English Version

THE PEOPLE'S REPUBLIC OF CHINA

THE THIRD NATIONAL REPORT UNDER THE CONVENTION ON NUCLEAR SAFETY

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Beijing

Content

1 INTRODUCTION

The Chinese government attaches high importance to nuclear safety, ratified and approved to participate in the "Convention on Nuclear Safety", has undertaken the safety responsibilities for nationwide nuclear power plants (NPPs), and made unremitting efforts to meet and keep a high level of nuclear safety standard accepted internationally.

1.1 General Situation of the Peaceful Utilizations of Nuclear Energy in China

Nuclear power shold be a safe, clean and economic energy source. Chinese government has always laid emphasis on and supported the peaceful utilization of nuclear energy and nuclear technology. Nuclear power development in China has been more than 20 years since the construction of Qinshan NPP, a first NPP unit designed and built by China. Through the practices in the construction and operation of Qinshan NPP and Guangdong Daya Bay NPP, and the subsequent addition of four NPPs during the period of "The Ninth State Five-year Plan"(1995-2000), China has obtained plenty of experience on design, manufacturing, construction and operation of NPPs. These nuclear projects have positive impact both on economy and society, as well as serve the basis for future self-reliance development of nuclear power. By the end of 2003, the eight operating units had a total installed capacity of 6364MWe that represents 1.63% of total installed capacity of electricity generation in 2003 in Mainland of China. In 2003, the electric generation from all operating NPPs was added up to 43.8 billion kWh, accounted for approximately 2.30% of total electric generation in China. Along with new NPPs entering service, shortage of electricity in the eastern coastal region was mitigated, and local economy development was improved.

Acompanying nuclear power development, the technology and capability in nuclear safety regulation, research and development, engineering design and equipment manufacture have been greatly improved. The valuable techniques and experience have been accumulated in the areas such as construction, commissioning, operation management and emergency preparedness, which have favorable impacts on self-reliance design and construction of large plants in the future.

The development of nuclear energy has actively improved the environment condition for human beings. The total electricity generated by NPPs in 2003, if converted to coal consumption, would be approximately 12.96 million tons of standard coal, thus reduced the 'greenhouse effect' and the annual gas release that could result in acid rain. The radioactive effluent discharges have been below the national limits since the first NPP put into operation. The radiation level in the surrounding area remains at a natural background level. All plants have not been discovered any adverse impacts on the environment.

1.2 Policy and Objective for Nuclear Power Development

In 2003, the total electricity generation installed capacity in Mainland of China was 390GW, which is in second place in the world. For the country of a population over 1.3 billion, however, the current total electric generation is below the demands. With the rapid economic development, the imbalance between supply and demand for electric power becomes more apparent. China is bearing a high pressure in environmental protection due to its energy source structure based on coal-fired power. The nuclear power, as a clean energy source, which is mature and can be produced in large scale, is expected to have a greater development. In the eastern coastal regions economically developed, especially, to develop nuclear power is an important choice to meet the electric demands，improve energy structure and reduce environmental pollution.

The Chinese government is actively developing and implementing its nuclear power development programming to coordinate the development of nuclear power. Under the principle of "On the basis of our own, to cooperate with foreign countries, to introduce foreign technologies and to promote localization", the construction of Chinese NPP is to consistently move toward standardization. By referring to the international advanced technique and experience and utilizing the existing technique, China can gradually achieve the objective of self-reliance on design, manufacture, construction and operation of large NPP. At the prerequisite of ensuring nuclear safety, the competition of nuclear power should be enhanced through reducing the costs of construction and operation.

With the rapid economic development, the demands for large capacity nuclear power units being characterized by safety, maturity, economy and advanced level will become more apparent. Nuclear power will play a more important role in promoting and improving of the diversity and safety of energy sources in China. By active research and development of own intellectual property and advanced technology, and thus further improving the safety and economy of NPP, nuclear power will play a more important role in the supply of energy sources in China.

1.3 Nuclear Safety Policy

When we make nuclear energy bring benefit to the human, we must ensure nuclear safety in order to protect the public and the environment. In 1984, the Chinese government established the National Nuclear Safety Administration (NNSA) to take responsibility for independent nuclear safety regulation of the civilian nuclear installations, thus formed a system of supervision of nuclear safety. The State Council promulgated "Regulations on the Safety Regulation for Civilian Nuclear Installations of the People's Republic of China" in 1986. The regulations prescribe that the principle of "Safety First" should be followed in the phases of siting, design, construction, operation and decommissioning of civilian nuclear power plants. It also indicated that sufficient measures should be taken to ensure quality and operation safety, prevent nuclear accidents and minimize potential adverse impacts, and protect the staff, the public and the environment from excessive exposure and contamination beyond the national limits, that is, exposure and contamination should be reduced to a level of as low as reasonably achievable(ALARA). Meanwhile, the Chinese government promulgated additional nuclear safety regulations in succession to clearly define the responsibilities of governmental departments and operating organizations, made duly revisions and improvements of the system of safety regulations to keep consistent with the international nuclear safety standard.

In October 2003, Chinese government implemented "Act of Prevention and Remedy of Radioactivity Contamination" to bring radioactive contamination control into a law-based regulation, further improve the regulation of nuclear safety and ensure nuclear safety.

The Chinese government has always attached high importance to regulation of nuclear safety, and has persistently strengthened the regulation of nuclear safety by increasing the human resource and financial support. The capability in regulation of nuclear safety will be improved and play an important role in guaranteeing nuclear safety.

The Chinese government pays more attention to the international cooperation in the field of nuclear safety, actively takes part in the related international activities, sticks to the principle of clarity and justness, and has conducted widely international cooperation on nuclear safety with the IAEA and other countries or international organizations.

1.4 Summary on Implementing Convention

In order to implement the obligations defined by the Convention, Chinese government set up a special group for implementation of the Convention. The group is responsible for organizing and coordinating the implementation of the obligations of the Convention in order to ensure that the requirements prescribed in the Convention and the decisions at each review meeting of the National Report for the Convention on Nuclear Safety will be implemented in China.

China submitted the first and the second national reports for the Convention on Nuclear Safety to the review meetings of the Convention on Nuclear Safety in October 1998 and October 2001, respectively. At the same time, China made serious responses to the written questions from other countries.

The comments for Chinese National Report by the second review meeting of the Convention on Nuclear Safety held in Vienna in April 2002 are as follows:

The Chinese National Report and afore-hand written responses for the 56 questions were fully affirmed. By thorough discussions and questions of the practices of regulation on Chinese nuclear safety at the review meeting, each contracting part considered the independence of Chinese National Nuclear Safety Regulatory Body and the combination of international standards with the specific situation of China as two good practices. The achieved progress recognized by all contracting parts is listed as follows:

— Actively promoted the legislation on nuclear safety, established and improved regulations and standards on nuclear safety;

— Strengthened cultivation of nuclear safety culture;

— Carried out periodic safety review and operation assessment;

— Strengthened the training of nuclear safety supervisors and operating personnel;

— Intensified operation experience feedback of the NPPs;

— Spread application of probabilistic safety assessment method;

— Carried out the research of countermeasure against severe accidents of the NPPs;

— Established and implemented the plan of improving equipment safety;

— Enhanced response ability of nuclear accident emergency;

— Enhanced environmental radiation monitoring ability;

— Increased manpower and financial resources on regulation for nuclear safety.

At the same time, all contacting parts expressed their persistent attentions to the following questions in the next review meeting of the Convention on Nuclear Safety to be hold in 2005:

— When will the related laws such as "Atomic Energy Act" and "Act of Prevention and Remedy of Radioactivity Contamination" be taken effect;

— The independency of regulation rights and practical activities of Chinese National Nuclear Safety Regulatory Body;

— Being faced with the challenges from the different types of reactors, current financial and manpower resources held by Chinese National Nuclear Safety Regulatory Body can only meet basic regulation demands;

— Continuously improving operation experience feedback;

— The applications of probabilistic safety assessment techniques;

— How are the results of periodic safety review applied in issuing license;

— The uniformity of emergency plans of nuclear accident with related local provinces and how to harmonize among the three-level emergency plans (nation, province and NPPs);

— Results of review on nuclear safety by IRRT.

Chinese government attaches high importance to the promises on the obligations in the Convention on Nuclear Safety. By review meeting, China learned the advanced experience on nuclear safety regulation from other contracting parts and found our deficiencies to be improved. China actively takes measures to resolve the problems mentioned by other contracting parts so as to make all Chinese NPPs achieve and keep a high level of nuclear safety.

This report is stressed on the problems above mentioned.

1.5 Themes of the Report

This report is prepared according to the requirements specified in the "Convention on Nuclear Safety" and "Guidelines Regarding National Reports Under the Convention on Nuclear Safety". It described synthetically and systematically the situation on implementing obligations in the convention by the end of 2003. The report also outlined the important activities in nuclear safety and the progress on regulatory activities of nuclear safety in China since the second review meeting.

Data of NPPs in Taiwan province of China are left open for the time being.

2. EXISTING NUCLEAR POWER PLANTS

2.1 List of Existing Nuclear Power Plants

By the end of 2003, there were eight units in operation and 3 units under construction in China. The listing of nuclear power plants is given in Annex 1.

2.2 General Situation of Existing NPPs

In China, with the exception of Qinshan Phase III NPP that adopted CANDU-6, other NPPs are all of PWR type. In the past three years, there were 5 units put into operation in succession, they are Qinshan Phase II NPP Unit-1, Guangdong LingAo NPP Units 1&2, Qinshan Phase III NPP Units 1&2. Qinshan Phase II NPP Unit-2 and Jiangsu Tianwan NPP are under construction. These NPPs were designed on the basis of some reference NPPs which had successful experience and good performance. Furthermore, some necessary improvements have been conducted to enhance the inherent safety characterristics of the NPPs.

Qinshan NPP and Guangdong Daya Bay NPP have operated for about ten years. The two NPPs have accumulated the considerable experience during the operation and maintained safe and steady operation, thus created a favorable social and economic benefit.

Qinshan Phase II NPP, which is equipped with 2 sets of 650MWe PWR units, is the first large commericial NPP that is designed, constructed, managed and operated by China. Its design has refered to Guangdong Daya Bay NPP and adopted some improvements.

The design and equipment making of Guangdong LingAo NPP which is equipped with 2 sets of 990MWe PWR units have been partly performed by China. On the basis of referring to the design of Guangdong Daya Bay NPP, Guangdong LingAo NPP has performed more than 30 items of significant improvements in nuclear island, including 13 items which were related to engineering safety.

Qinshan Phase III NPP, which is equipped with 2 sets of 728MWe CANDU-6 units, was imported from Canada. On the basis of the mature design of CANDU-6, some design improvements were conducted.

Jiangsu Tianwan NPP was imported from Russia. It is equipped with 2 sets of 1060MWe WWER-1000 units. The experience obtained in construction and operation of the previous WWER-1000 units was absorbed in the design.

2.3 Performance Indicators and Trend

In China, all operating NPPs have established and step by step perfected their performance indicator systems. They submit periodically the related data to the State Environmental Protection Administration (The National Nuclear Safety Administration), hereinafter, abbreviated as the SEPA (NNSA), nuclear industry administration and international organizations such as World Association of Nuclear Operators (WANO), etc. The WANO performance indictors of all NPPs from 2001 to 2003 are listed in Annex 2. It presented a good macro trend from 2001 to 2003.

2.4 Safety Status of NPPs In China

In order to conduct the nuclear safety regulation of NPPs on siting, construction, commissioning, operation and decommissioning, the SEPA (NNSA) issues relevant safety licenses and prescribes the permitted activities and the conditions that must be obeyed. In order to determine whether or not the documents provided by safety license applicant of nuclear power plant meet the requirements of national nuclear safety codes, the safety measures are adequate to protect the site personal, the public and the environment from radioactive jeopardy, the SEPA (NNSA) performs relevant reviews and inspection before issueing the licenses.

In order to ensure that the operating NPPs maintain and continuously enhance their safety level, the nuclear safety codes require that the operating organization should perform periodic review of NPP operation and submit the safety-related documents to the SEPA (NNSA). Qinshan NPP began its ten-year Periodic Safety Review (PSR) in 2001 and submitted the review report to the SEPA (NNSA) in September 2003. The SEPA (NNSA) will complete the final review in 2004.

Guangdong Daya Bay NPP submitted "The Periodic Safety Review Program" to the SEPA (NNSA) for approval at the end of 2000. After review and approval, up to now the PSR entered a phase of reviewing the special reports.

The safety barriers of the operating NPPs in China have shown integrity through tests and monitoring. The integrity of fuel element cladding satisfies the requirements of technical specifications. The leakage rates of the reactor coolant system and the containment are far below the limits of Technical Specifications.

The occupational exposure dose of the operating NPPs is far below the limits of national standards in China. The discharges of radioactive effluents of the NPPs have been effectively controlled and monitored. The level of discharge volume per year of NPPs is far lower than the state regulatory limits. There has been no undue dose release event occurring. The radioactivity level of the surrounding environment has been kept within the fluctuating range of ambient natural background.

At present, there are 3 units under construction in China. In the phases of siting, design, construction and commissioning, the activities related to nuclear safety are all under control. Effective supervision and reviews are performed by the SEPA (NNSA) according to the requirements in the related nuclear safety regulations of China, so as to guarantee the construction quality and nuclear safety of the constructing NPPs.

On the operational assessment, in 2002, China established the Operational Assessment Committee for NPPs and implemented the first national peer review of Qinshan Phase II NPP. According to the plan, the Operational Assessment Committee for NPP will complete the peer review for all 6 NPPs in China mainland by 2007. For the last three years, the Chinese NPPs have accepted an IAEA Pre-OSART and two WANO Peer Reviews, the results of the operational assessments showed that the reviewed NPPs'managements on operation, maintenance, training, technical support, radioactive protective, industry sfety, emergency, etc. were kept in order, the overall safety status was good. The overall safety level of nuclear power plants was improved and enhanced through the operation assessment.

All operating NPPs in China are in the prophase of their designed lifetime. It is shown that the safety of continuous operation of these NPPs is guaranteed through several years' operational practices, in-service inspections, tests, analyses, and several safety reviews and assessments carried out by the SEPA (NNSA), other competent departments of Chinese government and international organizations.

3. LEGISLATION AND REGULATION

3.1 Nuclear Safety Laws，Codes and Guides

3.1.1 General Description of Nuclear safety Laws， Codes and Guides

Since 1982, China has collected extensively and studied carefully the laws, regulations on nuclear safety used in nuclear power developed countries, consulted the nuclear safety codes and guides of the IAEA and established the Chinese nuclear safety regulation system.

Many units have been put into operation in China. The corresponding experience on safe operation of NPPs has been accumulated. According to the experience combined with the newest requirements of international nuclear industry, China continually perfects its nuclear safety laws and codes.

The system of laws，codes and guides for Chinese nuclear safety consists of state laws, administrative regulations of the State Council, department rules, guiding documents and reference documents. The state laws, which have higher legal effects than administrative regulations and department rules, are enacted by the National People's Congress and its Standing Committee. Administrative regulations, which have legal binding effects, are promulgated by the State Council according to the Constitution and laws. Departmental rules are promulgated by the related governmental departments within their purview according to the laws and the administrative regulations of the State Council and have legal binding effects.

(1) Laws

The existing state laws applicable to nuclear safety field are "The Constitution of the People's Republic of China" ,"Environmental Protection Act of the People's Republic of China" and "Act of Prevention and Remedy of Radioactivity Contamination of the People's Republic of China".

(2) Administrative regulations of the State Conucil

The existing administrative regulations that applicable to nuclear safety field are "Regualtions on the Safety Regulation for Civilian Nuclear Installations of the People's Republic of China", "Regulations on Nuclear Materials Control of the People's Republic of China" and "Emergency Management Regalations for Nulcear Accidents of Nuclear Power Plant". They are rules to stipulate the scope of nuclear safety management, regulatory body and its rights, principles and procedures of supervision and other important issues.

(3) Departmental rules

The detailed rules are departmental rules which stipulate specific implementing measures.

Nuclear Safety Codes are departmental rules enacting nuclear safety objectives and basic safety requirements.

(4) Guiding documents

Nuclear safety guides are guiding documents that explain or supplement nuclear safety codes and recommend relevant methods or procedures to implement safety code.

(5) Reference documents

Nuclear safety technical documents are reference documents in the technical fields of nuclear power plant.

The hierarchy of nuclear safety laws, codes and guides is listed in Figure 1.

3.1.2 Issuded Laws, Regulations and Guides

The Chinese government always attaches high importance to nuclear safety. Since October 1986 when the State Council promulgated "Regulations on the Safety Regulation for Civilian Nuclear Installations of the People's Republic of China", China has already issued a series of laws, regulations and guides which cover NPPs, other reactors, installations for nuclear fuel production, processing, storage and reprocessing, and facilities for radioactive waste processing and disposal, etc. All these formed an available law system that must be obeyed by nuclear installations in siting, design, construction, operation and decommissioning.

"The Environmental Protection Act of the People's Republic of China" was approved by the Standing Committee of the National People's Congress in 1989. It is the special law for protecting and improving the living environment, preventing and remedying contamination, guaranteeing human health and promoting social development. "Act of Prevention and Remedy of Radioactivity contamination of the People's Republic of China" was approved by the Standing Committee of the National People's Congress in 2003. The Act is applied to prevent environment contamination caused by discharges of radioactive gas, liquid and solid waste during the nuclear energy development, nuclear technology application, uranium (thorium) mining and associated mineral resources' exploitation and application. The purpose of the Act is to protect environment and health of the public. China will continue to strengthen the legislation of special laws on nuclear safety such as "Atomic Energy Act", etc.

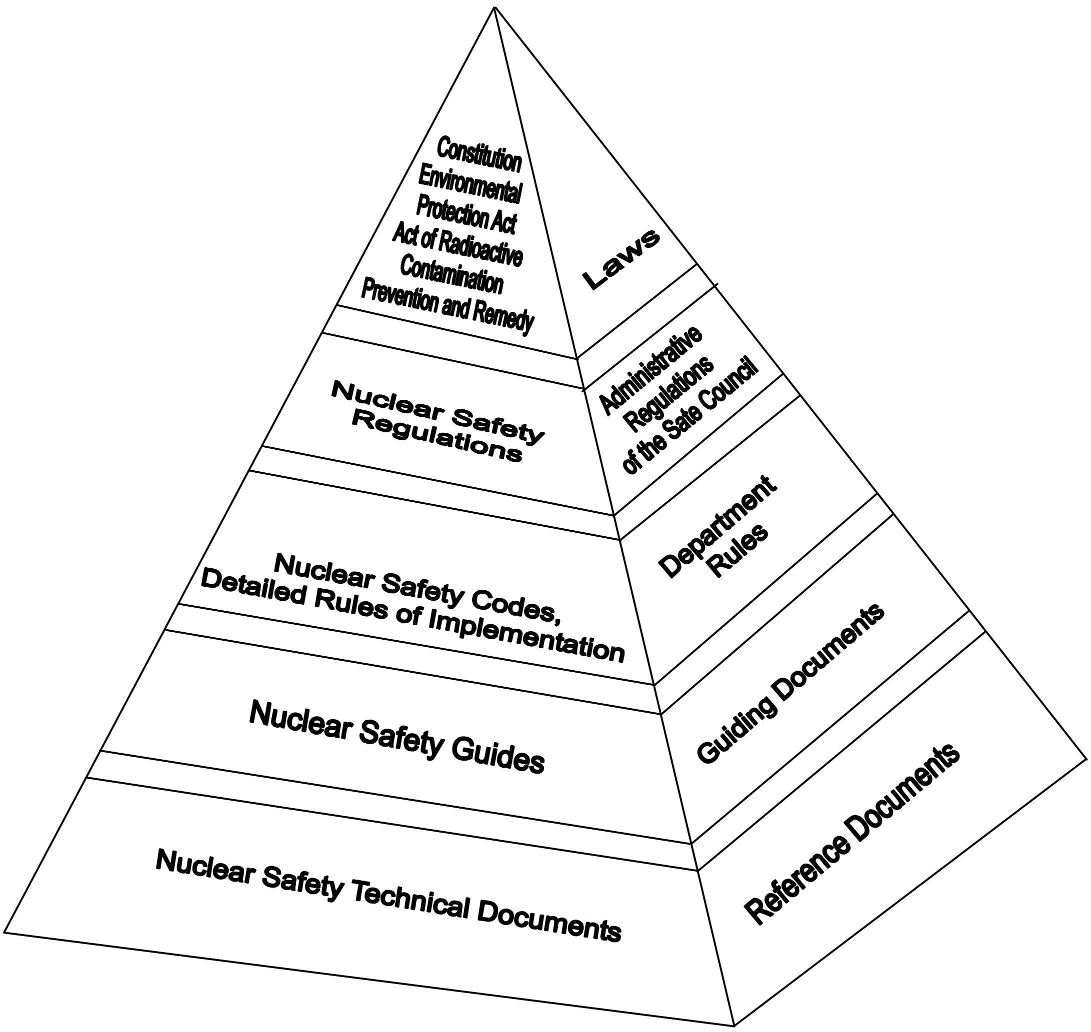

Figure 1 The hierarchical structure of laws, regulations and guides on nuclear safety of China

The State Council promulgated "Regulations on the Safety Regulation for Civilian Nuclear Installations of the People's Republic of China" and "Regulations on Nuclear Materials Control of the People's Republic of China" in 1986 and 1987 respectively. These regulations systematically stipulated the purpose and the scope of supervision of civilian nuclear installations and nuclear materials, established nuclear safety licensing system, specified rules for regulation of nuclear materials, defined the duty of regulatory bodies and the legal responsibility of operating organizations. In 1993, the State Council promulgated "Emergency Management Regulations for Nuclear Accidents at Nuclear Power Plant", which stipulates principles, countermeasures, and measures adopted for nuclear accident emergency.

