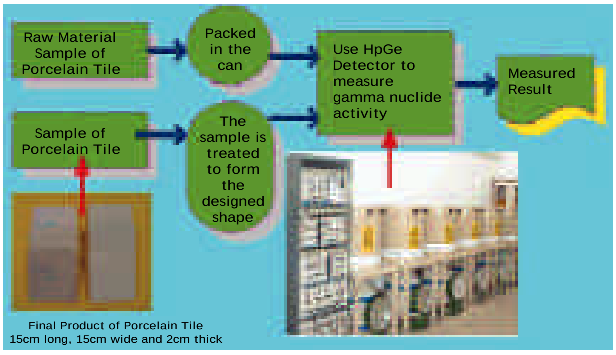


Figure 72 Procedure for testing radioactivity of porcelain tiles

Table 4 Gamma-spectrometer analytic results of raw materials of porcelain tiles

Unit: Bq/Kg

	Potassium-40	Thorium Series	Uranium Series
Glaze (white)	*_	564±1%	3125±0.6%
Glaze (yellow)	127±30%	666±1%	5079±0.6%
Glaze	96±28%	618±1%	2869±0.6%
Glaze	*_	733±1%	3918±0.5%
Thailand Feldspar	558±5%	103±1%	215±1%
Pottery	1202±5%	185±1%	241±1%

* Minimum Detectable Activity (MDA)

and thorium series in the glazes are higher than those in the raw materials of porcelain tiles. The specific activity of the uranium series is 12 to 24 times higher, while that of thorium series is 3 to 7 times higher. Table 4 also shows that the amount of natural radioactive nuclides contained in the raw materials of porcelain tiles is about the same as those contained in common feldspars found in the domestic market.

Figures 73 to 75 show that the average specific activity of potassium-40 is about 6 times higher than that of the uranium and thorium series. Since glazes contain very little potassium-40, it can be proved that potassium-40 contained in porcelain tiles mainly comes from the raw materials of feldspars. From the above analysis, it can be concluded that the content of uranium and thorium natural radioactive nuclides in porcelain tiles is higher than that of other common construction materials such as cement, concrete, clay, steel, red brick or hollow brick. Glazes that form a glass like colorful film on the surface of porcelain tiles are the main sources of radioactive nuclides.

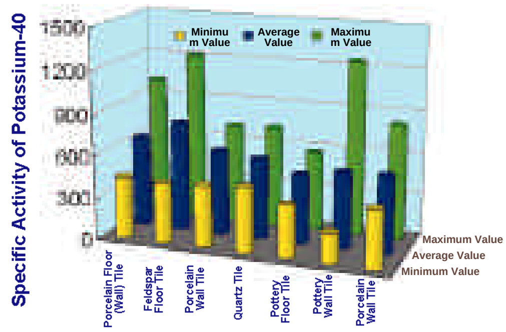


***Figure 73** Specific activity of potassium-40 in different types of porcelain tiles*

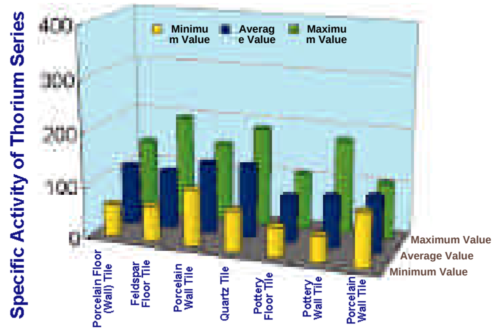


***Figure 74** Specific activity of thorium series in different types of porcelain tiles*

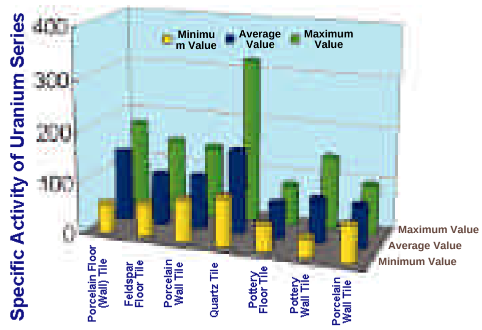


***Figure 75** Specific activity of uranium series in different types of porcelain tiles*

Among different kinds of glazes, white glaze is the most important. Its major component is sodium zirconia silica, usually used as a base color or opacifying agent while blending with other colors. In addition, white glaze can be used to prevent cracking and stabilize colors. Therefore, it is the most frequently used kind of glaze. Generally speaking, reasons that cause variations in the content of natural radioactive nuclides in glazes are quite complex and hard to control. Additionally, glaze is only used on the surface of a porcelain tile, which is just a small part of the whole tile. Any change in the glaze formula will cause substantial changes in the radioactive effects. Although it is clear that the specific activity of the glazes is higher, the small amount of usage makes it difficult for us to evaluate its actual radioactive effects.

In conclusion, porcelain tiles contain small amounts of natural radioactive nuclides that might cause increase of the indoor radiation. However, porcelain tiles are mostly made of feldspars, which contain very little radioactive material (even lower than those contained in ordinary cement floors or bricks). The indoor use also helps reduce the total amount of radiation due to the shielding effect.

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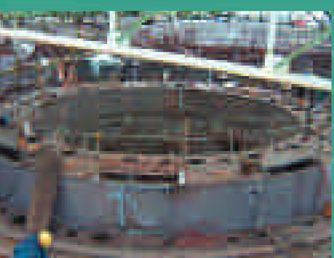

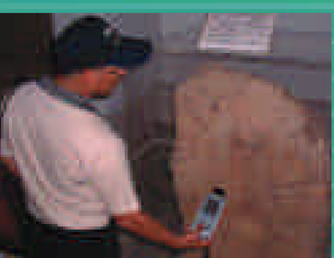

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