Since 1986, according to different technical fields, the SEPA (NNSA) and the related departments have promulgated in succession a series of nuclear safety codes and detailed rules related to siting, design, operation and quality assurance of NPPs. China Atomic Energy Authority (CAEA) and the Ministry of Health have also issued some departmental rules.

In addition, the related departments consecutively formulated relevant nuclear safety guides. Based on implementation, supplement and revision have been made for the issued codes and guides. Therefore, a relatively complete system of regulations and rules on nuclear safety has been formed.

Existing laws, regulations, guides on nuclear safety in China are listed in Annex 3.

3.1.3 Newly Issued Laws,Regulations and Guides on Nuclear Safety

Since the Second Review Meeting of The Convention on Nuclear Safety in 2001, China has promulgated a series of new laws, regulations and guides, the related activities are as follows:

"Act of Prevention and Remedy of Radioactivity Contamination of the People's Republic of China" was approved by the Standing Committee of the National People's Congress in the Third Meeting on July 28, 2003. The purpose of the Act is to prevent and control radioactive contamination, protect environment, guarantee human health, promote exploitation and peaceful utilization of nuclear power and nuclear techniques. It is applicable to all the preventive activities related to the nuclear installations on siting, construction, operation, decommissioning and nuclear technology, uranium mining, radioactive mineral resources application, conducted in Chinese territory and marginal sea. The main contents of the act are as follows:

— surveillance and management of the radioactive contamination prevention；

— radioactive contamination prevention of nuclear installations;

— radioactive contamination prevention of nuclear technology utilization;

— radioactive contamination prevention of uranium mining, radioactive mineral resources;

— radioactive waste management.

"Act of Prevention and Remedy of Radioactivity contamination of the People's Republic of China" was put into force on October 1, 2003. This Act is a specific law approved by the Standing Committee of the National People's Congress for radioactive contamination prevention and remedy. With its promulgation and putting into force, the Act has brought the radioactive contamination prevention of China into a law-based management.

China has been making further revision and perfection of nuclear safety regulations, the new revisions of "Code on the Safety of Nuclear Power Plant Design" and "Code on the Safety of Nuclear Power Plant Operation" are promulgated on April 18, 2004. The matched nuclear safety guidelines and other relevant nuclear safety codes are in modification. After being reviewed, they will be promulgated. The new nuclear safety codes not only adopt the international new development results but also make modification according to the concrete circumstances of China.

In addition, the related departments consecutively formulated departmental rules, including:

— Reporting System of Nuclear Accident Emergency for NPP;

— Management Rules of Emergency Crossing the Boundary for Radioactive Influence due to Nuclear Accident ;

— Medical Treatment Standard for Radiation Damage;

— Management Methods for Operation Assessment of NPP;

— The Basic Standard on the Ionization Radiation Protection and Radioactive Source Safety;

— Management Rules for Nuclear Accident Emergency Exercise of NPP.

3.2 Nuclear Safety Regulation

3.2.1 Nuclear Safety Regulation System

The State Council decided that The State Environmental Protection Administration will externally reserve the name of The National Nuclear Safety Administration. The SEPA (NNSA) is in charge of its unified and independent regulation of the safety of NPPs throughout the country. The licensing system is one of main measures of the SEPA (NNSA) in regulation. By means of the management of licenses, the SEPA (NNSA) regulates NPPs, nuclear materials and nuclear activities.

The SEPA (NNSA) is in charge of the regulation of environmental protection of NPPs throughout the country.

The Nuclear Industry Administration is in charge of the safety management of NPPs and is subject to nuclear safety surveillance of the SEPA (NNSA.)

According to nuclear safety regulations, the licensee (or applicant) of NPP bears all responsibilities for the safety of NPPs, nuclear materials and nuclear activities.

By means of license examination and approval, supervision, enforcement of laws, rewards and punishment, implementation of nuclear safety surveillance relevant to licensee's activities, the SEPA (NNSA) ensures that licensee can bear the responsibilities for nuclear safety and carries out nuclear activities in conformity with legal provisions.

3.2.2 Duties and Responsibilities of Regulatory Bodies on Nuclear Safety

The SEPA (NNSA) and the Ministry of Health are responsible for surveillance on the nuclear safety of NPPs, environmental protection, the individual dose, hygienic and health conditions of the site personnel and the general public, respectively.

3.2.2.1 Duties and Responsibilities of the SEPA (NNSA)

(1) to organize drafting and formulating regulations related to the safety of NPPs and to review technical standards of nuclear safety;

(2) to organize review and assessment of both the safety performances of NPPs and the capability of the operating organizations to ensure safety, and to issue or revoke nuclear safety licenses;

(3) to be responsible for performing nuclear safety inspection;

(4) to be responsible for investigation and treatment of nuclear accidents;

(5) to provide guidance and surveillance in drawing up and implementing emergency preparedness plan in cooperation with the relevant departments;

(6) to organize the relevant departments to conduct scientific researches related to safety and management of NPPs, propagation and education as well as relevant international professional contacts;

(7) to be responsible for safety inspection of civilian nuclear materials;

(8) to be responsible for regulation of civilian nuclear pressure retaining components;

(9) to conduct mediation and arbitration of disputes related to nuclear safety jointly with related departments.

(10) to be responsible for formulation, supervision and enforcement of regulations and standards on environmental management of NPP;

(11) to be responsible for reviewing instrument of ratification of the environmental impact assessment reports of NPP;

(12) to be responsible for the monitoring of radiological environment of NPP;

(13) to be responsible for the management of radioactive waste;

(14) to be responsible for the organizing and implementing the system of professional qualification of registrated nuclear safety engineers ;

(15) to participate in emergency response activities.

3.2.2.2 Duties and Responsibilities of the Ministry of Health

The duties and responsibilities of the Ministry of Health are

(1) to be responsible for formulating hygienic rules and standards related to personal of nuclear facilities and general public;

(2) to be responsible for monitoring exposure dose of the occupational personal and the public;

(3) to be responsible for reviewing and approving the evaluation of the health effects on human body due to nuclear contamination;

(4) to be responsible for the prevention and cure of radiation injury.

3.2.3 Organization Structure of Regulatory Bodies

The headquarters of the SEPA (NNSA) is in Beijing, and its four regional offices are established in Shanghai, Shenzhen, Chengdu and Beijing, respectively. The regional offices are responsible for the routine inspections of nuclear safety in these areas.

In order to perform the inspection better, the SEPA (NNSA) has established the Nuclear Safety Center (NSC) as its technical support and guarantee center.

The SEPA (NNSA) has also established an Advisory Committee on Nuclear Safety and Environmental Radaition Protection. The Advisory Committee is to provide advice in formulation of legislation, development of the technical capability of nuclear and review, inspection on nuclear safety.

The organization structure of the SEPA (NNSA) is listed in Figure 2.

3.2.4 Nuclear Safety Inspection

The SEPA (NNSA) and its accredited regional offices sent regional inspection groups (inspectors) to the site of plant siting, manufacture, construction and operation of NPPs to exercise the following duties:

(1) to examine whether or not the safety-related information that is submitted conforms to actual situation;

(2) to inspecte whether or not the construction is carried out in accordance with the approved design;

(3) to inspecte whether or not the management is performed in accordance with the approved quality assurance program;

(4) to inspecte whether or not the construction and operation of the NPPs accords with the nuclear safety regulations and the conditions specified in the licenses;

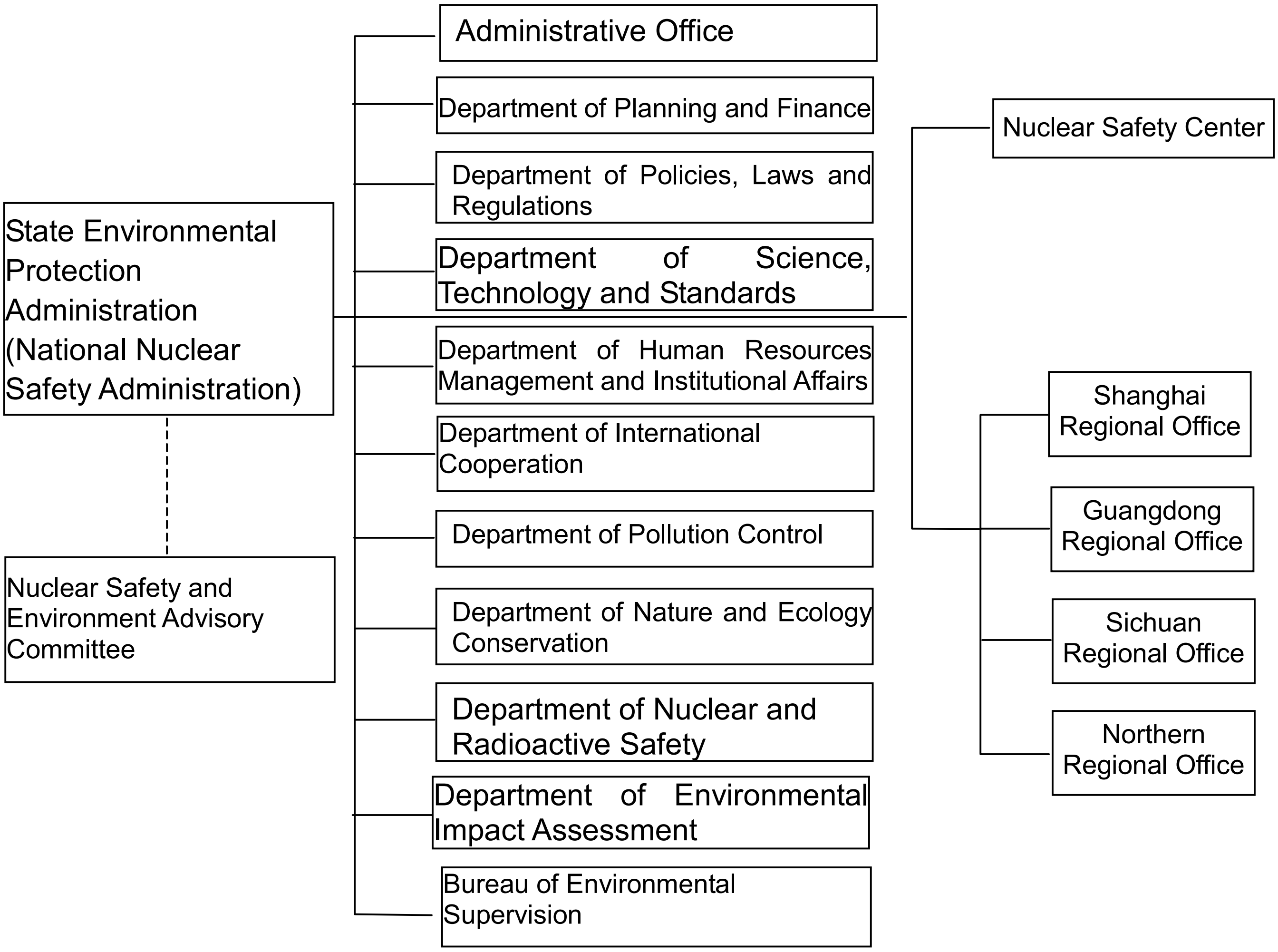

Figure 2 The organization structure of the SEPA (NNSA)

(5) to investigate whether or not the operating organization has a adequate capability for safe operation and carrying out emergency response plan;

(6) other functions necessary to be supervised.

When performing a mission, the nuclear safety inspectors have the right to access the sites of components manufacturing, construction and operation of NPPs to investigate and collect information related to nuclear safety.

When necessary, the SEPA (NNSA) has the right to take compulsory actions, including charging NPPs to stop operation.

3.3 Licensing System

China adopts licensing system for nuclear safety.

Nuclear safety license is a law document that is approved by national regulatory body and authorizes applicant to deal with the specific activities related to nuclear safety (such as siting, constructing, commissioning, operation and decommissioning of NPPs, etc.).

3.3.1 Types of Licenses for NPP

(1) Construction permit of NPP;

(2) Operation license of NPP;

(3) License for operators of NPP;

(4) Other permits subject to be approved which include the review comments on NPPs siting and instrument of ratification for the first fuel loading of NPPs, instrument of ratification for decommissioning of NPPs, etc. .

(5) Instrument of ratification of environmental impact assessment report at different phases of NPPs.

3.3.2 Issuance of NPP Licenses

The procedures of application and issuance of licenses in China are shown in Figure 3.

The applicant should submit the application, safety analysis report and other related documents required by the code to the SEPA (NNSA). Only after appraisal and approval, the applicant is allowed to carry out relevant nuclear activities.

During the process of appraisal, the SEPA (NNSA) should ask for opinions of the related departments of the State Council as well as the governments of province, autonomous region or municipality directly under the central government where NPPs are located.

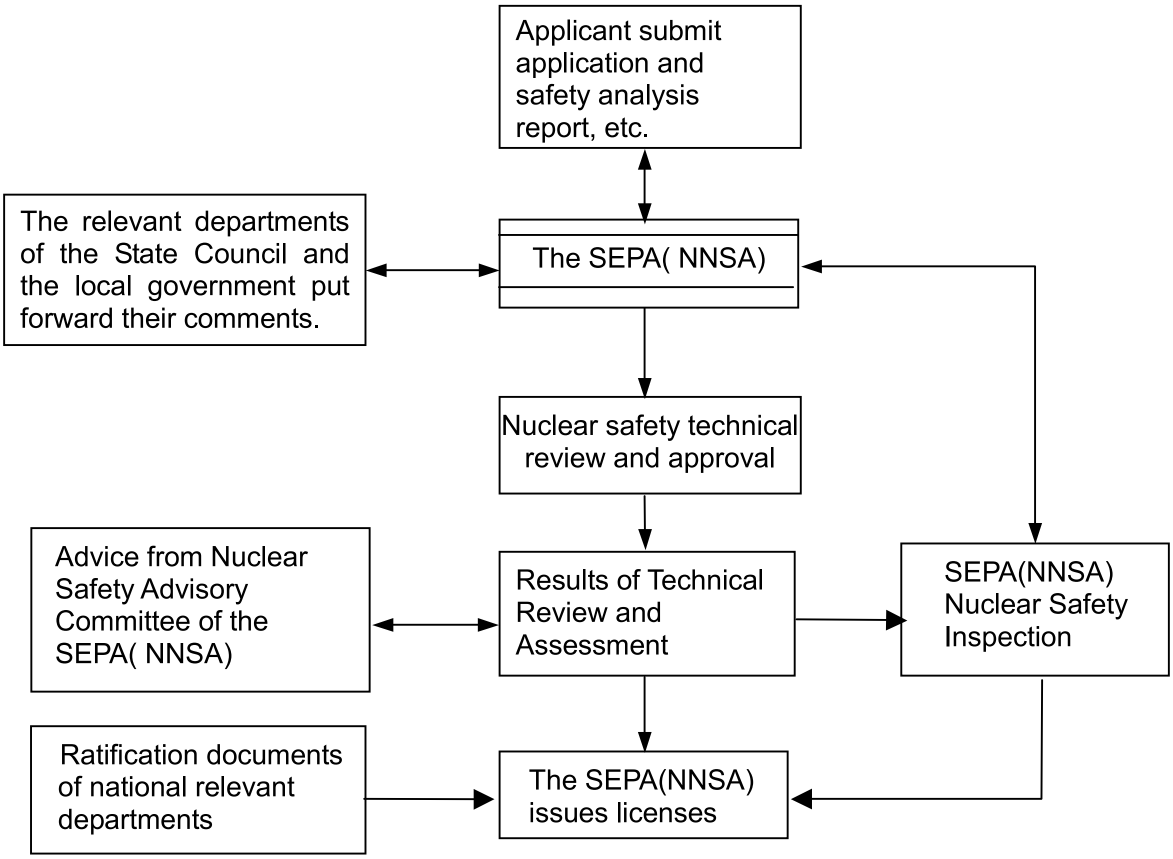

Figure 3 The procedures of application and issuance of licenses

After getting the results of technical appraisal, asking for comments of the related departments of the Sate Council and local government, and also seeking advice from the Nuclear Safety Advisory Committee, the SEPA (NNSA) decides independently whether the licenses are to be issued or not, meanwhile the SEPA (NNSA) stipulates the essential necessary license conditions.

Since the Second National Report under the Convention on Nuclear Safety, the SEPA (NNSA) issued the following new licenses:

(1) the instrument of ratification for the first fuel loading of Unit 1 of Qinshan Phase II NPP on October 9, 2001;

(2) the instrument of ratification for 18-month refueling of Guangdong Daya Bay NPP on December 3, 2001;

(3) the instrument of ratification for the first fuel loading of Unit 1 of Guangdong LingAo NPP on December 8, 2001;

(4) the instrument of ratification for the first fuel loading of Guangdong LingAo NPP unit 2 on June 22, 2002;

(5) the instrument of ratification for the first fuel loading of Unit 1 of Qinshan Phase III NPP on July 17, 2002;

(6) the instrument of ratification for the first fuel loading of Qinshan Phase III NPP unit 2 on March 13, 2003;

(7) on March 31, 2003, the SEPA (NNSA) issued the corresponding license to Daya Bay Nuclear Power Operation and Management Co. Ltd.(DNMC) and approved "Operation License of Units 1&2 of Daya Bay NPP" that is shared by China Guangdong Nuclear Power Holding Co. Ltd. (CGNPC) and DNMC. It also approved "Ratification of the First Fuel Loading of Units 1&2 of LingAo NPP" that is shared by LingAo Nuclear Power Co. Ltd. and DNMC and decided the licence would have one year's tryout, and then it will make a decision on the next licensing scheme according to the results of concrete application.

3.3.3 Responsibilities of the Licensee

The operating organization of the NPP is directly responsible for the safety of its NPP it operates. Its main responsibilities are as follows:

(1) to comply with the relevant laws, administrative regulations and technical standards of the country to ensure the safety of NPPs;

(2) to accept the safety surveillance from the SEPA (NNSA) and the Ministry of Health, etc.; to report the safety situation timely and faithfully and to provide relevant information;

(3) to take overall responsibility for the safety of its NPPs, the safety of nuclear materials, and the safety of the site personnel, the public and the environment.

3.4 Nuclear Industry Administration

China Atomic Energy Authority (CAEA) is the nuclear industry administration in China. It is in charge of development of peaceful utilization of atomic energy in China, establishment of relevant regulations and control of nuclear material. It takes part in IAEA and conducts its activities on behalf of the Chinese government.

3.4.1 Duties and Responsibilities of the CAEA

Duties and Responsibilities of the CAEA are as follows:

(1) to research and draft out policies and regulations for peaceful utilization of atomic energy in China;

(2) to research and establish developing programme, planning and nuclear industry standard for peaceful utilization of atomic energy in China;

(3) to organize demonstration, review and approval of significant science and technology project on peaceful utilization of nuclear energy; be in charge of supervision and coordination of the implementation of significant science and technology projects in nuclear energy;

(4) to conduct control of nuclear material; and review and management of nuclear export;

(5) to promote exchange and cooperation in nuclear energy field among governments and also among international organizations; take part in the IAEA and related activities on behalf of Chinese government;

(6) to lead on organizing national coordination committee for nuclear accident emergency; be in charge of developing, preparing and implementing emergency plan for nuclear accident;

(7) to take responsibility for management of physical protection and fire protection of NPPs.

3.4.2 Organization Structure of the CAEA

The CAEA includes five departments and four functional offices. They are Administration Department, System Engineering Department, International Cooperation Department, General Planning Department, Science and Technology Quality Control Department, National Nuclear Accident Emergency Office, Nuclear Material Control Office, Isotope Management Office and Nuclear Power Office.

4. GENERAL SAFETY CONSIDERATIONS

4.1 Priority to Safety

4.1.1 The Principle of "Safety First" and Nuclear Safety Objectives

"Safety First" is regarded as the nuclear safety principle of all the NPPs in China.

In all activities of siting, design, construction, operation and decommissioning of the NPPs, the principle of "Safety First" has the utmost priority. Organizations and individuals engaged in nuclear power activities must follow through this principle. In the case of contradiction of safety with other aspects, such as economical or rate of progress, etc., any resolutions should be subordinated to the requirements of nuclear safety.

The general nuclear safety objectives are defined as establishing and keeping an effective defense against radiation jeopardy to protect the site personal, the public and the environment.

The general objectives are supported by two interrelated and complementary safety objectives which are objective for radioactive protection and objective for technical safety. Technical measures, together with management and procedure measures, guarantee an effective defense against radiation jeopardy.

(1) Objective for radioactive protection are to ensure that radioactive exposure and scheduled effluent of radioactive waste under all operation conditions of NPP are within the stipulated limits and in accordance with ALARA, and to mitigate the radioactive effects of all accidents.

(2) Objectives for technical safety are to take all reasonable actions to prevent accidents in NPP and mitigate their consequences, to minimize the radioactive consequences of all possible accidents including accidents with very low probability considered in design of NPP and be within the specified limits, to ensure that probability for accident with severe radioactive consequences is very lower.

4.1.2 Licensee's Commitment to Safety

The principle of "Safety First" and nuclear safety objectives are principal requirements for all organizations engaged in nuclear power activities. The operating organization shall give its commitment to NPP safety. All other organizations such as design and construction organizations, suppliers should give their corresponding safety commitments,. The commitment to safety is to be written in the policy statement of quality assurance program and be inspected by operating organization and supervised by the SEPA (NNSA). All organizations shall fulfill the task of commitment in their own target of management.

Commitments to safety: All activities related to the NPP safety shall accord with the standards in safety codes. Nuclear safety is placed on the position of top priority. The position shall not be restricted and affected by production schedule and economic benefit. NPP shall establish and maintain effectively "defense in depth" system to protect the NPP staff, the public, and the environment from radioactive hazards. Safety review and assessment system shall be established to monitor and assess relevant activities, to find out and correct the faults and deficiencies created from work as well as to pursue high quality work target so that safety performance could be sustainable improved.

4.1.3 Cultivation of Safety Culture

In order to achieve excellent safety performance and enhance the safety culture level, Chinese NPPs made the following improvements in the course of cultivation of safety culture:

(1) Establishing and perfecting rules and regulations for safe production: nuclear safety policy, industrial safety policy and radiation protection policy are developed, safety goals are set and categorized and controlled; safety production responsibility regulations are established and perfected, management programs, management procedures and work procedures are revised and improved constantly; activities related to safe production are supervised and inspected so that potential safety accidents could be eliminated timely.

(2) Establishing safety performance indicators: a set of safety performance expectations and indicators is established in each NPP to assess safety culture and general safety status of NPP quantitatively. Weakness in the safety management of NPP could be found out through trend analysis of various indicators and corresponding corrective actions could be taken for improvement. These indicators include not only 8 WANO performance indicators which could be used for evaluating operational performances of NPP but also other indicators which come from

management experience in its own NPP and successful management practices in other NPPs.

(3) Plant managers lay stress on support to and participation in the cultivation of safety culture and take their examples and leadership as the key factors of improving safety culture. Moreover, they emphasize on the resource investment concerning safety issues, make efforts to establish non-censure safety culture environment and encourage plant staff to report any mistake which occurred or was found in a conscious, timely, complete and precise manner.

(4) Safety committee is established in each NPP. As an independent organization, the committee review important issues concerning nuclear safety and quality, assess the effectiveness of operational safety of NPP and put forward suggestions to the general manager on improving operational safety according to nuclear safety regulations, domestic and foreign operation experience and actual status of their own plants.

(5) Establishing an enterprise that is good at learning is advocated to attach importance to create learning atmosphere in each NPP, to be willing to seek for learning and exchanging with the domestic and foreign peers, so that the safety management of NPP could become more active. Through the systematic and continuous training, the performance of plant staff could be in accordance with the goals of safety culture. By investigations, analyses, treatment, follow-up and evaluation of the events, plant staff could learn lessons and make progress. By way of self-assessment, plant staff could be encouraged to be actively involved in plant safety management, i.e., plant staff could improve themselves through self-review. With the help of assessment activities such as WANO peer review and IAEA OSART, communication, exchange and cooperation with international peers could be strengthened, and higher safety performance objectives could be met.

(6) Emphasizing on the contribution of plant staff to safety: the philosophy of "questioning attitude, rigorous and prudent working approach and necessary communication" is advocated and practiced so that the environment advantageous to safety could be established and working attitude advantageous to safety could be encouraged. The management concept of "People Foremost" is advocated that humanistic management could be combined with procedures and regulations, while the plant staff could work in a rigorous and prudent approach and the consciousness

of safety culture could be merged in everyday activities of plant staff.

(7) Establishing operation experience feedback system: plant staff are encouraged to report any abnormal. Event investigation and analysis are implementd timely and corrective actions are taken. Management of NPP and reliability of equipment are improved effectively with the help of operation experience feedback system.

(8) Emphasizing on the active involvement of contractors: contractors shall obey plant rules related to safe production and receive the same training concerning safety culture. Cooperative relationship between NPP and contractor has been built up to ensure the working quality of contractors to be kept improving.

(9) Enhancing the information exchange with the public: the NPPs inform the public and the media about the safe production and environmental protection performance as well as arrange correspondents and the public to visit the NPPs schematically could not only facilitate the public to understand and support the nuclear power and help the nuclear power to be kept in transparency to the public, but also help the plant staff to improve their safety attitude so that they could be conscious of their safety responsibilities and improve their working qualities.

(10) Establishing sound interactive relationship between NPPs and the nuclear regulatory body: the issues such as the safety management of NPPs, the attention to safety on which the NPPs pay, the transparency when dealing with events and the implementation of nuclear regulations are comprehensively reviewed by the SEPA (NNSA) through nuclear safety review and supervision in order to accelerate the establishment of safety culture and assist NPPs in finding areas for improvement.

4.1.4 Regulatory Control

China has adopted a safety licensing system for NPPs. The SEPA (NNSA) is responsible for enactment and approving the issuing of safety licenses for NPPs. Before approving the issuing of safety licenses, the SEPA (NNSA) rigorously and independently examine the license applicant's conditions. These conditions are continuously checked and examined in the later safety supervisory activities which not only go into the NPP operating organization but also go deep into the design, construction organizations and suppliers, if necessary.

Nuclear safety supervision exercised by the SEPA (NNSA) is independent and compulsory. The SEPA (NNSA) has the right, if necessary, to take compulsory actions to demand the operating organizations of NPPs to adopt safety measures or to stop any activities that endanger the safety, moreover, to penalize the licensees in the way of warning, improving in a limited period, halting for rectification and revoking nuclear safety licenses.

The SEPA establishes its own independent surveillance system around the NPPs to take supervisory measurements of the NPP's effluents and the level of environmental radioactivity.

The Ministry of Health performs surveillance and management of the health of the NPP personnel engaged in radioactive work.

4.1.5 Management of Nuclear Industry Administration

China Atomic Energy Authority (CAEA) is responsible for safety management of NPPs, including the following main activities:

(1) Organizing the preparation of plans on nuclear power and nuclear power technology development and issuing guidelines on nuclear power technology development. CAEA organizes domestic research institutes and NPPs to carry out research and development of critical techniques related to nuclear safety and provides financial support.

(2) Organizing non-periodic review activities on NPPs including organization and administration during construction, project progress, investment and quality control, production preparedness, nuclear material control, emergency preparedness, physical security and fire protection.

(3) Promoting the establishment of nuclear power operational assessment system: uniform criteria are adopted for the operational assessment in order to strengthen the industrial management, to encourage the comparison, competition and learning among NPPs and to improve the safety and economics of NPPs. The committee of operational assessment for NPPs was organized in 2002 and the first domestic peer review for Qinshan Phase II NPP was carried out in November, 2002 subsequently. The operational assessment system is planned to be improved after years of assessment practice.

(4) Organizing the compilationt of "Quarterly Report on the Production of Operating NPPs" and "Annual Report on Nuclear Power Operation in China" and

issuing operation experience topic report periodically, improving the event report system gradually and organizing various kinds of seminars and workshops to enhance the mutual information exchange and common share among NPPs, promoting the establishment and operation of nuclear industrial operation experience feedback system with the joint effort of the regulatory body.

(5) Strengthening the management of training and qualification for operators and senior operators of NPPs and establishing the qualification review commission for operators and senior operators of NPPs, together with the regulatory body, revising the "Standard for License Examination of Operators of NPP" based on the operation experience and the specific features of new nuclear units, organizing the exchange among staff from NPPs periodically and exploring the approaches to improving training and qualification of operators and senior operators of NPPs.

4.1.6 Good Practices Related to Safety

In the development of nuclear power industry, the Chinese government, the nuclear industry administration and the nuclear regulatory body will continue to track the advanced experience or good practice in foreign countries of advanced nuclear power on surveillance of nuclear safety and operation of NPPs and to keep nuclear safety requirements and level of China consistent with international level in order to ensure not only no increase of risks to the public but also further improvement of nuclear safety level.

(1) Nuclear safety regulations are revised based on the IAEA NUSS series and relevant international standards, as well as the practices in nuclear safety administration of China.

(2) Regional offices for nuclear safety regulation have been established for the site surveillance on NPPs. A professional team for nuclear safety regulation has been maintained.

(3) The "Temporary Regulation on the Professional Qualification of Registered Nuclear Safety Engineer", which was enacted in November, 2002, specifies the nuclear safety engineer professional system for those are engaged in the nuclear related activities.

(4) Domestic operational assessment system has been established based on IAEA OSART and WANO peer review. These three kinds of evaluations could

supplement each other.

(5) Nuclear regulatory body, nuclear industry administration and NPPs continue to promote not only operation experience feedback in different levels but also information exchange among NPPs through different ways.

(6) Importance to effective exchange activities with international peers has always been attached. Through the extensive cooperation and exchange with international organizations such as IAEA and WANO, experience on nuclear safety administration from international peers could be learnt so that both the ability of nuclear safety regulation and the level of operational safety of NPPs could be improved gradually.

(7) Safety culture construction has been promoted continuously and transparent safety culture in NPPs is advocated. Reporting incident and event timely is encouraged. Training and propagation on improving human performance are actively performed. Review on safety culture could help to determine and correct weakness in safety culture so that safety culture could be improved constantly.

(8) Probabilistic Safety Analysis and Periodic Safety Review are carried out to analyze safety status of critical areas in operational safety of NPPs and to take corresponding corrective actions.

4.2 Financial and Human Resources

4.2.1 Financial Resources

Chinese government allocates certain amount of funds for technical research and development of nuclear power and its safety. In order to adapt to the demands on development of NPPs in China, Chinese government has increased financial budget and infrastructure to ensure implementation of the functions in nuclear safety regulation. The nuclear safety review charging system, which was put into effect, works as a financial resourse supplement of SEPA (NNSA).

All expenses for safe operation and improvement of NPPs are borne by NPPs. After an NPP has been put into operation, a defined percentage of the revenue from generating electricity is preserved for safety improvement, radioactive waste management and final decommissioning of the plant. Items for improving the safety and their expenses have a priority in the annual plan and financial budget.

"Act of Prevention and Remedy of Radioactivity Contamination of the People's Republic of China" specifies:

— The operating organization of nuclear power plant shall prepare the decommissioning plan for nuclear power plant. The expenses of decommissioning and radioactive waste treatment shall be included in the budgetary estimate of investment or production cost.

— The environmental protection administration of the State Council is responsible for the regulatory surveillance on nuclear facilities. The expenses of construction, operation and maintenance of regulatory surveillance shall be included in budget.

Concerning the preparatory fund for nuclear accident emergency, "Emergency Management Regulations for Nuclear Accidents of Nuclear Power Plant" specifies: preparatory fund for on-site emergency of nuclear accident shall be provided by nuclear power plant and be included in the budgetary estimate of NPP engineering project investment or operation cost. Preparatory fund for off-site emergency of nuclear accident shall be provided jointly by NPP and local government.

4.2.2 Human Resources

With the rapid development of nuclear industry in China, correspondingly， the requirement of human resource will have a trend towards rapid increase. Therefore, the Chinese government and the operating organizations of NPPs are preparing personnel education and cultivation plan to meet the increasing demand for human resources of nuclear power in China. When drawing up nuclear power development programming, Chinese government also makes target for cultivating personal.

At present, the qualified personnel required in the field of nuclear power come from following resources:

(1) Chinese nuclear industry fostered a batch of qualified nuclear engineering specialists and management personnel. They are knowledgeable and experienced in design, construction and operation management and serve as the backbone of the scientific and technical team of the NPPs.

(2) The NPPs in operation have fostered a batch of professional and managing

personnel not only for the NPPs under construction but also for nuclear safety regulatory body. Versatile professionals and managers are fostered through the way of work post shift.

(3) There are many professionals from conventional electrical plants in Chinese electricity industry who could be chosen to nuclear industry.

(4) Research and design institutes, colleges and universities related to nuclear industry and relevant industries also provide human resources.

(5) Related graduates of universities and colleges every year are new human resources of NPPs.

(6) Some foreign nuclear power specialists are recruited through contracts.

4.2.2.1 Human Resources in NPP

Recruitment, training, retraining and authorization of operating personnel are conducted according to the safety guide entitled "Staffing of Nuclear Power Plants and Recruitment, Training and Authorization of Operating Personnel".

Training/Retraining programs and procedures are prepared and implemented in NPPs according to the work post qualification derived from task analysis, in accordance with the requirement of relevant regulations, guidelines and standards. Only those who are qualified or authorized after experiencing appropriate training and examination could implement relevant work.

The management of period of validity management for staff qualification and authorization is conducted in NPPs. In case the period of validity is exceeded, personnel shall be re-qualified or re-authorized and even retrained, if necessary, to ensure that they meet the requirement of specific posts

Training organization in nuclear power plant is responsible for planning, implementation, assessment and improvement of training. Training center is equipped with training facilities, including a full-scope training simulator, for training, retraining and examination for licensed operators and management staff.

Considering the reactor operators' significance to safety, the management of training, examination and qualification for RO/SRO is much stricter, more details is described in 5.3.3.10.

Requirement on the management of training, authorization and qualification for domestic and foreign contractors is the same as for NPPs. Moreover, management policies of contractors are prepared to control and regulate training management.

4.2.2.2 Qualification, Training and Examination of Nuclear Safety Regulatory Personnel

In order to ensure the quality of nuclear safety regulation, the main requirements for nuclear safety regulatory personnel are specified in "The Rules for the Implementation of Regulations on the Safety Regulation for Civilian Nuclear Installations of the People's Republic of China" as follows:

(1) Have educational level equal to or above bachelor's degree;

(2) Be able to implement regulatory activities, to make judgement correctly and to write qualified reports, with at least five years of engineering experience or three years of nuclear safety regulatory experience;

(3) Be familiar with national nuclear safety regulations and obey strictly;

(4) Be of honesty, rightness, impartiality, preciseness and modesty.

The SEPA (NNSA) selects personnel who meet the above mentioned requirements. After training and passing examinations, these personnel will be issued with "Certificate of Nuclear Safety Regulator" by the SEPA (NNSA).

4.2.2.3 Registered Nuclear Safety Engineer

In order to improve the quality of professional personnel in the field of nuclear safety, enhance the management of key posts of nuclear safety, ensure the nuclear safety and radiological environmental safety and maintain the national and the public's interests, Chinese government enacted and issued the "Temporary Regulations on the Professional Qualification of Registered Nuclear Safety Engineer" in November, 2002, which regulates the professional qualification of personnel in key posts related to nuclear safety who are in those organizations engaged in the application of nuclear energy and nuclear technology as well as providing technical services on nuclear safety.

Uniform national examination is organized each year after corresponding systematic training and certification are applied upon examinees. Subjects of the examination include codes and regulations related to nuclear safety, comprehensive knowledge on nuclear safety, practical nuclear safety and case analysis of nuclear safety. The "Professional Certificate for Registered Nuclear Safety Engineer in People's Republic of China" is issued after passing the examination. The expiration date of registered nuclear safety engineer is two years.

Professional scopes of registered nuclear safety engineer are: review of nuclear safety, inspection of nuclear safety, operation of NPP, nuclear quality assurance, radiation protection, radiological environmental monitoring and other fields closely related to nuclear safety which is specified by the SEPA (NNSA).

4.3 Human Factors

4.3.1 Actions Taken to Prevent and Correct Human Errors

China attaches importance to the research on human factors to find out effective measures taken to reduce human errors for maintaining and keeping the safety level of the NPPs.

(1) Human factors should be considered in the design of NPP: Working areas for plant personnel are designed according to the principle of man-machine efficacy. In designing control room, working load, probability of occurring human errors, and response time of operational personnel should be considered to minimize the physical and mental labor of operational personnel so that the corresponding safety operational procedures can be conveniently implemented during normal operation or accident conditions. Multi-alarm indications occurring simultaneously or almost simultaneously are reduced as many as possible to avoid any confusion to operational personnel.

In accordance with the development of Chinese nuclear power plants and meeting the international safety requirement of new plants, the "Technical Policy on Several Important Safety Issues in the Design of New nuclear Power Plants" was issued by SEPA (NNSA) in August of 2002, in which the requirement of human factor and man-machine interface was put forward. In April of 2004, the updated "Regulation on Safety Design of Nuclear Power Plants" addressed the requirement of optimizing operation design of operators.

(2) Specific full-scope simulators are used in the training and qualification examination of operators. The combination of operation mode and accident status and operational experience are involved both in the simulator training and

qualification.

(3) Nuclear power operation experience feedback system is established in operating organizations, enterprises groups, nuclear industry administration, the SEPA (NNSA) and technical support organizations, respectively. Experience and lessons related to human factors from IAEA and WANO can be analyzed and used in combining with Chinese practical situation to reduce human errors, and to improve the operation management and safety regulation.

4.3.2 Measures in the Operation Management

(1) Establishing a system for specific individual responsibility for each post to reduce human errors occurring in management and coordination.

(2) Establishing a system for response to operating events. Investigation and analysis shall be immediately conducted when important events occur. When human factors are involved in, the relevant training for operation personnel should be timely carried out in accordance with that kind of human errors.

(3) Establishing work licensing system: Operation, maintenance, periodic testing, and any safety related activities in NPPs are required to be done with license and permit.

(4) Establishing a system for root cause analysis of the events related to human factors to analyze typical or recurring events related to human factors, so as to find out the deficiencies in management policies and organization structures and strive to take more effectively preventive measures.

(5) Establishing internal and external operation experience exchange systems to find out management deficiencies and hidden weaknesses in the aspect of human factors through analysis and comparison so as to prevent similar human errors and avoid recurrence.

4.3.3 Functions of the Regulatory Body and the Operating Organization

The Chinese Regulatory Body establishes the related regulations on human factors, and through nuclear safety monitoring, checks whether the safety related staff in the plants is qualified, and checks whether the licensee timely and really reports and corrects the deficiencies and abnormals related to human factors, in order to facilitate the requirements for human factors being effectively met in the plants.

The operating organizations select qualified staff members and provide necessary training and instruction to fit their responsibility in all operation and accident status. Before conducting the task of operation, maintenance and periodical tests in NPPs, risk analysis and assessment are to be performed. The technical supervisors must be on site in the term of significant and high risk task. The professional staff are to be assigned for important operation and test. The on-site safety and quality monitoring are conducted in routine jobs and the measurement and treatment principle are provided to prevent the human errors.

The Chinese nuclear power plants have taken a lot of efforts to optimize personnel activities and reduce human error to improve human performance:

(1) Pay high attention to the research of human factors by considering personnel, equipment, regulations and organization and management to get the methodologies and measurement of reducing human error.

(2) Enhance the training related human factors to aid the staff clearly understanding the type, causal factors and behavior of human error to foster good habit of reducing human error.

(3) Three kinds of strategies are adopted for human errors or potential errors:

— Prevention: identify the potential status which lead to human error, assess potential risk and consequence, foster good working habit and apply the tools of reducing human errors;

— Detection: detect the potential status and behavior which may lead to human error, and timely correct, report and perform incidents and accidents investigation;

— Correction: correct the low level human error and deficiencies to prevent accident occurring.

(4) Advocate correctly using the tools for reducing human error such as STAR self check, question attitude, strictly work by following the procedures, good communication, teaching each other, and stop while uncertain or unsafe status to foster good organization culture of preventing human errors;

(5) Establish a comprehensive regulation system and organization, standardize human behavior, enhance the monitoring and control to operation status and human behavior;

(6) Establish the quantified performance indicators to control the incidents related human errors. The indicators are to be traced, analyzed and reviewed to timely identify and correct the deficiencies in personnel, equipment and organization and management;

(7) Enhance the management of personnel training, authorization and qualification, and conduct monitoring and checking personnel qualification and actual performance in order to reduce human error by maintaining the quality of the personnel.

(8) Emphasize the application of operation experience, carefully investigate and study the human factor related safety significant events, treat the errors as opportunities for learning and improving, systematically collect, screen, analyze, learn and apply the external operation experience in order to reduce human errors;

(9) Periodically review the status and safety factors related to human factors to identify and timely correct the deficiencies in order to assure the continuous improvement of human factor condition and human performance.

4.4 Quality Assurance

4.4.1 Quality Assurance Policies

NPPs in China always insist the policy "Safety First". The Quality Assurance Program (QAP) at each phase of NPP is established and implemented in accordance with the requirements of "Code on the Safety of Nuclear Power Plant Quality Assurance". The controls on the activities related to the quality in NPP are specified， and the appropriate control conditions are provided for accomplishing all activities affecting the quality。

The top management of NPP takes overall responsibilities for effectively implementing the QAP。 All personnel taking part in the activities related to safety and quality should comply with the requirements of QAP and be responsible and accountable for reporting quality problems discovered. An independent quality assurance department is set up to be responsible for the establishment and management of QAP. The effectiveness on the implementation of QAP is verified by performing inspection, surveillance and audit. The quality assurance department has the authority and sufficient independence from cost and schedule when disposing the quality problem until the quality problem has been disposed and resolved effectively.

The quality assurance policy of NPP in China is specified as follows:

(1) Identifying the quality assurance responsibilities

The operating organization of an NPP has overall responsibility for ensuring the safety of this NPP. The operating organization shall establish and implement the overall quality assurance programme consistent with the requirements contained in the Code on the Safety of Nuclear Power Plant Quality Assurance. The operating organization may delegate to other organizations the work of establishing and implementing all, or a part, of the programme but shall retain responsibility for the effectiveness of the overall programme, without prejudice to the contractors' obligations of legal responsibilities. The management in the constituent areas of activities shall provide effective implementation of the separate QAP .The basic responsibility for achieving quality in performing a particular task rests with those assigned task but not with those seeking to ensure by means of verification that it has been achieved.

(2) Fulfilling the quality assurance requirements

The quality assurance program encompasses the activities that are necessary to achieve the appropriate quality of the respective item or service and the activities that are necessary for verifying that the required quality is achieved and that objective evidence is produced to that effect. The quality assurance requirements in QAP should be described in documentary manner and executed strictly during the activities. Each organization participating in the NPP project is required compulsorily by means of the contract to plan, manage, execute and verify the activities in systematic manner and document each activity so as that each activity is performed by responsible person, according to the established requirements and with evidence to be tracked.

(3) Performing verification on conformance

Verification on the conformance with established quality requirements is an important part during quality assurance activity. The persons responsible for verification and inspection should be those who are independent of performing the work; persons who perform independent review and surveillance should also be independent of the organization responsible for carrying out the work so as to ensure the items or activities are sufficiently controlled and verified in phases of siting, design, manufacturing , commissioning and operation.

(4) Controlling in grading method

Although a set of principle on quality assurance is applicable for all activities affecting quality, appropriate methods or levels of control and verification shall be assigned to those items and activities according to their importance to safety so as to ensure that the quality on item and activity important to safety is attached more importance and controlled.

(5) Assessing the effectiveness of QAP

The quality assurance auditing system shall be established to verify the adequacy and effectiveness of QAP by reviewing, checking and investigating the establishment and implementation of QAP. Management of all organizations participating in the programme review at appropriate intervals the status, adequacy and effectiveness of the quality assurance programme for which they have designated responsibility by performing periodically management review. The QAP shall be revised timely as necessary.

4.4.2 Basic Requirements on Quality Assurance

The respective basic quality assurance requirements are clearly defined in "Code on the Safety of Nuclear Power Plant Quality Assurance", which include

— establishing and implementing effectively the overall QAP in NPP and separate QAP for each activity; establishing the procedures, instructions and drawings in written , and periodically reviewing and revising them; performing periodically management review to identify the status and adequacy of QAP, taking corrective action if necessary;

— establishing a documented organizational structure, with clearly defined functional responsibilities, levels of authority and lines of internal and external communication; controlling and coordinating working interfaces between organizations; controlling the selection, staffing, training and qualification of personnel to ensure that suitable proficiency is achieved and maintained by personnel;

— controlling the preparation, reviewal, approval, distribution and change for the document necessary for the execution and verification of the work to preclude the use of outdated and inappropriate documents;

— controlling design process, design interface and design change, and performing design verification to ensure that applicable specified design requirements are correctly translated into specifications, drawings , procedures or instructions;

— controlling the preparation of procurement documents, evaluating and selecting the suppliers, and controlling the procured items and services to ensure that the requirements of procurement documents are followed;

— identifying and controlling materials, parts and components, controlling the handling, storage and shipping of items, and appropriately maintaining items important to safety to ensure that the quality is not degraded;

— controlling processes affecting quality used in design, fabrication, construction, testing, commissioning and operation of NPP to ensure that the processes are performed by qualified personnel, using qualified equipment in accordance with approved procedures;

— establishing and effectively implementing inspection and test programme, verifying that item and activity meet specified requirements to demonstrate that the structure, system and component can work satisfactorily. Controlling selection, calibration and usage of measuring and test equipment, and performing identification and control on indication of inspection, test and operating status;

— controlling identification, review and disposition of non-conformance, defining the responsibilities and authority for review and disposition, and reinspecting repaired and reworked items;

— identifying and correcting conditions adverse to quality. For significant conditions adverse to quality, determing the cause of such conditions, and taking corrective actions to prevent repetition;

— establishing and executing quality assurance recording system, controlling identification, collection, indexing ,filing, storing, maintenance and disposal of records to ensure that records are legible, complete and correct to provide the evidence on quality of item and/or activity;

— establishing and executing internal and external auditing system to verify the implementation and effectiveness of QAP. Taking corrective actions for the deficiencies discovered during audit, and taking follow-up actions for tracking and verification.

In addition, a series of complementary requirements and implementing recommendations against the above-mentioned basic requirements are provided in ten(10) safety guides of quality assurance.

4.4.3 Establishment, Execution, Evaluation and Improvement on QAPs of NPPs

Chinese NPPs set considerable store by establishing quality assurance system. A lot of manpower resources and financial resources are utilized per year to ensure the effective operation of the system and the realization of the safety objectives. A special quality assurance department which is granted an adequate power is established to prevent and control effectively the activities endangering safety and quality until the problems are fully resolved .

4.4.3.1 Establishment of QAP

Within the lifetime of NPP in China, QAPs are developed for all stages including siting, design, construction, commissioning, operation, and decommissioning in accordance with the requirements of the Code on nuclear safety. The QAP established by operating organization for each stage of NPP shall be provided to the SEPA (NNSA) for review and approval. Similarly, separate QAP applicable for the work undertaken shall be established and implemented by NPP contractor according to the requirements of the Code. The separate QAP of contractor should be provided to operating organization for review and approval.

4.4.3.2 Execution, Evaluation and Improvement of QAP

Quality assurance is an essential aspect of 'good management' in NPP of China. The QAP is implemented effectively through thorough analysis of the tasks to be performed, identification of the skills required, the selection and training of appropriate personnel, the use of appropriate equipment and procedures, the creation of a satisfactory environment, a recognition of the responsibility of the individual who is to perform the task, verification that each task has been satisfactorily performed and the production of documentary evidence to demonstrate that the required quality has been achieved.

QAP is binding on everybody：

— manager: elaborately planning on each activity, assigning resources in reason and providing instruction and other necessary support in order to achieve the organizational objective;；

— operator: achieving quality by qualified personnel, using qualified equipment, material and tool, according to approved procedure and method and under appropriate environment, and record shall be formed in written.

— evaluator: evaluating the effectiveness of management process and implementation, and using the information obtained in evaluation into continuous improvement of work.

Quality assurance organization which is independent of other departments and under direct leadership of top management is set up in each NPP of China, and responsible for establishment, management, surveillance, evaluation and improvement of QAP. The quality assurance department can discover deficiency existing in quality assurance system by carrying out planned internal and external quality assurance surveillance, audit, review and evaluation, and take improvement action timely. Furthermore, non-conformance and corrective action are controlled strictly. Various quality information and trends are collected , analyzed and reported to high level management periodically. Relevant corrective action is taken promptly as necessary.

4.4.3.3 Management Review

The validity of QAPs shall be reviewed at appropriate intervals by the managing departments of organizations involved in the program each year. The basis of review and evaluation is the results of the quality assurance surveillance and audit performed in the year and information (such as quality problem, status of corrective actions, trend of quality, accident and failures, training and qualification of personnel, etc.) provided by other related departments of the plant. While reviewing the effectiveness of QAP implementation, each element of the programme shall be evaluated and following aspects are emphasized during evaluation:

(1) Severe quality deficiencies existed before but resolved last year;

(2) Important corrective actions performed or being performed which may influence the improvement of the quality as anticipated;

(3) Severe quality deficiencies unresolved;

(4) Overall evaluation for the effectiveness of program's implementation based

on program's applicability;

(5) Analysis of the cause of bringing about the deficiencies based on the quality deficiencies discovered and put forward proposal of corrective actions aimed at these deficiencies.

Corrective action shall be taken when programme deficiencies are discovered. Related organizations and units shall be notified in written and timely manner.

4.4.4 Regulatory Control Activities

The SEPA (NNSA)'s control of the quality assurance activities of NPP is described as follows:

(1) reviewing and approving NPP quality assurance programme and other documents important to safety, including the modifications on the documents in line with Code on the Safety of Nuclear Power Plant Quality Assurance and relevant safety guides;

(2) performing nuclear safety supervision on the implementation of NPP QAP, selecting control points on related quality plans and conducting supervision on site; organizing technical review and verification on the result of significant safety and quality activities;

(3) organizing technical review on significant non-conformance and performing effective supervision on the disposing process;

The SEPA (NNSA) and local regulation stations perform a series of supervision and inspection on significant activities relating to safety and quality for each NPP by strictly following the requirements of the code and relevant policy or documents, and conscientiously fulfilling the supervision functions on nuclear safety. The specific supervision activities are described in relevant chapter of this report.

4.5 Assessment and Verification of Safety

4.5.1 Licensing Process for Different Stages of an NPP

In order to conduct the nuclear safety regulation in the phases of sitting, construction, commissioning, operation and decommissioning of NPP, the SEPA (NNSA) review and approve the corresponding licenses, and proscribe the corresponding activities and conditions which must be obeyed by the licensee.

Sitting－The appropriateness of the site, design basis related to site environment and the feasibility of implementing emergency plans are the main aspects to be reviewed by the SEPA (NNSA). After the review and assessment is approved, "Reviewing Comments on Nuclear Power Plant Sitting" and the "Instrument of Ratification of the Environmental Assessment Report of Nuclear Power Plant" are then issued by the SEPA (NNSA).

Construction－The applicant submits the "Application for the Construction of Nuclear Power Plant" to the SEPA (NNSA), together with the "Preliminary Safety Analysis Report"(PSAR), the "Quality Assurance Programme of Nuclear Power Plant" at design and construction stages, the "Instrument of Ratification of the Feasibility Study Report for Nuclear Power Plant", and the "Report of the Environmental Impact of Nuclear Power Plant". After the design principles of NPP are reviewed and assessed by the SEPA (NNSA), a conclusion is reached on whether the NPP is safe after constructing. After the review and assessment is approved, the "Construction License for Nuclear Power Plant" is issued.

Commissioning－For the first fuel loading at the commissioning phase, the applicant submits the "Application for First Fuel Loading of Nuclear Power Plant" to the SEPA (NNSA), together with the "Final Safety Analysis Report of Nuclear Power Plant" (FSAR), the instrument of ratification of the "Environmental Impact Assessment Report of Nuclear Power Plant", the "Commissioning Programme of Nuclear Power Plant", the "Emergency Plan of the Operating Organization of Nuclear Power Plant", etc. The SEPA (NNSA) reviews these documents and determines whether the NPP is constructed according to the approved design, whether it is in compliance with the requirements of nuclear safety regulations, and whether it achieves the required quality with complete and qualified quality assurance records. After the review and assessment is approved, the "Instrument of Ratification for First Fuel Loading of Nuclear Power Plant" is issued.

Operation－The applicant submits the "Application for Operation License of Nuclear Power Plant" to the SEPA (NNSA), together with the revised "Final Safety Analysis Report of Nuclear Power Plant", the "Reports of Commissioning and Trial Operation of Nuclear Power Plant after the Fuel Loading" and the "Report of the Environmental Impact of Nuclear Power Plant". The SEPA (NNSA) reviews and determines whether the results of trial operation are consistent with the design and examines the revised operational limits and conditions and then if every thing is up to standard the "Operation License of Nuclear Power Plant" is issued.

Decommissioning－The applicant submits the "Application for Beginning of Decommissioning of Nuclear Power Plant" to the SEPA (NNSA), together with the "Decommissioning Report of Nuclear Power Plant" and the "Report of the Environmental Impact of Decommissioning of Nuclear Power Plant". The SEPA (NNSA) determines whether the decommissioning procedures and status of each stage of decommissioning are in compliance with the safety requirements. After the review and assessment is approved, the "Instrument of Ratification for Decommissioning of Nuclear Power Plant" is issued.

The basic principle of "Safety First" is persistently applied through out the course of review and assessment of the application for safety licenses and the course of issuance of safety licenses of NPP in China.

4.5.2 Main Methods of Safety Assessment and Verification in NPPs

Periodical safety review (PSR), probabilistic safety assessment (PSA), aging management, plant self assessment and external assessment are main methods of operational plant safety assessment. Periodical test and in-service inspection are main means of safety verification.

4.5.2.1 Periodical Safety Review

Chinese safety regulation requires that the nuclear power plant must be systematical reviewed again by considering operation experience and gained new significant safety information in the lifetime. The reviewing strategies and safety factors to be assessed are provided by the operating organization and approved by SEPA (NNSA). The first PSR is to be conducted after a ten-year's operation and after then once per ten years.

When conducting PSR, the effectiveness of current Safety Analysis Report is determined by considering the actual status of the plant, the operation experience, the expected condition at the end of lifetime, the current analysis methodologies, the applicable regulations, standards and technical level. Necessary corrective actions and reasonable modifications are to be taken by the plants based on the result of PSR.

Qinshan nuclear power plant started its first PSR in 2001 after its ten years operation and finished at September of 2003. Now the PSR reports have been submitted to the SEPA (NNSA) for reviewing.

Guangdong Daya Bay NPP started its PSR. During the PSR, based on the requirement of nuclear safety regulations, the safety practices of similar NPPs of China and foreign contries are considered. At present, the PSR has entered the phase of specific topic review.

4.5.2.2 Probabilistic Safety Assessment

In the "Technical Policy on Several Important Safety Issues in the Design of New Nuclear Power Plants" issued by the SEPA (NNSA) in August 2002, it was emphasized that the PSA methodology is a complement to deterministic methodologies and should be applied in the design of NPPs. It was also required that the plants should find the weaknesses by using the PSA technique, and put forward the recommendations based on the PSA results combined with foreign and domestic operation experience in order to improve the operation safety.

Qinshan NPP finishes its Level-1 PSA at full power in November 2003, and accepted an independent review from the group of the IAEA experts in December 2003. Some design weaknesses and the areas to be improved or optimized in operation were found through applying and developing this technique.

Guangdong Daya Bay NPP was finished its Level-1 PSA and submitted the report to the SEPA (NNSA) for review. Guangdong LingAo NPP, Qinshan III NPP and Jiangsu Tianwan NPP have all finished Level-1 PSA of designs.

4.5.2.3 Aging Management

As required by nuclear safety regulations, there must be adequate safety margins for SSCs in the design of NPP in order to consider the related mechanisms of aging and wearing, and potential performance degradation, so as to ensure that the SSCs should keep their capacities of carrying out their functions in the lifetime.

After operation of the NPP, it is requested to develop aging management program, adopt the measurement of monitoring, testing, sampling and checking, review the expected aging mechanisms in the design, and identify the unexpected potential conditions and performance degradation during operation.

When implementing periodical safety review, aging management was reviewed as a specific area to confirm that aging has been effectively managed by the plants, all required safety functions has been maintained, and an effective control of aging and degradation was realized.

Qinshan NPP has been operating for twelve years and Guangdong Daya Bay NPP has been operating about ten years up to now. According to the experience, some components, especially the electronic components, will be getting aging when the plant enters the next ten-year's operation. Qinshan and Guangdong Daya Bay NPPs are performing the aging assessments of systems, which covers the areas of cumulated effects of plant aging, plant modifications, operation experience and technical development. They are also developing and implementing the aging management programs which define the aging management policy, procedures, performance indicators, staffing, resource, recording and other measurement of management. Moreover, they are establishing aging managing measures and conducting the researches on the methodologies of detecting and mitigatiing the aging, as well as monitoring, analyzing, assessing, and tracking the actual status of SSCs, so as to keep the plants operate at a high safety level in the lifetime.

4.5.2.4 Periodical Tests

As required by nuclear safety regulations, the NPPs developed monitoring program on the basis of experience of foreign NPPs and monitoring requirements of components provided by the manufacturers. The monitoring program is involved with monitoring plant parameters and system status, monitoring chemistry and radiological chemistry sampling, test and calibration of the instrumentation, tests and inspections of the safety-related systems.

Periodical tests are the main measures for implementing plant monitoring program. They are used for determining whether or not the safety-related systems and components continuously carry out their functions as required by design. The procedures of periodical tests are required to be implemented and verified in the phase of commissioning, and fully implemented after commercial operation.

Through periodical tests, the NPPs have verified the functions of safety-related components and timely detected and corrected the deficiencies.

4.5.2.5 In-Service Inspection

According to the requirements in the nuclear safety regulations, guidelines and related technical standards, NPPs have developed in-service inspection programs for critical components, the in-service inspection programs were put into use after approved by the SEPA (NNSA). Besides the items required by the Technical Specifications, some additional items were added according to experience feedback from the foreign and domestic NPPs.

During the recent three years, Qinshan, Guangdong Daya bay, Qinshan II and Guangdong LingAo NPP have completed nine in-service inspections in total during the refueling outages. According to the results, the safety performance of the NPPs meets the requirements in the Technical Specifications, the three safety barriers keets integral. The results of in-service inspections were reviewed by SEPA (NNSA).

4.5.2.6 Internal and External Assessment in NPPs

For safe and reliable operation, Chinese NPPs have established comprehensive system for internal and external assessments by continuously learning the advanced managingt experience from foreign NPPs in combination with the development practices of domestic NPPs, see Figure 4.

Internal assessment includes independent assessment in NPPs and self assessment at different management levels. Independent assessment is conducted by authorized departments or organizations, through auditing, monitoring and technical reviewing to check and verify each job done by plant staff or contractor. The results of independent assessment are important inputs to self assessment.

Self assessment at different management levels existed in routine jobs. Its purpose is to determine the effectiveness on establishing, promoting and achieving the goals of nuclear safety, and identify and correct managing weaknesses and obstacles to achieving nuclear safety goals. Self assessment of top managing departments focuses on strategic goals suitable for organization, including safety goals. The line management pays more attention to monitoring and review of working process, including the monitoring of tasks, service and process, review and confirmation of design documents, review of procedures and records, observation of independent assessment, and periodical walk-down of facilities.

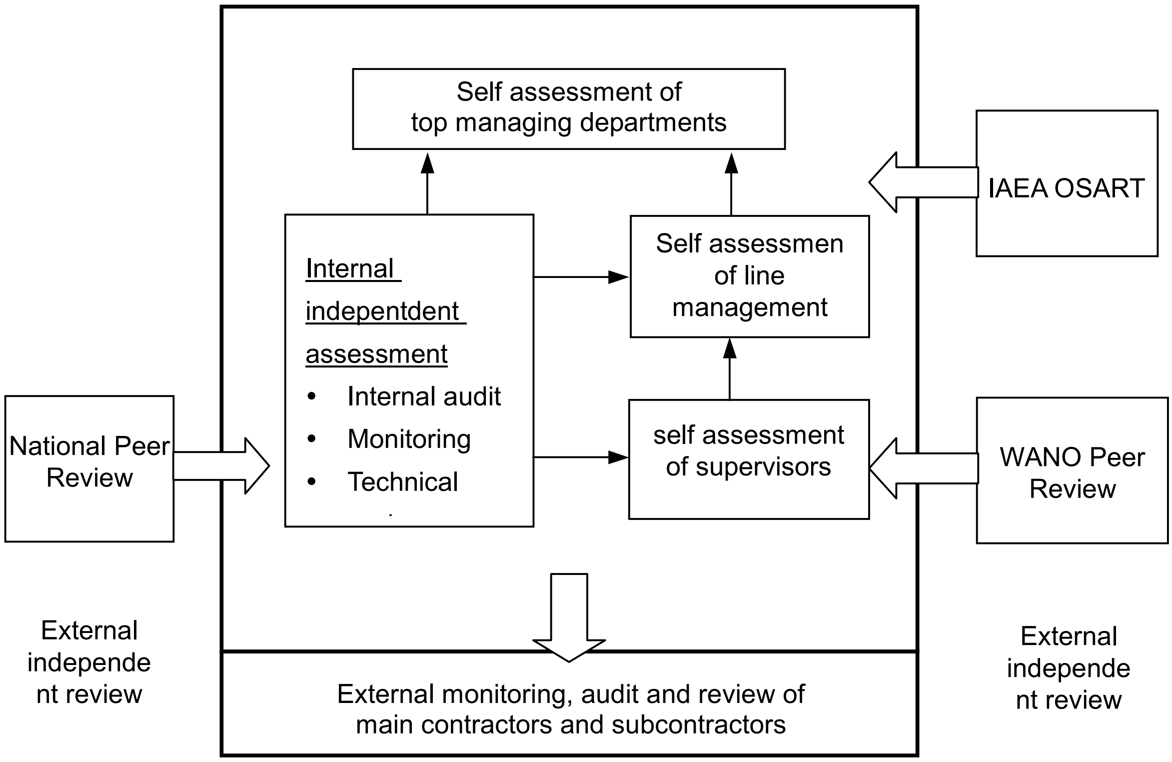

Figure 4 Assessment System of NPPs

In 2002, a system for national operation assessment was set up under the promotion by CAEA. The results of reviews indicated that the reviewed plants were kept in good safe conditions.

4.5.3 Control Activities of Regulatory Body

The SEPA (NNSA) conducts strict control over all key points in construction, commissioning, fuel loading, and operation of the NPPs. For example, the SEPA (NNSA) sent inspectors to the NPP site to conduct inspection and witness for hydro-pressure tests of primary loop, leak-tight tests of containment, etc., and to organize integrated examinations before the first fuel loading. The SEPA (NNSA) defined the control points for all stages of the first fuel loading, first criticality, and power escalation under the license conditions of "Instrument of Ratification of the First Fuel Loading". The SEPA (NNSA) also set the control points for re-criticality after refueling outage of NPP. In recent three years, the SEPA (NNSA) monitored and reviewed periodical safety reviews of Qinshan and Guangdong Daya Bay NPPs. In

2003, the SEPA (NNSA) paid high attention to the safety reviews and inspections on re-work of pressure vessel of Unit 2 of Qinshan Phase II NPP due to welding defects, the first loading approval sheet for Jiangsu Tianwan NPP, and spent fuel transportation of Guangdong Daya Bay NPP.

The SEPA (NNSA) always regards the routine inspections of NPPs as its principal tasks. Considering the newly operating units in recent years, the SEPA (NNSA) has strengthened its routine inspections and inspections of refueling outage, actively conducted the activities on analyses of operation incidents and operation experience feedback, and effectively guaranteed the safety of the NPPs.

According to "Program on Nuclear Safety Inspections in Construction Phase of NPPs", the SEPA (NNSA) made a further perfection of safety inspection styles during construction of NPPs. Meanwhile, the SEPA (NNSA) consulted with the IAEA experts and related foreign experts for nuclear safety reviews for many times.

4.6 Radiation Protection

4.6.1 Principled Requirement of Radiation Protection

Chinese government promulgated a seriesof laws, regulations and state standards to ensure the implementation of radiation protection goals.

(1) "Act of Prevention and Remedy of Radioactivity Contamination of the People's Republic of China" promulgated by the Standing Committee of the National People's Congress on June 28, 2003, requires that:

— The operating organizations of the NPPs are in charge of protection and remedy of radioactive contamination under monitoring and management of administrational competent department and other related departments, and responsible for all consequences caused by radioactive contaminations required by the law;

— The operating organizations should survey the categories, concentration and amount of radionuclide in the effluents to the surrounding, and periodically report the survey results to administrational environment protection department of State Council and local governments.

— The operating organizations should minimize the effluent of radioactive waste. The airborne and liquid effluents must be below the state standard of protection and remedy of radioactive contamination, and the operating organization must periodically report the effluents survey result to administrational environment protection department.

(2) On April 1 of 2003, the new state standard GB18871-2002, "Principal Standard of Ionization Radiation Protection and Radioactive Source Safety" was issued to replace original standards GB8703-88, "Radiation Protection Requirements" and GB-4792-84, "Principal Standard of Radioactive Health Protection". The standard requires that the radioactive substance release should be controlled, the all critical approaches which lead to public exposed should be determined, and the affection to human being and environment should be evaluated. The new standard meets the international standards, and involved the recommendations from ICRP. The limits of personal dose in "Principled Standard of Ionization Radiation Protection and Radioactive Source Safety" are required as follows:

— The occupational exposure

The occupational exposure of any worker should be controlled so that the following limits are not exceeded:

• an effective dose of 20 mSv per year averaged over five consecutive years defined by regulatory body (not for retroactive average);

• an effective dose of 50 mSv in any single year;

• an equivalent dose to the lens of the eye of 150 mSv in a year;

• an equivalent dose to the extremities (hands and feet) or the skin of 500 mSv in a year.

• When, in special circumstances, the dose averaging period may exceptionally be up to 10 consecutive years, and the effective dose for any worker shall not exceed 20 mSv per year averaged over this period and shall not exceed 50 mSv in any single year, and the circumstances shall be reviewed when the dose accumulated by any worker since the start of the extended averaging period reaches 100 mSv; the temporary change in the dose limitation shall not exceed 50 mSv in any year and the period of the temporary change shall not exceed 5 years.

— The exposure to general public

The estimated average doses to the public shall not exceed the following limits:

• an effective dose of 1 mSv in a year;

• in special circumstances, an effeetive dose of up to 5 mSv in a single year provided that the average dose over five consecutive years does not exceed 1 mSv per year;

• an equivalent dose to the lens of the eye of 15 mSv in a year;

• an equivalent dose to the skin of 50 mSv in a year.

(3) In each stage of nuclear power plant, the radiation protection principled requirements are defined in series regulations on siting, design, operation and the others by the regulatory body. The requirements are as following:

— During siting of NPP, the protection to general public and environment from over exposure due to release caused by radiation accident should be assured. Meanwhile, the normal radioactive substance release should be considered.

— During design of NPP, the radiation protection requirements should be considered, such as optimization of layout, setting the barriers, reducing the number and the duration of personnel working in radiation area, and treatment of radioactive substance to proper shape.

— Measurement should be carried out to reduce the amount and density of radioactive substance in plant or released to environment.

— The potential radiation accumulation in the personnel working area should be considered, and the products of radioactive waste should be minimized.

— The operating NPP should evaluate and analyze the radiation protection requirement and plant actual condition, estabilish and implement the radiation protection program, ensure correctly implementing each program by monitoring, checking and auditing, verify the achievement of the goals, and take necessary corrective actions.

— The radiation protection responsible department establishes and implements the radioactive waste management program and environment survey program, and evaluates radiation affection of radioactive release to environment.

(4) In the "Technical Policy on Several Important Safety Issues in the Design of New nuclear Power Plants" which was issued in August 2002 by the SEPA (NNSA), it

is required that nuclear safety analysis should be completed during in the design of NPP to evaluate the acceptable dose of staff in NPP and general public, and potential consequence to environment. It is also required that the NPP should take measures to control exposure of radiation and decrease the possibility of accident. The safety design of NPP must follow the principle of low probability of accident with high dosage or high radioactive substance release, and no or little radiation consequence of high probability incidents.

(5) The related requirements on the dose equivalent limits and the annual discharge limits are stipulated by the state standard, "Rules on the Environmental Radiation Protection of Nuclear Power Plant" (GB6249-86) as follows:

— The annual effective dose to any members (adults) of the general public caused by the discharge of the radioactive substance of each NPPs shall be less than 0.25mSv.

— In addition to satisfy the requirement set by the upper item, the annual discharge of each NPP in normal operation shall be lower than the discharge limits listed in below table:

The Annual Discharge Limits of Each PWR NPP in Normal Operation (Unit: Bq)

Radioactive airborne effluents			Radioactive liquid effluents	
Noble gas	Iodine	Particles (Half life≥8d)	Tritium	Other nuclides
2.5×10^{15}	7.5×10^{10}	2.0×10^{11}	1.5×10^{14}	7.5×10^{11}

4.6.2 Measures Taken in NPPs to Keep As Low As Reasonably Achievable (ALARA)

4.6.2.1 Application of ALARA Principle in Design

(1) General design considerations

— Proper layout and shielding are adopted for the SSCs which contain radioactive substance.

— Minimize the times and duration of working in radiation area in the design.

— The radioactive substance is processed into proper shape for easy transportation, storage and treatment.

— The amount and density of radioactive substance which disperses in plant and releases to environment are reduced.

(2) Design consideration for equipment

— Reliable and durable equipment, components, and materials are selected to reduce or eliminate the need for maintenance;

— The selected coating materials for equipment and components are easily flushed and decontaminated;

— Modularized designs of equipment and components are adopted for easy disassembly and replacement or move to a lower radioactive area for repair;

— Redundant equipment or components are prepared to reduce the demands for instant repair when radiation levels may be too high or feasible approaches are unavailable to reduce radiation levels;

— Equipment and components can be remotely operated, maintained, repaired, monitored, and inspected.

(3) Design consideration for equipment layout

— Improve accessibility of equipment;

— Provide radioactive equipment with shielding;

— Provide proper and sufficient ventilation;

— Control contamination, conduct obvious isolation between contaminated area and non-contaminated area, and decontaminate the contaminated area;

— The processing technology and detection of radioactive substance;

— Arrange equipment, instrumentation and sampling spots in low radiation area.

4.6.2.2 Application of ALARA Principle in NPP Operation

The operating NPPs achieve the radiation protection goals by taking all possible and reasonable measures as bellow:

(1) Establish radiation protection programs and procedures. The radiation protection department in NPP is independent from departments of operation and maintenance, and is staffed with well trained and qualified personnel. The radiation

protection program is established on the basis of national regulations and standards and operation experience of other foreign NPPs, and amended or improved by using previous experience and practice. The radiation protection department confirms that all the radiation related activities are conducted on schedule and normalized, as well as monitored independently.

(2) Set the goals of radiation protection management. The NPPs establish the annual radiation protection management goals including the indicators of cumulated dose, maximum personal dose, internal exposure, external exposure, the number of the events breaking rules of radiation protection, etc. Strictly control the contamination and activities in radiation areas, and ensure that the actual performance is controlled within managing limits. Evaluate the dose data for using as reference in future.

(3) Emphasize the training and retraining of the staff, including the ones of contractors. The staff engaged in radiation protection should be trained with focus on the specialty knowledge, protection skills, optimized examples to enhance their overall capacity and on-site ALARA decision-making capability. Meanwhile, the engineer for radiation protection training conducts the radiation protection training of all staff to acquaint them with the radiation jeopardy and the necessary protection measures.

(4) Prepare the detailed radiation protection plan. When working on or near the components with high radioactivity, an aforehand plan should be made, the operating methods should be defined, and a guideline for occupational radiation protection should be developed based on ALARA principle. Drills should be done and protection plan should be made prior to high radioactive jobs in order to conduct the control of crucial activities and reduce the exposure dose.

(5) For a given task, the department for radiation protection studies the radiation information in the plant, carries out a survey of the on-site conditions, estimates the jeopardy of radiation and contamination, and decides the protection measures and substitute approaches. Before the work that may have high radioactivity, the workers should receive the brief explanation, simulative drills and radiation protection guidelines in the working areas.

(6) Strengthen the managing and technical measures of the activities involved with radioactivity, such as reinforce the control of entrance to and exit from radiative area, strengthen the periodical test and maintenance of instrumentation to ensure that

all instrumentation is kept in good condition, and perform the oxygenation operation of primary system during cooldown and depressurization.

Since most of exposure dose of the plant staff are undergone during refueling outage, the plants have paid high attention to radiation protection activities and effectively taken and reinforced the measures above mentioned during the refueling outage.

4.6.3 Personnel Exposure Control

4.6.3.1 The Occupational Exposure

As the survey of the occupational exposure, the annual average dose equivalent for the site personnel in the operating NPPs of China is far below the dose equivalent limit set by the national standards. The survey results are listed in Annex 1.

4.6.3.2 Radiation Exposure of the Public

The environment monitoring centers of the province in which the Chinese NPPs are located have performed the monitoring of the environment around NPPs. The results indicate that the radioactivity in surrounding environment is kept at a level of the natural background. The maximum individual dose equivalent of the general public due to the discharge of the radioactive effluents during the operation is far below the dose equivalent limit set by the national standards.

4.6.4 Environment Radioactivity Monitoring

According to critical nuclides, critical exposure and transfer paths and critical public groups defined in the environment impact report (EIR), NPPs have established environment monitoring programs for monitoring the radioactivity in environment, to ensure that the requirements in related state laws and regulations are met, the discharges of radioactive substance are kept within discharge limits, and the public are protected from injury due to radioactivity during nuclear plants operation. The survey data of nuclear plants environment radioactivity are evaluated and analyzed in the aspects as follows:

— the effectiveness of controlling the release of radioactive substance to the environment;

— the radiation exposure to the public by the radioactive effluents of NPPs;

— the long-term tendency of environment radioactivity;

— the transfer and diffusion of radioactive substance in the environment;

— the validation of environment model used in EIR.

(1) The environment investigation of pre-operation

The NPPs fulfill two-year investigation of the ambient radioactivity and the ocean ecosystem. The plants obtain the information of critical nuclides, critical exposure (and transfer) paths and critical public groups. The media of the environment to be investigated include the air, surface water, ground water, land-living organisms, water-living organisms, food, soil, etc. The investigation range of γ radiation in the environment is 50km, the investigation range of other items is 20km. The analyzing and measuring contents include the radiation level in the environment and the radioactive nuclides related to NPPs.

Before putting into operation, the Chinese NPPs have monitored and recorded the level of the ambient background, to ensure the scope and frequency of environment monitoring are representative and meet the requirement of related regulations.

(2) The routine environmental radiation monitoring

In order to satisfy the environmental evaluation needs, the NPPs fully use the investigation data obtained before the operation to achieve the optimization of environmental monitoring. The emphases of environmental monitoring are put on those items that bring the most hazards to the critical public groups.

Conforming to state environment protection regulations and environmental radioactivity monitoring standards, the NPPs effectively monitor and evaluate the environment according to their environment monitoring programs.

Through monitoring and analysis of living organisms, air, soil and sea and others, and comparing with the level of the ambient background, it was indicated that: in the past three years, the radioactive level was kept at the ambient background investigations at the surrounding of operating NPPs in China.

(3) The radioactive effluent monitoring

All kinds of airborne and liquid radioactive effluents are monitored after NPP's operating. The measuring contents include the total discharge amount, the discharge concentration and the main nuclides to be analyzed. The monitoring results indicate that the radioactive effluents of each plant are below the limits of state standards during operation.

The percentage of radioactive effluents to the limits of state standards from 2001 to 2003 of Chinese NPPs is listed in Annex 2.

(4) The meteorological monitoring

The plants have developed the meteorological monitoring program to monitor the conditions of air diffusion. The wind direction, wind speed and air temperature at different elevations, as well as precipitation and air pressure are continuously monitored in selected monitoring points which are representative. Moreover, the communication between the operating organization and the local provincial meteorological department has been kept to exchange the related meteorological data.

(5) The environmental emergency monitoring under accident

The operating organization has established a monitoring plan for environmental emergency submitted to the provincial environment protection department before the trial operation of NPP. The monitoring plan for environmental emergency formulates some deduced action levels for the purpose of evaluating the monitoring results and determining as soon as possible whether it is necessary to take relevant actions

The operating organization has installed such instruments as the radiation monitors, the sequential radiation detectors, the contamination monitors, the air samplers and the environmental media samplers, etc., which are periodically checked, calibrated and tested, if necessary, to ensure that these emergency response facilities are available when they are to be used.

(6) The evaluation of the public doses and environment impacts in normal operation and in the accident

The operating organization evaluates the dose equivalent imposed upon the general public and the impact on the environment in the normal operation and in the accident of NPP by using the data obtained from the monitoring of the accumulative γ-radiation dose around the site boundary and the sampling analyses of the environment media such as the atmosphere dust, the land-living organisms, the soil, the water, etc.

4.6.5 Control Activities of the Regulatory body

— To stipulate rules and guiding documents related to the radiation protection and the radioactive waste management.

— To stipulate rules, guiding documents and standards related to the radiation protection and the discharge limits of radioactive effluents.

— To evaluate whether the NPPs conform to the related regulations and standards by reviewing design, construction and operation of the radioactive waste management installations, as well as the personnel qualifications and records.

— To demand the operating organizations to take remedial and corrective measures for the items discordant with the requirements of the related regulations and standards;

— To review the Environmental Impact Report (EIR) submitted by the operating organization of the NPP.

— To review and approve the control limits of the annual discharge of airborne and liquid radioactive effluents.

— To review the environment monitoring report submitted by the operating organization, and to organize the provincial environmental monitoring center to perform environment monitoring.

— To initiate the drafting of "Act of Prevention and Remedy of Radioactivity Contamination of the People's Republic of China".

— Have edited the "National Radiation Environment Monitoring Schedule (Temporary) ".

— Have completed the first edition of "Regulation on Safety Monitoring of Radioactive Substance Transportation".

— In 2002, performed a specific inspection on radiation protection of Guangdong Daya Bay NPP.

The radiation environment monitoring stations set up by local environment departments in each province independently monitoring the radioactive effluence. They check the monitored data with those from the NPPs, and compare with the international NPPs. They also provide the survey report to the SEPA (NNSA) and local environment protection administrations, and evaluate the effects of the effluence on environment. The SEPA (NNSA) and local environment protection administrations review the monitoring reports provided by the operating organizations of NPPs and by the local radiation environment monitoring stations to ensure the veracity and authenticity of the results.

4.7 Emergency Preparedness

4.7.1 Basic Requirements for Emergency Preparedness

The "Emergency Management Regulations for Nuclear Accidents at Nuclear Power Plant" specifies the policies as follows: the principle of emergency management of nuclear accidents should be ever on the alert, positively compatible, unified command, energetic coordination, protection of the public, and protection of the environment. China has established a regulatory system for nuclear emergency and a three-level emergency preparedness system for nuclear accidents, Hence, the necessary and effective emergency response actions can be taken in case of severe accident of NPP.

The emergency preparedness includes: establishing emergency organizations, preparing emergency response plan and emergency response implementing procedures, preparing emergency response facilities and conducting periodic emergency response training and exercises. Specific requirements for NPP emergency preparedness are stated in the nuclear safety regulations.

Chinese government has issued 21 nuclear emergency codes or standards which involve the report system for nuclear accident emergency, medical treatment, emergency management of severe accident, emergency management for radioactive material transportation, management of nuclear accident trans-boundary, etc., thus promoted the normalized management of nuclear accident emergency.

4.7.2 Emergency Preparedness Measures

4.7.2.1 Emergency Preparedness System

According to "Emergency Management Regulations for Nuclear Accidents at Nuclear Power Plant", a three-level emergency preparedness system is carried out in China, which consists of the National Coordinating Committee for Nuclear Emergency (NCCNE), emergency organizations of local governments and NPP operating organizations for nuclear accident. See Figure 5.

Within the three-level emergency preparedness system, the main duties of the organizations concerned are as follows:

(1) The NCCNE is responsible for organizing and coordinating the national emergency management of nuclear accidents;

— Carrying out the policies on national emergency management of nuclear accidents, drawing up national policy for nuclear emergency activities;

— Organizing and coordinating emergency response activities of the related departments subordinate to the State Council, the nuclear industry administration, local government, NPPs and other nuclear installations as well as the Army;

— Reviewing national work programming for nuclear emergency and annual work plan;

— Organizing the preparation and implementation of the national emergency response plan of nuclear accidents, reviewing and approving off-site emergency response plan;

— Approving the declaration and termination of the off-site emergency status at appropriate time, when responding to emergency;

— Unifying the activities for decision-making, organizing and commanding of emergency response supports, reporting to the State Council at any moment;

— Putting forward suggestions to the State Council on implementing special emergency response actions at appropriate time;

— Fulfilling relevant international conventions on nuclear emergency and bilateral or multilateral cooperation agreements. Reviewing and approving bulletin and international notification for nuclear accident; working out the scheme for requesting international aids;

— Conducting other affairs assigned by the State Council;

If necessary, the State Council leads, organizes, and coordinates national nuclear emergency management.

(2) The National Nuclear Emergency Response Office (NNERO) is an administrative organization for national nuclear emergency. It is a subordinate

department of CAEA. Its main responsibilities are as follows:

— Carrying out nuclear emergency policies of the State Council and the NCCNE;

— Taking charge of routine activities of the NCCNE;

— Implementing national nuclear emergency plan, inquiring, coordinating and supervising emergency preparedness activities of member organizations of the NCCNE, notifying, guiding, and coordinating related emergency preparedness of local governments and NPPs;

— Taking charge of receiving, handling, transmitting, notifying, and reporting information on nuclear and radiation emergency; Undertaking the affairs for implementing relevant international convention and bilateral or multilateral cooperation agreements, and requesting international aids as a national emergency liaison point to the external,

— Preparing national nuclear emergency work programming and annual work plan; Working out scientific research plan and scheme of technical support system for emergency;

— Organizing the reviews of the off-site emergency plan, the off-site integrated exercise plan, and the joint exercise plan of on-site and off-site; making the review comments.

— Organizing activities of liaison persons and experts advisory group.

— Organizing relevant training and exercise on nuclear emergency.

— Collecting information, putting forward report and proposal, timely communicating and executing decisions and orders from the State Council and the NCCNE, checking and reporting the evolution of implementation when responding to emergency,

— Undertaking related affairs decided by the NCCNE after termination of emergency situation.

(3) The SEPA (NNSA) is responsible for the independent regulation for nuclear safety of nuclear accident emergency of NPP, as well as reviewing and approving on-site emergency response plan of NPP and supervising the preparation and implementation of emergency response plan of NPP.

(4) The relevant departments of the SEPA, the MH, and the Army conduct relevant emergency activities for nuclear accident according to their respective responsibilities.

(5) The Commission of Nuclear Emergency Response of the province at which the NPP located is responsible for emergency management for nuclear accident in its district, its main duties are:

— Implementing national regulations and policies of emergency response for nuclear accidents;

— Organizing to prepare the off-site emergency response plans and the emergency preparedness of nuclear accidents;

— Conducting unified command of the off-site emergency response actions;

— Organizing the supports to emergency response actions;

— Notifying timely the nuclear accident situations to the neighboring provinces, autonomous regions and municipalities directly under the Central Government;

— If necessary, the provincial government leads, organizes and coordinates emergency response management of nuclear accidents within its administrative area.

(6) The organization for nuclear accident emergency of NPP is responsible for:

— implementing national regulations and policies of nuclear emergency for nuclear accidents;

— preparing on-site emergency response plans and emergency preparedness of nuclear accidents;

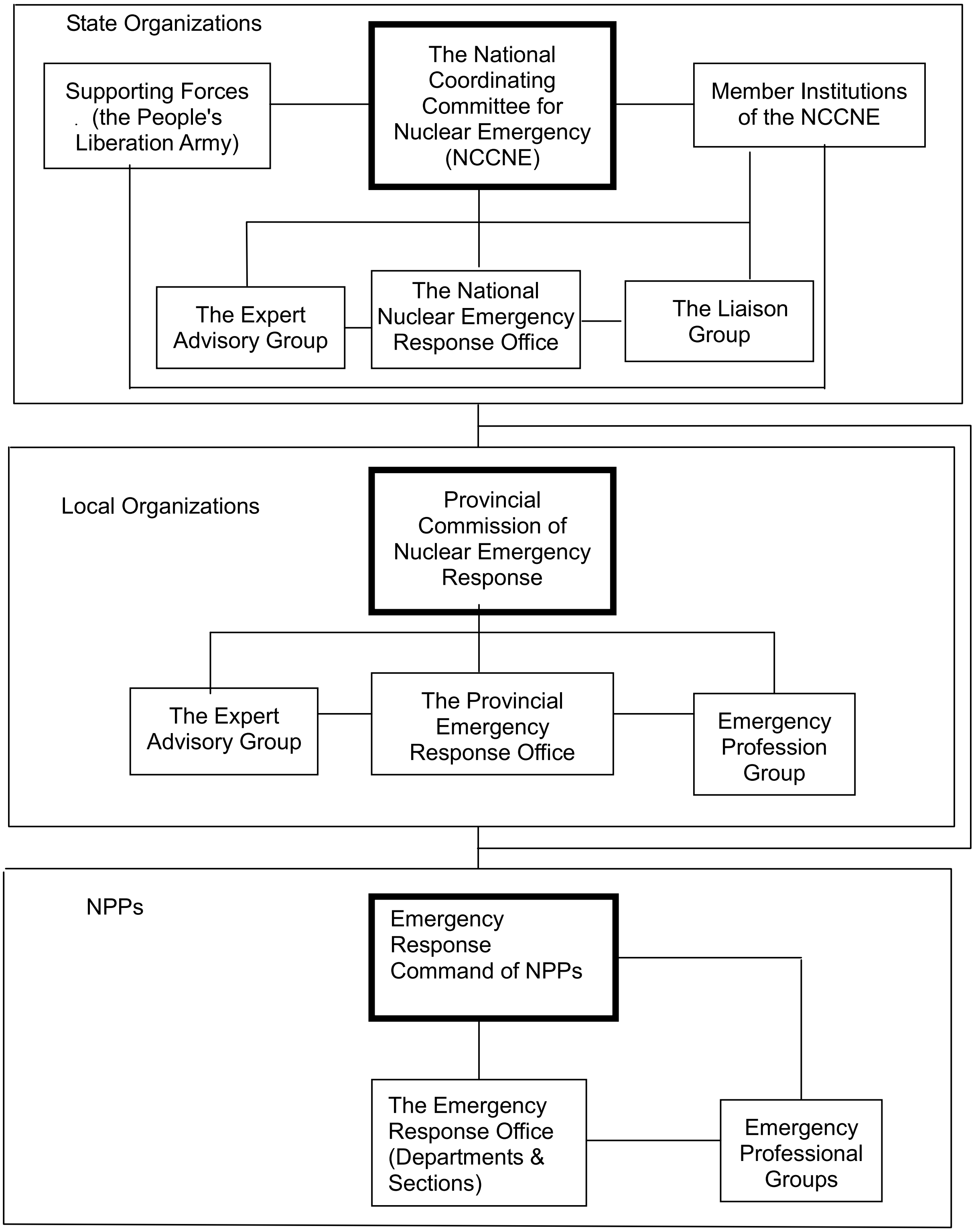

Figure 5 Organizational Structure of National Nuclear Emergency Response System

— determining the grade of emergency conditions of nuclear accidents and implementing the unified command of emergency response actions of the plant;

— reporting timely the accident situation to the superior authority, the SEPA (NNSA) and the organizations assigned by the provincial government and putting forward recommendations on declaration of off-site emergency condition and implementation of emergency protective measures;

— assisting and coordinating the organizations assigned by the provincial people's government to conduct the emergency response management of nuclear accidents.

In three provinces, that is, Zhejiang, Guangdong and Jiangsu, respective commissions of nuclear emergency response have been established and been made up of a vice provincial governor who acts as the director and relevant departments and the army. Meanwhile, the front organizations for nuclear emergency response, which belong to local government, have also been established in Haiyan County, Zhejiang Province, Shenzhen, Guangdong Province and Lianyungang, Jiangsu Province respectively.

4.7.2.2 Classfying and Reporting of Emergency Conditions

The emergency situations of nuclear accidents are classified into the following four scales:

(1) Emergency on Standby: In case of some specific situations or external events which may lead to endangering the safety of NPP, relevant plant personnel will be on standby. Some off-site emergency organizations may be notified.

(2) Plant Emergency: The radiation consequences of the accident are confined within a partial area of the plant, on-site personnel are activated and off-site emergency response organizations concerned are notified.

(3) On-site Emergency: The radiation consequences of the accident confined within the site, on-site personnel are activated and off-site emergency response organizations are notified while some off-site emergency organizations may be activated

(4) Off-site Emergency: The radiation consequences of the accident go beyond the site boundary, both on-site and off-site personnel are activated and the plans for on-site and off-site emergency response are needed to be implemented.

In the case of emergency on standby, the emergency response organization for nuclear accident of NPP shall report timely to its competent authorities and the SEPA (NNSA), if necessary, report to the provincial commission of nuclear accidental emergency response. In case radioactive material may release or may have released, the emergency response organization for nuclear accident of NPP shall declare timely plant emergency condition or site emergency condition and promptly report to competent authorities, the SEPA (NNSA) and the provincial commission of nuclear accidental emergency response.

In case radioactive material may spread or have spread beyond the site boundary, suggestion on entering the off-site emergency condition and taking corresponding emergency prevention measures shall be promptly put forward to the provincial commission of nuclear accidental emergency response. Upon receiving emergency report from nuclear emergency response organization of NPP, the provincial commission of nuclear emergency response shall promptly take corresponding countermeasures and preventive measures and report timely to the National Nuclear Emergency Response Office. Off-site emergency condition will be declared after approval by the NCCNE. But in some special cases, the provincial commission of nuclear emergency response can declare the off-site emergency in advance and then report to the NCCNE promptly.

Under the off-site emergency condition, relevant departments such as the National Nuclear Emergency Response Office and the SEPA (NNSA) shall send staff to the site and direct the nuclear emergency response actions.

4.7.2.3 On-site and Off-site Emergency Plans of NPP

Focusing on the nuclear accidents that probably occur, on-site emergency response plan is prepared by operating organization, off-site emergency response plan is prepared by local government and the national emergency response plan of nuclear accident is prepared by the NCCNE. The contents of the three levels of emergency response plans are mutually linked and harmonized. Each plan has its implementing procedures as a detailed supplement. Besides, emergency schemes are prepared respectively by the main member organizations of the NCCNE, emergency support organizations and the Army. The emergency response plans and the schemes are prepared, reviewed and approved, and revised periodically according to regulations.

The contents of emergency response plans include the emergency response organizations and their responsibilities, the detailed schemes of emergency preparedness and response, facilities and equipment, coordination and supports from the organizations concerned, and other technical aspects. According to the principle for being positively compatible with nuclear accident emergency, a national technical support system for nuclear emergency is established to guarantee the capability on nuclear emergency response by fully utilizing the existing conditions, establishing and maintaining necessary technical supporting centers or technical aid organizations such as ones for emergency decision support, radiation monitoring, medical rescuing, meteorological service, NPP operation technical supports, etc.

The emergency plan of the operating organization of NPP is reviewed and approved by the SEPA (NNSA), the emergency response plan of the local provincial government where the NPPs are located is reviewed and approved by the NCCNE and the national emergency response plan is reviewed and approved by the State Council.

4.7.2.4 The Public's Acquaintance with Emergency Preparedness

The National Nuclear Emergency Response Office has established information communication network to enhance communication among relevant departments, local governments, the NPPs and the public.

Local governments are responsible for the popularized education of the public around the NPPs on the basic knowledge of nuclear safety and radiation protection, and propagating knowledge on emergency protection, such as alarm, shielding, evacuation and taking preventive anti-radiation medicine in case of an emergency, and giving directions on how to take these actions.

The operating organization of NPP takes various measures such as utilizing local broadcast and TV, publicizing propaganda material and inviting local public to visit plant and to take part in or to watch emergency exercises, to make the public to eliminate nuclear panic, and to effectively participate in emergency response activities in case of an emergency.

The NPPs and their provincial environmental protection departments publish the annual environmental surveillance results to the public via proper news media.

Emergency organizations in different levels have established relatively broad social basis for nuclear emergency to promote the harmonic coexistence among NPPs and their neighboring communities and environment through various kinds of .communication activities on nuclear energy.

4.7.3 Training and Exercises for Emergency Preparedness

In order to enhance the professional level of the staff and provide enough manpower for nuclear emergency preparedness and response, the national and local emergency organizations conduct training activities by means of workshop, technical training and emergency knowledge exam to strengthen training and discipline of human resource on nuclear emergency..

All emergency response personnel, including emergency commanders, of Chinese NPPs are trained and examined systematically before the first fuel loading. The training and the examination required by their conducting planned emergency activities should be performed at least once a year in the NPP operation lifetime.

Emergency training in NPP includes basic training, special training and on-job training with the content of emergency preparedness and response, which are applied to general staff of NPP (including contractors), personnel engaged in emergency organization and personnel on posts requiring higher techniques and skills.

Emergency response exercise is implemented before the first fuel loading to verify the effectiveness of emergency preparedness of new NPPs in recent years, according to the requirements of nuclear regulations.

Various types of emergency exercises are carried out periodically for operating NPPs to verify, improve and strengthen the abilities of emergency preparedness and emergency response.

The following emergency exercises have been implemented by Chinese government since the second review meeting of the convention on nuclear safety:

(1) Comprehensive on-site emergency exercise before the first fuel loading was organized by Qinshan Phase II NPP in September 2001.

(2) Comprehensive on-site emergency exercise before the first fuel loading of unit 1was organized by Guangdong LingAo NPP in November, 2001.

(3) Comprehensive on-site emergency exercise was organized by Qinshan NPP in March 2002, focusing on the evacuation of on-site non-emergency personnel,

to evaluate and verify the feasibility and effectiveness of the revised On-Site Emergency Plan of Qinshan NPP.

(4) The first joint on-site and off-site emergency exercise was organized jointly by Zhejiang Provincial Commission of Nuclear Emergency Response and Qinshan Phase III NPP on July 2002. This exercise was assessed by a national team that was organized by the National Nuclear Emergency Response Office, focusing on response actions against postulated accidents of Qinshan Phase III NPP.

(5) Drills that personnel reach the designated positions and joint drills for a special scenario were organized by the Guangdong Provincial Commission of Nuclear Emergency Response on January 2003.

(6) The first comprehensive off-site emergency exercise was organized by Jiangsu Provincial Committee for Nuclear Emergency at Nanjing and Lianyungang simultaneously with the postulated accident of unit 1 of Tianwan NPP as the simulated scene.

4.7.4 Progress of Emergency Preparedness Activities

(1) The Chinese government approved the "National Nuclear Emergency Response Plan", which was revised by the National Coordinating Committee for Nuclear Emergency, in November, 2001. Responsibilities and interfaces among different organizations are clarified and the coordination and management of emergency system are strengthened. Because of the preparation of "National Nuclear Emergency Preparedness Programming" and "the Tenth Five-Year Plan of National Nuclear Emergency Research", objectives and requirements of emergency preparedness are further clarified.

(2) Based upon the principle of reasonable assignment of responsibilities and enhancement of cooperation, the NCCNE organizes annual plan coordinating meeting, workshops and seminars, organizes consultants and counterparts to take part in provincial, local and NPP emergency exercises, strengthens the review, coordination and regulation of emergency plan, organizes review and assessment on emergency activities of different emergency organizations, stimulates the mutual understanding among the members of NCCNE, establishes the working mechanism of unified command and energetic coordination.

(3) The newly built National Emergency Response Center (NERC) has been

put into service and the communication among NERC, member departments of the National Coordinating Committee for Nuclear Emergency, provincial emergency organization, NPPs and technical support centers is being established. Facilities and emergency response capabilities of emergency command centers of Zhejiang Province, Guangdong Province and Jiangsu Province have been greatly improved so that prompt and effective emergency rescue could be provided in case of emergency.

(4) Nuclear emergency research and development has progressed fruitfully in many fields such as core evaluation, accident source term, radiological surveillance, meteorology guarantee, dosage estimation, geographical information, decision-making, optimization of resource configuration and rescue of radiation damage on personnel, so that the technical and management level of emergency preparedness in China could be improved. Meanwhile, a national nuclear emergency technical support system is formed and strengthened including the following fields: emergency information and publication, nuclear emergency regulations and standards, technical support on nuclear emergency operation, aviation radiation surveillance, decision-making support system, radiation damage rescue and nuclear emergency meteorology, etc.

4.7.5 International Arrangements

As one of the Contracting Parties of "Convention on Early Notification of a Nuclear Accident" and "Convention on Emergent Assistance of Nuclear Accident or Radiation", China implements its obligations required by these two conventions.

The "Regulations on Emergency Management of Radiological Impact of Nuclear Accidents Trans-boundary", which was issued by the CAEA in April, 2002, emphasizes that China will carry out obligations in accordance with relevant international conventions and take corresponding emergency response actions in case of radiological impact of nuclear accidents trans-boundary.

In case of nuclear accidents resulting in impact trans-boundary, the National Nuclear Emergency Response Office collects related accidental information and notifies accidental information directly to or via IAEA to those countries or regions which are or may be involved in.

Meanwhile, the multilateral and the bilateral international cooperation can be used to promote the personnel and information exchange and learn the experience and lessons, hence, the management level of nuclear emergency in China can be enhanced. Nowadays China has carried out bilateral cooperation and technical exchange activities with France, USA, Canada, Russia, Ukraine, Japan, Korea, etc.

4.8 International Cooperation on Nuclear Safety

Chinese government pays great importance on international cooperation on nuclear safety. China signed and approved those international conventions like "Convention on the Physical Protection of Nuclear Materials", "Convention on Early Notification of a Nuclear Accident", "Convention on Emergent Assistance of Nuclear Accident or Radiation" and "Convention on Nuclear Safety", and strictly implements the duties under these conventions.

Both Chinese government and operating organizations of NPPs have always emphasized on the active communication with international peers. For instance, inviting experts from the IAEA to carry out operational safety assessment for NPPs in China for many times and inviting WANO peers to implement peer review. Agreements for sister plants have been singed with the foreign NPPs, which adopted similar reactor type or technolgies, for the purpose of periodic exchanges and mutual visits and learning from each other so that management level of nuclear safety could be improved.

In recent three years, extensive bilateral and multilateral international cooperation among Chinese Government and those of other countries are developed fruitfully in order to stimulate the improvement of nuclear safety regulatory level and ensure the operational safety of NPPs:

— Nuclear Safety Cooperation and Steering Committee between the regulatory bodies meets annually between China and France. Bilateral cooperation plan on nuclear safety, especially regulatory experience exchange among personnel from regulatory bodies as well as regulatory technical cooperation and exchange (e.g. PSA, PSR), are arranged to improve the regulatory level of nuclear safety;

— In view of two CANDU units of Qinshan Phase III NPP imported from Canada, a Steering Committee between the regulatory bodies of China and Canada is established and cooperation is arranged periodically each year. Twelve Canadian nuclear safety inspectors, together with Chinese nuclear safety inspectors, implemented inspections on commission and nuclear safety before operation of Qinshan Phase III NPP in April and September 2003, respectively.

— Based upon the two WWER1000 type units of Jiangsu Tianwan NPP imported from Russia, Chinese and Russian regulatory bodies meet regularly and cooperate on nuclear safety review and inspection.

— For years, the effective cooperation on nuclear safety between Chinese Government and the IAEA has promoted the multilateral cooperation in the field of nuclear safety. The annual meeting on nuclear safety regulation of CANDU type NPPs was held in November 2003 in Shanghai to exchange the practice and experience on nuclear safety review and inspection;

— Chinese Government has established cooperative relationship with the national regulatory bodies of USA, Japan, Korea, etc. Cooperation on personnel training and technical exchange has played an active role in improving nuclear safety level and regulatory capabilities.

— The 13th Pacific Basin Nuclear Conference was held in Shenzhen, China, in October 2002, with the topic of "Nuclear Energy is Safe, Clean, Economic and Sustainable Energy in the 21st Century". The conference has promoted the peaceful utilization of nuclear energy and the improvement of capabilities of guaranteeing nuclear safety within the scope of IAEA multilateral cooperation frame.

The Chinese Government believes that active international cooperation is of great significance in ensuring nuclear safety and beneficial for each parties involved in by means of bilateral and multilateral ways.

5. SAFETY OF NUCLEAR POWER PLANTs

5.1 Siting

5.1.1 Regulations and Requirements on Nuclear Power Plant Siting

Referred to the nuclear safety standards of IAEA and other countries, the SEPA (NNSA) established nuclear safety regulations and guides on nuclear power plant siting, which mainly are the "Application and Issuance of Safety License for Nuclear Power Plant", the "Code on the Safety of Nuclear Power Plant Siting", the "Earthquakes and Associated Topics in Relation to Nuclear Power Plant Siting", the "Atmospheric Dispersion in Relation to Nuclear Power Plant Siting", the "Siting Selection and Evaluation for Nuclear Power Plant with Respect to Population Distribution", the "External Man-induced Events in Relation to Nuclear Power Plant Siting", and the "Hydrological Dispersion of Radioactive Material in Relation to Nuclear Power Plant Siting", etc (see Appendix 3).

5.1.2 Licensing Process of Siting

According to the requirements of nuclear safety codes, the "Application and Issuance of Safety License for Nuclear Power Plant", etc., the applicant should submit "Feasibility Report of Nuclear Power Plant" (siting part) and "Environmental Impact Report of Nuclear Power Plant" to the SEPA (NNSA) prior to the selection of the site. These reports which must adequately demonstrate that the site satisfies the requirements for NPP construction and the national environmental protection standards are examined and evaluated by the SEPA (NNSA), to determine whether the nuclear power plant to be built will be safely operated on the selected site, and to grant "Reviewing Comments on Nuclear Power Plant Siting" and the "Instrument of Ratification of the Environmental Impact Report for Nuclear Power Plant".

5.1.3 Criteria for NPP Siting

The siting for Chinese nuclear power plants should comply with the "Code on Safety of Nuclear Power Plant Siting". The following aspects have been taken into considerations.

(1) Effects of external events occurring in the region of the particular site (these events could be natural or man-induced origin).

(2) Characteristics of the site and its environment which could influence the

transfer of released radioactive substance to human body.

(3) Density and distribution of the population and other characteristics in the zone around the site needed for evaluating the possibility of implementing emergency response measures and the risks to individuals and the population.

5.1.3.1 Criteria of Design Basis for External Natural Events

(1) Proposed sites are adequately investigated with respect to all site characteristics that could affect safety in relation to design basis natural events.

(2) Natural phenomena that may exist or can occur in the region of a proposed site should be identified and classified according to the potential effects on the safe operation of the nuclear power plant. This classification is used to identify the important natural phenomena from which design bases are derived.

(3) Historical records of the occurrences and severity of the above mentioned important natural phenomena in the region are collected and carefully analyzed for the reliability, accuracy and completeness.

(4) Appropriate methodologies are adopted to establish the design basis natural events for some important natural phenomena. The methodologies should be proved to be compatible with the characteristics of the region and the current state-of-the-art.

(5) The size of the region that should be studied in determining design basis natural events by certain methodology must be large enough to cover all the features and areas which could contribute to the determination of the design basis natural events and their characteristics.

(6) Important natural phenomena are expressed as input in inferring the design bases natural events for NPPs.

(7) In the derivation of design basis events, site specific data are used unless such data are unavailable. In this case, the data from other regions that are similar to the region of interest may be used.

5.1.3.2 Criteria for Design Basis for External Man-induced Events

(1) Proposed sites are adequately investigated with respect to all the characteristics that could affect safety in relation to the design basis man-induced events.

(2) The region at which the NPP site is located should be investigated to find out those facilities and human activities that might endanger the proposed nuclear power plant under some conditions. These conditions are classified according to the severity of the effects they may have on safety. This classification is used to identify important man-induced events for which design basis man-induced events are derived. The foreseeable significant changes in land use, such as expansion of existing facilities and human activities or the construction of high-risk installations should be considered.

(3) Information concerning the frequency and severity of those important man-induced events is collected and analyzed for reliability, accuracy and completeness.

(4) Appropriate methodology is adopted for establishing the design basis man-induced events. The methodology should be compatible with the characteristics of the region and the current state-of-the-art.

(5) Each important man-induced event is expressed as input in deriving the design bases man-induced events for NPPs.

5.1.3.3 Criteria for Defining Potential Effects of the Nuclear Power Plant on the Region

(1) In evaluating the radiation impact on the site region under NPP's operating condition and accident condition that may need emergency measures, appropriate estimates have to be made for expected or potential releases of radioactive substances after taking into account the design of the plant and its safety features. In the review of siting, these radioactive releases are often treated as radiation source terms.

(2) The direct and indirect approaches that radioactive substances released from the NPP could reach and affect the people should be evaluated. In this evaluation, abnormal characteristics of region and site should be taken into account and the special attention should be paid to the role of the biosphere in accumulation and transport of radioactive nuclides.

(3) The relationship between the site and the design of the NPP should be examined to ensure that the radiation risk to the public and the environment arising from the releases defined by the source terms is acceptably low.

(4) The design of the nuclear power plant should compensate for any unacceptable effects on the region where the NPP is located, otherwise the site should be deemed unsuitable.

5.1.3.4 Criteria for Considering Population Factor and Emergency Response Planning

(1) The region at which the proposed site is located is studied to evaluate the present and foreseeable future characteristics and distribution of the population of the region. Such a study includes evaluation of present and future uses of land and water within the region and takes into account any special characteristics which may influence the potential consequences of radioactive releases to the individuals and the population.

(2) With respect to characteristics and distribution of the population, the site and plant combination should satisfy that

— under operating conditions the radioactive exposure of the residents remains as low as reasonably achievable and accords with national regulations in any case;

— under accident conditions, including those which may lead to taking measures for emergency response, the radiation risk to the residents is acceptably low and in accordance with national regulations.

After thorough evaluation, if it is shown that there will be no appropriate measures to meet the above requirements, the site is then deemed unsuitable for the construction of the proposed NPP.

(3) A periphery zone around a proposed site should be established in view of the potential radiation consequences of the public and the capability of implementing emergency response plans as well as any effect of external events which may hinder implementation. Before starting construction of the NPP, it shall be affirmed that no basic problems exist in the periphery zone for establishing an emergency response plan before the NPP operation. In order to meet this requirement appropriately,

— a reasonable evaluation of the radioactive releases under accidents including severe accidents is performed by using appropriate site specific parameters .

— the feasibility of the emergency response plans is evaluated.

5.1.4 Implementation of Codes on the Safety of Nuclear Power Plant Siting

In the phase of siting, according to the requirements in "Code on the Safety of Nuclear Power Plant Siting", all site-related factors affecting the safety and the impacts of the NPP on the individuals, the society and the surrounding environment during its predicted life have been evaluated by the applicant.

5.1.4.1 Natural Events Affecting the Safety

During the siting, the natural factors affecting the safety are investigated and evaluated in detail, and the engineering design bases are determined according to the investigation results and the related safety requirements. The natural factors affecting the safety of the NPP are as follows.

— floods due to precipitation and other causes,

— tsunami,

— floods and waves caused by burst of dam and dyke, etc.,

— surface faulting,

— slope instability,

— site surface collapse, subsidence or uplift,

— earthquakes,

— soil liquefaction,

— tornadoes,

— tropical cyclones, and

— other important natural phenomena and extreme conditions.

5.1.4.2 Man-induced Events Affecting the Safety

The factors affecting the nuclear power plant such as aircraft crashes, chemical explosions, the site parameters affecting the long-term residual-heat removal from the reactor core and other important man-induced events, etc, have been investigated. As the results of the investigation, the impact of these low-probability events to the safety of nuclear power plant is very small, and is within the acceptable level by proper design.

During nuclear power plant siting, the activities causing external man-induced events and the controls of their future development in the site region have been adequately taken into considerations by the relevant government departments according to the protection level demanded by the NPP.

5.1.4.3 Nuclear-Safety Impact of Nuclear Power Plant on Surrounding Environment and Inhabitants

During NPP siting, the risks imposed by the potential releases of radioactive substances to the surrounding environment and the inhabitants have been adequately considered, and the pathways leading to the risks have been studied and controlled.

Factors such as the dispersion of radioactive substances in the atmosphere, in the surface water and the ground water, the population distribution, the utilization of the land and the water, etc. have been extensively investigated, periodically observed, studied and analyzed by using the computerized models so as to effectively control the radiation risks caused by the potential radioactive releases to the surrounding environment and inhabitants.

5.1.5 Sustaining Surveillance Activities Related to the Siting

The system of radioactive contamination monitoring has been established in China according to the requirements in "Laws on the Environment Protection of the People's Republic of China", the "Act of Prevention and Remedy of Radioactivity Contamination", and the regulations and rules of siting, design, and safe operation of NPP. The SEPA (NNSA) is responsible for performing supervisory sustaining monitoring of the important nuclear installations, and for managing the radioactive contamination monitoring. Meanwhile, the operating organizations are required to monitor the types and the concentration of the radioactive nuclides in the surrounding environment of nuclear power plants, and the amount of radioactive nuclides in the effluents of nuclear installations.

According to the requirements of the safety guides related to NPP siting, factors affecting the site safety of NPP such as meteorological, hydrological and geological phenomena have been monitored and evaluated continuously by the operating organizations to ensure the safety of the nuclear installations.

5.2 Design and Construction

5.2.1 Regulations and Requirements of the Design and Construction of NPPs

5.2.1.1 Regulations and Requirements of the Design of NPPs

By reference to the relevant nuclear safety standards of IAEA and other related national standards, the "Code on the Safety of Nuclear Power Plant Design", and a series of guides on nuclear power plant design, such as "General Design Safety Principles for Nuclear Power Plants", "Anti-seismic Design and Appraisal for Nuclear Power Plants", "Safety Function and Component Classification for BWR, PWR and PTR", "Protection Against Internally Generated Missiles and Their Secondary Effects in Nuclear Power Plants", etc. (totally 15 guides, see Annex 3) have been established by the SEPA (NNSA).

During reviewing the design of the imported NPPs, the SEPA (NNSA) requires the applicant of the "Nuclear Power Plant Construction Permit" to illustrate that the standards and specifications to be used are complied with the requirements of regulations on nuclear safety of China. If there are no these standards and specifications in China, their adoption should be approved by the SEPA (NNSA).

The safety of NPPs relies on the guarantee of three basic safety functions (reactivity control, residual heat removal, and the confinement of radioactivity). The defense-in-depth concept is helpful to maintain these three basic safety functions, and is conducible to preventing the general public and the environment from radioactive hazard.

The defense-in-depth concept is applied to all activities of NPPs. The application of the defense-in-depth concept in design of NPPs requires that multiple levels of protection measures, including the inherent safety features, the equipment and procedures, etc., should be provided, so as to prevent accidents or to provide appropriate protection when accidents happen.

The design criteria provided by the "Code on the Safety of Nuclear Power Plant Design" are as follows.

(1) Radiation protection

Measures shall be provided to ensure that the radiation protection objectives can be met.

The acceptance criteria of radiation protection in the safety design of the NPP shall follow the principle that plant conditions resulting in high radiation doses or radioactive releases shall be of low likelihood of occurrence, and conditions with relatively high probabilities shall have only small radiological consequences.

(2) Safety function

— Means shall be provided to safely shutdown the reactor and maintain it in a safe shutdown condition in operational states and during / after accident conditions.

— Means shall be provided to remove residual heat from the core after reactor shutdown, including accident conditions.

— Means shall be provided to reduce the potential for the release of radioactive materials and to ensure that any releases are below prescribed limits during operational states and below acceptable limits during the accident conditions.

(3) Plant safety characteristics

An overall requirement of the nuclear power plant design is that its sensitivity to Postulated Initiating Events shall be reasonably low. The plant should be designed and operated so that the consequence of any Postulated Initiating Event is a sequence as near to the below first item as can reasonably be achieved.

— A Postulated Initiating Event produces no significant safety related effect or only a change in the plant towards a safe condition by inherent characteristics.

— Following a Postulated Initiating Event, the plant is rendered safe by the action of systems that are continuously operating in the state required to control the Postulated Initiating Event.

— Following a Postulated Initiating Event, the plant is rendered safe by the action of systems that need to be brought into service in response to the Postulated Initiating Event.

(4) Design basis

The design shall specify the necessary capabilities of the plant to cope with a specified range of operational states and accident conditions within the defined radiation protection requirements. The design basis includes the specifications for normal operation, conditions created by the Postulated Initiating Events, important assumptions and, in some cases, the particular methods of analysis.

(5) Severe accidents

It should be recognized that certain unlikely event sequences have the potential to cause significant core degradation. The combination of the engineering judgement and the probability methods should be used to consider these severe accident sequences, and to determine the reasonable and practicable prevention measures and mitigation measures.

At present, according to the international nuclear power engineering practice and the actual conditions of Chinese NPPs, the SEPA (NNSA) is establishing the prevention and mitigation measures of the severe accidents for the built NPPs, and has put forward higher requirements about the prevention and mitigation measures of the severe accidents for newly built NPPs.

(6) Quality of nuclear power plants

All safety functions of the structures, systems and components shall be defined. Structures, systems and components shall be classified on the basis of their importance to safety.

Adequate attention shall be paid to all aspects of quality to ensure high functional reliability that is commensurate with the safety function to be performed.

The equipment shall be designed according to applicable approved standards, and shall be selected to be consistent with the nuclear power plant reliability goals required for safety. Where codes and standards are used as design rules they shall be identified and evaluated.

In the selection of equipment, consideration shall be given to both spurious operation and unsafe failure modes.

(7) Provisions for in-service testing, maintenance, inspection and monitoring

The design of structures, systems and components important to safety shall have a quite high level of reliability. They can be calibrated, tested, maintained, repaired, and inspected or monitored with respect to their functional capability during the life of the nuclear power plant.

(8) Design for system and component reliability

The combination of the following one or several measures shall be used to achieve and maintain the required reliability commensurate with the importance of the safety functions to be performed within all three echelons for defense:

— redundancy,

— single failure criteria,

— diversity,

— independence,

— fail-safe design,

— auxiliary facilities,

— common cause failure,

— equipment outages.

(9) Design for optimized operator performance

The working areas and working environment of the site personnel shall be designed according to ergonomic principles.

Overall consideration of human factors and the man-machine interface shall be included in the early stage of design process and continue throughout the entire process.

In the control room the operator shall be provided with clear displays of those parameters that indicate the current status of all equipment and systems necessary to achieve the safety functions in a coordinate manner. Similar facilities shall be made for the supplementary control point.

The design shall be advantageous to the operator's successful actions in a limited time available, under the expected ambient environment and psychological pressure. The need for operator intervention on a short-time scale should be minimized.

(10) Heat transfer to an ultimate heat sink.

Heat transfer system shall be provided to transfer residual heat from structures, systems and component important to safety to an ultimate heat sink. These systems shall have very high levels of reliability, during normal operation, under anticipated operational events states and accident conditions.

In addition, the "Code on the Safety of Nuclear Power Plant Design" also specifies the requirements about the protection against fire and explosion, the effects associated with equipment failures, the sharing of structures, systems and components in multi-reactor NPPs, the systems containing fissionable or radioactive materials, evacuation routes and means of communication, as well as the control of access to NPPs and the decommissioning of NPPs.

5.2.1.2 Basic Requirements of Nuclear Power Plant Construction

Basic requirements of nuclear power plant construction are mainly embodied in the nuclear regulation, the "Code on the Safety of Nuclear Power Plant Quality Assurance", and its guides. The general requirements of quality assurance are described in 4.4. Focused on the concrete features of the construction activities, the requirements provided by nuclear safety guide, "Quality Assurance during the Construction of Nuclear Power Plants", are as follows.

(1) General requirements

— Make plans on in situ construction (including the verification) and form written documents.

— Stipulate and finish the required activities according to the written procedures, the working instructions, the specifications and the drawings.

— Perform on-site management to assure the necessary quality of the items to be built and assembled.

— Control the receiving, storage, load and unload of the materials and the equipment to prevent them from abusing, misuse, damage, degradation or missing tags.

— Specify and implement requirements of flushing fluid systems and relevant components and the management requirements of the cleanness.

— Finish the quality/safety-related items and surface painting or coating according to the approved procedures.

— Manage the measuring and testing equipment, and control the selection, labeling, calibration and utilization of the equipment.

— The workers shall receive necessary trainings and have necessary working skills to finish the jobs.

(2) Installation, inspection and test of the items

During the construction of the NPP, there are three types of activities: installation, inspection and test which are all conducted for soil, foundation, concrete and structural steel; mechanical equipment and systems; monitoring instruments and electrical equipment.

The main links of the above activities are strictly controlled.

— The verification of the prerequisites before construction and installation.

— The management and control during construction and installation.

— The inspection and test of the built structures and the installed equipment and systems.

(3) Analysis and evaluation of the results of inspection and test.

The results of the inspection and test are collected, rearranged, analyzed and assessed to judge whether the required operational level of the structures, equipment and systems is achieved, and to determine the subsequent actions.

5.2.2 Process of Review and Approval of the Qualification and the Permit for Design and Construction

(1) The applicant engaged in the nuclear island design should apply to the Ministry of Construction for the qualification license. After passing through the qualification review, the Ministry of Construction will issue the qualification license for nuclear island design to the applicant.

(2) The applicant engaged in design, manufacture and installation of nuclear pressure retaining components should apply for the qualification license both from the competent department and the SEPA (NNSA). The SEPA (NNSA) issues the corresponding qualification license after it is reviewed by the competent department and finally checked and approved by the SEPA (NNSA) jointly with the departments concerned.

(3) After the site is selected, the applicant for the "Construction Permit of Nuclear Power Plant" shall submit documents listed below to the SEPA (NNSA) 12 months before pouring concrete to the nuclear island base.

— "Application for the Construction of Nuclear Power Plant";

— Instrument of Ratification of the "Feasibility Study Report for Nuclear Power Plant";

— Instrument of ratification of the "Environmental Impact Report of Nuclear Power Plant" (one month before issuing the construction permit);

— "Preliminary Safety Analysis Report for Nuclear Power Plant";

— Outline of the "Quality Assurance Program of Nuclear Power Plant" (both in the design and construction stages).

The SEPA (NNSA) organizes the specialists concerned for reviewing and performing assessment. After confirming that the contents of documents listed above accord with the requirements of nuclear safety regulations, the SEPA (NNSA) issues the applicant the "Construction Permit of Nuclear Power Plant".

5.2.3 Defense-in-Depth Conception and Its Applications

5.2.3.1 Defense-in-Depth Conception

The design process of Chinese NPPs incorporates the defense-in-depth concept so that multiple levels of protection are provided, for example:

(1) The provision of multiple means to ensure each of the basic safety functions, i.e. reactivity control, residual heat removal and the confinement of radioactivity;

(2) The use of reliable protective devices in addition to the inherent safety features;

(3) The supplement of the control of the NPP by automatic activation of safety systems and by operator actions;

(4) The provision of equipment and procedures to back up accident prevention measures, to control the course, and to limit the consequences of accidents.

(5) Conservative design, as well as the construction and operation of NPPs in high quality to ensure the minimum of abnormal operation and failures;

(6) The provision of multiple physical barriers to prevent the radioactive materials from releasing to the environment.

As a basic requirement, all levels of defense shall be available at all times as specified for the various operational modes. The existence of other levels of defense is not a sufficient basis for continued operation in the absence of one level of defense.

5.2.3.2 First Application of the Defense-in-Depth concept

The first application of the defense in depth concept to the design process of Chinese NPPs is that a series of echelons of equipment and procedures are provided in order to prevent accidents or to ensure appropriate protection in the event when the prevention of accidents fails.

(1) The aim of the first echelon of defense is to prevent deviation from normal operation and failures, and to ensure that the radioactive substances are located in the design position and monitored. In order to achieve this aim, the following measures have been adopted in the design process of Chinese NPPs:

— Adequate attention is paid to all aspects of quality, such as the selection of materials, specifications, the use of construction and operation experience and procedures of inspection, maintenance, testing, etc. These relate not only to the functional aspects of the process and safety systems together with their auxiliary installations within various echelons of defense, but also in particular to the set of physical barriers against the escape of radioactive substances.

— Wherever possible, the equipment is designed according to appropriate approved standards, is of a design proven by previous equivalent application conditions, and is selected to be consistent with the reliability goals required for safety. Where codes and standards are used as design rules they are identified and evaluated before hand.

(2) The aim of the second echelon is to detect and intercept deviations from normal operation conditions in order to prevent anticipated operating occurrences from escalating into accident conditions. To meet this objective, in the design process of NPPs, special systems (e.g. the chemical and volume control system, the feed water control system and the reactivity control system, etc.) are provided, and the operating procedures are established to prevent or minimize damage from postulated initiating events, and to prevent equipment failures and human errors from evolving into the design basis accidents.

(3) For the third echelon, it is assumed that, although very unlikely, the escalation of certain anticipated operational occurrences or postulated initiating events may not be arrested by a preceding echelon; more severe events may

happen and develop. These very unlikely events are anticipated in the design basis of Chinese NPPs, which provide inherent safety features, fail-safe design, additional equipment and procedures to control their consequences and to achieve stable and acceptable conditions following accident conditions.

(4) The aim of the fourth echelon is to cope with the severe accidents which may be beyond the design basis, and to ensure the consequences of radioactivity as low as reasonably achieved (ALARA). The most important object of this echelon is to protect the confinement function. This aim is achieved by providing supplementary measures and procedures to prevent the accidents from developing, by mitigating the consequences of the selected severe accidents, and by supplying accident management procedures.

(5) The aim of the fifth echelon is to relieve the radioactive consequences imposed by the probable release of radioactive materials in the accident conditions. Appropriate emergency control centers are established, and the plans for on-site emergency and off-site emergency are formulated by China.

5.2.3.3 Second Application of the Defense-in-Depth Concept

During the design process of Chinese NPPs, the second application of the defense-in-depth concept is the provision of multiple physical barriers in NPPs to prevent the escape of radioactive substance to outside. These barriers include the fuel matrix, the fuel cladding, the reactor coolant system pressure boundary and the containment.

(1) Fuel elements

In designing fuel elements, the deterioration factors such as external pressure of the coolant, chemical effects, static and dynamic loading, etc. are considered. The in-core irradiation testing of fuel elements verifies that it can withstand its intended irradiation in the reactor core.

Fuel elements can keep their integrity under design-basis accidents.

The fuel is monitored by performing continuous measurements of overall reactor coolant activity and by performing periodic measurements of the concentration of certain isotopes in the reactor coolant. Plant Technical Specifications and the operating instructions provide the maximum permissible activity in the primary coolant.

(2) Reactor coolant system pressure boundary

The design pressure and temperature for each component in the reactor coolant system are selected to be above maximum coolant pressure and temperature under all normal and anticipated transient load conditions, at the same time each component is designed to have its stress under allowable stress limit.

The reactor coolant system components achieve an adequate margin of safety by using proven materials and various design standards, proven fabrication technologies, non-destructive testing in the factory and integrated hydrostatic testing of assembled components. In addition to the loads imposed on the system under normal operating conditions, consideration is also given to abnormal loading conditions, such as pipe ruptures and earthquakes.

In designing the reactor vessel, the embrittlement effect under irradiation is considered. In the overall life of the NPP, the vessel is monitored with samples to find out whether the brittle effect of the reactor vessel under irradiation is in compliance with each anticipated conditions.

Multiple pilot-operated safety valves and pressure relieving devices are provided for the reactor coolant system.

Transient analyses have been included in reactor coolant system design, which conclude that design conditions are not exceeded during normal operating condition. Protection and control set points are based on these transient state analyses. The margin of the system includes the effects of thermal lagging, coolant transportation time, pressure drops, system relief valves characteristics, and instrumentation and control response characteristics.

The reactor coolant system has provisions for inspection, testing and surveillance of critical positions.

By controlling the chemistry of the reactor coolant and the chemistry of the secondary circuit water chemistry, the protection of components against corrosion is ensured.

(3) The containment

The containment is designed to enclose the nuclear steam supply system (NSSS). The containment design ensures that, in the condition of normal operation and if the loss of coolant accident (LOCA) happens, the leakage rate from the containment is less than 1‰ to 3‰ per day of the mass of gas contained in the containment at accident pressure.

The containment is designed to allow periodic integrated leakage testing at the design pressure.

The containment structure, including access openings and penetrations, is designed to accommodate the transient peak pressure and temperature associated with the postulated LOCA of the design basis.

The containment spray system has adequate cooling capacity to prevent over-pressurization of the structure. The containment pressure will return back to near atmospheric pressure within one day following a loss of coolant accident (LOCA) or a steam line break accident.

The containment is designed to absorb the dynamic effects brought by some special and credible external events (missiles, etc.).

Containment design, construction and testing all comply with the requirements of the approved standards.

5.2.4 Prevention and Mitigation of Accidents

5.2.4.1 Measures of the Accident Prevention

The accident prevention of Chinese nuclear power plants relies on high-standard design and manufacturing equipment, and good operation practice to prevent failures, relies on the quality assurance to survey whether design targets are achieved, relies on the detection to find out the function deterioration or early failures during operation, and relies on some procedures to ensure that the small perturbation or early failures may not escalate into more severe conditions, for example:

— the adequate use of inherent safety features,

— the adequate margins for material properties and technical parameters during the design and operation of the nuclear power plant,

— the adoption of effective technologies proven by the engineering practices,

— systems and components which monitor and control the nuclear power plant operation being designed as far as possible to be of fail-safe, redundancy, diversity and physical segregation of the same type components if necessary,

— the strict and overall quality assurance of the equipment and the material significant to safety,

— the periodic monitoring, inspection and testing of components related to safety,

— the timely detection of abnormal conditions which may affect nuclear safety using monitoring systems with alarm and automatic initiation of corrective actions in many cases,

— the probability risk assessment(PRA) of nuclear power plant for seeking weak points in design, and

— the operational experience feedback for improving the design and operational procedures of nuclear power plant.

In the design stage of Chinese nuclear power plants, human errors which may occur during operation are considered. In order to minimize human errors, first of all, the transient actions of the nuclear power plant operation are designed to be automatic as far as possible to provide operators more time to make diagnoses and decisions, and relieve their psychological pressure. Secondly, the design of the man-machine interface system, especially the design of the control room, is improved to reduce as far as possible the probability of making wrong judgements, and shorten the response time of operators. The design for optimized operator performance is mentioned in 5.2.6.

5.2.4.2 Measures of the Accident Mitigation

Measures of accident mitigation of Chinese nuclear power plants are categorized into three types, i.e. the accident management, the engineering safety features and the emergency response measures.

The accident management procedures, which extend the function of the emergency operational procedure (EOP) to cope with the beyond design basis accidents and to prevent and mitigate lower probability accidents including accidents which may severely damage the fuel elements, are provided in Chinese nuclear power plants.

In Chinese nuclear power plants, there are containments to enclose radioactive substances releasing from the core, and reduce to minimum the discharge of radioactive substances to the environment. In order to facilitate the operators to find out quickly the cause of beyond-design-basis accident, take appropriate corrective actions and control accident consequences in a planned way, suitable equipment, instrumentation and auxiliary diagnostic measures, including the instrumentation which can obtain data in the control room, are provided in Chinese nuclear power plants.

The accident emergency response measures of Chinese nuclear power plants are described in 4.7.

5.2.4.3 Countermeasures of Severe Accidents

(1) Requirements for the newly built nuclear power plant

"Technical Policy on Several Important Safety Issues in the Design of Newly Built Nuclear Power Plant" which stipulates that the countermeasures for severe accidents shall be considered in the design of newly built nuclear power plants, was issued by the SEPA (NNSA) in August 2002.

Although high-reliability design is provided for current nuclear power plants to cope with the design-basis accidents (DBAs) so as to prevent the core from severe damage and to inhibit the releases of radioactive substances, it is still possible to cause severe damage of the core by certain extremely low probability events. Hence, the newly built nuclear power plants are required to take following measures into considerations for severe accidents based on the existing operational experience and combined with the results of safety analyses and safety studies.

— Identify the important events sequences which can lead to severe accidents by combining the probabilistic and deterministic methods with rational engineering judgments.

— Determine which severe accidents shall be considered in the design according to a set of review criteria.

— For the selected event sequences, evaluate the modifications of design and the changes of procedures which may decrease the events' probabilities or mitigate their consequences if occurred. These measures shall be taken if they are reasonable and feasible.

— Consider the whole designed capabilities which include using certain systems and components (for example, safety-class and non-safety-class systems and components) under the conditions beyond their predefined functions and anticipated operational conditions, and using additional temporary systems and equipment to make the severe accidents return back to the controlled status and/or to mitigate their consequences. These systems and equipment shall fulfill their functions in the anticipated situation.

— For the multiple-unit site, applications of available means and/or supports from other units should be considered provided that the safe operation of other units should be not jeopardized.

— Accident-management procedures shall be formulated for the representative and predominant severe accidents.

(2) Countermeasures taken by operating NPPs

Although above requirements are put forward for the newly built nuclear power plants, all operating NPPs, reference to above requirements and international experience combined with their own actual conditions, have performed the studies of severe accidents. Some reasonable and feasible prevention and mitigation measures will be phased in.

— Actively investigate and study up-to-date development of severe-accident research of foreign organizations and nuclear power plants.

— Initiate the research plans and formulate the severe-accident management guidelines so as to protect the pressure vessel boundary containing fission-product and the containment, to mitigate the consequences of severe accidents, to decrease the releases of radioactive substances to the environment, and to finally recover nuclear power plant to a controlled and steady state.

— Perform engineering evaluations and modifications for the systems and facilities for mitigation of severe accidents, thus enhance the capability in mitigating the severe accidents.

(3) Actively perform studies of severe-accident countermeasures.

In recent years, high attention has been paid to the studies and the development of severe-accident countermeasures by Chinese administrative authority of nuclear industry, the regulatory body of nuclear safety and nuclear power plants. The research plan on studying and developing the severe-accident countermeasures was stipulated and adequate funds were invested for those studies and developments.

5.2.5 Adoption of the Proven and Up-to-Standard Process and Technology

(1) The operating organizations are required to adopt the proven and up-to-standard process and technology by the SEPA (NNSA). The documents (e.g., the FSAR) submitted to the SEPA (NNSA) by the operating organizations shall describe the adopted process and technology, which must be validated and verified by the operating organizations.

(2) The codes and standards adopted in the design process of Chinese nuclear power plants have been identified and evaluated before their application, in order to confirm their applicability and adequacy and to ensure that the quality satisfies the required safety function.

(3) The manufacture and construction methods are laid down carefully. The staff members are selected correctly and are well trained, their qualification is reviewed. The manufacture and construction of structures, systems and components are done by the domestic and foreign experienced contractors and suppliers. The operating organizations review their contract and supplying capability, engineering experience of manufacturing and construction, and the corresponding files and records that illustrate their qualification.

(4) Designs and Their Improvements of Chinese Nuclear Power Plants

Qinshan Nuclear Power Plant is the first plant which is self-designed and constructed in China. On the basis of fully drawing on the mature experience of foreign commissioned PWR nuclear power plants, China has carried out a large number of research, development and testing projects. The successful operation of Qinshan Nuclear Power Plant has proved that the design is successful. In addition, since its first operation in December 1991, Qinshan NPP has continually performed technical modifications for the systems and equipment thus ensured the safe operation for more than ten years.

Guangdong Daya Bay Nuclear Power Plant, which is imported from France, adopted mature design and technology. The plant has safely operated for about ten years and obtained good operational performance. Operational management is consistently strengthen, in the meanwhile, the ten-year modification plan (from 1994 to 2004) has been formulated so as to perform new analysis, research and design for the safety important systems and equipment, and to propose required engineering modification projects. For example, the fifth emergency diesel generator was added to enlarge the safety margin of nuclear power plant; the specialized modification of 18-month core refueling pattern has been conducted to enhance the availability of the units. The designs of a batch of engineering-modification projects were fully demonstrated through detailed risk analyses and testing verifications combined with operational experience of the foreign similar units.

Qinshan Phase II Nuclear Power Plant is a commercial nuclear power plant which is self-designed and self-built by China. Under the policy of "Mainly Based on Our Own, and Collaborated with Foreigners", by reference to the design of Guangdong Daya Bay Nuclear Power Plant, the plant was built by introducing technologies and jointly manufacturing. In the meanwhile, domestic relevant research institutes of nuclear power were united to surmount the technical difficulties in the significant projects of research, development and testing of the plant. All these efforts has settled the foundation for the plant to adopt the proven and qualified process and technology.

Guangdong LingAo NPP was designed by reference to Guangdong Daya Bay NPP, and more than 30 main improvement projects were conducted in the design of the nuclear island according to the operational experience of Guangdong Daya Bay Nuclear Power Plant. Among them, 13 improvement projects were safety-related such as the improvement measures to prevent accidental boron dilution, prevention measures to avoid core uncovery during the cold shutdown, the fire detection of the primary coolant pump, multi-point hydrogen measurement in the containment, the improvement related to the rod-drop time of the control rods, etc. Guangdong LingAo NPP has operated safely and steadily for more than 2 years.

Qinshan Phase III NPP imported from Canada is a CANDU-6 PHWR which adopts mature technologies. According to the actual conditions of China, some necessary improvements have been performed, such as the ameliorations of the discharge standards of low-level radioactive liquid waste and its process, the material used by the inlet and outlet branch pipes of the heat transport system, the design of steam generators, the design of the control room, and the pump station for intake of the sea water, etc.

Jiangsu Tianwan NPP imported from Russia is a WWER-1000 PWR which adopts mature technologies. According to the operational experience of 18 WWER-1000 PWRs in Russia, some improvements in the design have been conducted, for example, adopting four trains of the safety systems and the double-wall containment, considering the severe accidents and the anticipated transients without scram (ATWS), adding an emergency boron injection system, arranging the fuel pool with a 10-year's spent fuel storage capability within the containment.

5.2.6 Optimized Design for Operator Performance

The working areas and working environment of the site personnel of Chinese NPPs are designed according to ergonomic principle.

(1) The adoption of necessary measures to ensure that the lighting, moisture and temperature of working areas are satisfactory.

(2) The integrated arrangement of the display devices and instrumentation to minimize the walking distance while operators are monitoring and controlling the nuclear power plant.

(3) The proper allocation of information and operation push-bottoms according to their function on the main control console. Distinction of different function blocks is realized by using different colors. The indication of the control of values and pumps is arranged by using different symbols.

(4) The adoption of different audio and video devices to facilitate operators to distinguish different class alarms.

(5) The careful selection of alarm information sources and the arrangement of their priorities to avoid the information on the display and alarm system in the control room excessive and in disorder.

(6) Adequate time furnished by responses of automatic systems to help operators check and confirm automatic responses and execute stipulated procedures, lessen as far as possible the necessity of intervene of the operators in

short term, and alleviate their mental burden.

(7) The control and display symbols to facilitate the operators to remind the devices under monitoring and control.

(8) Control devices and their function displays in the places where operators can watch and manipulate them easily.

5.2.7 Regulatory Activities of the SEPA (NNSA)

(1) In the past three years, the main regulatory activities of the SEPA (NNSA) for the construction permit of nuclear power plant, the design-qualification license of nuclear pressure retaining components and the manufacture-qualification license of nuclear pressure retaining components are as follows.

— From 2001 to 2003, the SEPA (NNSA) finished the review and ratification of the requirements on the construction permit of Tianwan Nuclear Power Plant, and issuing review conclusions for all pendent issues.

— The SEPA (NNSA) organized relevant experts to review the applications for renewal of expired permits and some license applications from the relevant organizations, and issued eight qualification licenses for design, manufacture and installation of the nuclear pressure retaining components to relevant organizations, in which five ones were renewal licenses, and three ones were new licenses.

— In manufacturing the pressure vessel of the Unit-2 of Qinshan Phase II Nuclear Power Plant, Shanghai Boiler Company Limited did not properly conduct control of manufacture activities according to the requirements of nuclear safety regulations and the permits, and led to severe quality problems in the wielding joint of the safe-end of the pressure vessel junction pipes, delayed the first fuel loading of the plant and caused a great economical loss. On December 30, 2003, it was punished by the SEPA (NNSA) for revoking the license on the manufacture of the civilian nuclear pressure retaining components.

(2) In the Past three years, the SEPA (NNSA) organized and finished the supervision of the significant engineering activities, major non-conformance items and nuclear safety events during the designs and constructions of Qinshan Phase II NPP, LingAo NPP, Qinshan Phase III NPP and Tianwan NPP.

5.3 OPERATION

5.3.1 Basic Requirements of Nuclear Power Plant Operation

In order to ensure the safety of nuclear power plant operation, the "Code on the Safety of Nuclear Power Plant Operation" and 11 operational guides (see Annex 3) have been stipulated. The operational experience of years has proven that the formulated operational regulations and guides basically meet the actual operational needs.

Focusing on the safe operation of nuclear power plants, the nuclear safety regulations stipulate that the following essential requirements must be met.

(1) Operational limits and conditions

The operating organization shall establish operational limits and conditions covering technical and administrative aspects. Operational limits and conditions shall reflect the final design and shall be reviewed and approved by the national regulatory body before the commencement of operation. Operational limits and conditions shall contain requirements for different operational states including shutdown. The operating organization of NPP must establish surveillance program and implement it correctly.

(2) Commissioning

The detailed commissioning program and QA program shall be prepared, and the responsibilities for implementing and reporting for all parts in the program shall be clearly defined. Commissioning program shall be approved by the SEPA (NNSA). Only after finishing the evaluation and review of the results obtained in current commissioning phase and affirming that all objectives were achieved and requirements for nuclear safety regulations were met, the operating organization could be permitted to enter the next phase of commissioning and tests.

(3) Structure of the operating organization and the operational personnel

The organizational structure shall be clearly defined and staffed with competent managers and sufficient qualified personnel. The assignment of responsibilities, authority grades, relationship between supervisor and underling staff, and internal and external communication channel shall be clearly defined.

The operation managers bear the direct responsibility for the safe operation of the NPP. The operating organization shall empower a sufficient authority to the operation managers to ensure them effectively fulfilling the responsibilities. The operational management departments of the plant shall be suitable for implementing all functions that have direct effects on safe operation of the plant. The responsibilities for implementing these functions shall be clearly defined in written documents.

(4) Operation procedures

Before the commencement of operation, the operating organization must formulate the written detailed operation procedures. The operating personnel must be familiar with the contents of operation procedures and their revisions.

All procedures must be reviewed periodically. Any revision of these documents must be notified to the operation personnel and other holders of the documents. Revisions must be conducted in accordance with written procedures and approved only by authorized persons.

Except being clearly defined in the procedures, the operation personnel are not allowed to change, even temporarily, the physical configuration of the plant before receiving the written orders from authorized persons. In any case, such changes shall not violate the operational limits and conditions.

(5) Maintenance, testing, examination and inspection

Before commencement of operation, the operating organization must prepare the programs for periodic maintenance, testing, examination, and inspection of structures, systems, and components needed by safe operation. These programs must be kept in the archives and be available to the national regulatory body. They shall be reevaluated according to operating experience.

The operating organization must make arrangements for satisfactory periodic test, examination, and inspection to be performed by qualified persons using appropriate equipment and techniques. The programs for maintenance, test, examination, and inspection shall take into account the operational limits and conditions as well as any other applicable regulatory requirements.

(6) Core and fuel management

The operating organization must take charge of and make arrangements for all activities associated with core management and fuel management to ensure the safe use of fuel in the reactor and the safety in displacement and storage of fuel in the plant site.

For fuel and core components, handling procedures shall be written which include the transfer of fresh and irradiated fuel, the storage on site, and the preparation for delivery from the site.

The packaging, transport, and delivery of fresh and irradiated fuel shall be carried out in accordance with national and applicable international regulations.

(7) Modifications

Before their implementations, the modifications of structures, systems and components important to safety, the modifications of the operational limits and conditions which affect the bases on which the operating license was issued, and the modifications of procedures and other documents originally approved by the national regulatory body shall be submitted to the SEPA (NNSA) for approval.

(8) Radiation protection

Radiation protection program shall be established by the operating organization. The operating organization shall verify, by means of surveillance, inspections and audits, that the radiation protection program is being correctly implemented and that its objectives are achieved, and shall take corrective actions if necessary.

(9) Effluent and waste management

The operating organization shall prepare discharge limits for effluents and establish methods and procedures for monitoring and controlling such discharges in order to comply with relevant regulations. The operating organization shall establish a waste management program. The packaging, transport and dispatching of radioactive wastes shall be carried out in accordance with the relevant regulations.

(10) Operation review and experience feedback

The operating organization shall perform regular operation reviews of NPPs. The evaluation of operating experience of its own NPP and other NPPs shall be performed systematically by designated competent persons. Abnormal events important to safety shall be investigated to determine their root cause and to avoid the recurrence of the incidents.

In addition, the "Code on the Safety of Nuclear Power Plant Operation" also provides the specifications for emergency preparedness, quality assurance program, safeguard, record and report, and decommissioning.

5.3.2 Operation Licensing Process

The licensing process for operation license of Chinese NPP is divided into two phases: Phase 1, before operation, the operating organization applies for the "Instrument of Ratification for the First Fuel Loading of Nuclear Power Plant" at first. Phase 2, after the first fuel loading, the operating organization applies for the "Operation License of Nuclear Power Plant" 12 months after the trial operation on full power.

5.3.2.1 Licensing Process of "Instrument of Ratification for the First Fuel Loading of Nuclear Power Plant"

The operating organization shall submit the "Application for the First Fuel Loading of the Nuclear Power Plant" to the SEPA (NNSA) prior to the first fuel loading of the nuclear power plant together with the following documents.

— "Final Safety Analysis Report" (12 months before the first fuel loading);

— "Instrument of Ratification of the Environmental Impact Report of Nuclear Power Plant";

— "Commissioning Program of Nuclear Power Plant" (six months before the first fuel loading);

— Qualification certificates of operators for the nuclear power plant (one month before the first fuel loading);

— "Emergency Response Plan of the Operating Organization of Nuclear Power Plant" (six months before the first fuel loading);

— "Report of the Construction Progress of the Nuclear Power Plant" (six months before the first fuel loading);

— "In-service Inspection Program of the Nuclear Power Plant" (six months before the first fuel loading);

— The results of the pre-service inspection (one month before the first fuel loading);

— "Commissioning Report of Nuclear Power Plant Before Fuel Loading" (one month before the first fuel loading);

— The certificate of possessing nuclear material of the nuclear power plant (one month before the first fuel loading);

— The list of operation rules of nuclear power plant (one month before the first fuel loading);

— "Maintenance Program of Nuclear Power Plant" (six months before the first fuel loading);

— "Quality Assurance Program of Nuclear Power Plant" (commissioning stage);

The SEPA (NNSA) organizes relevant experts to review and assess the above mentioned documents. After confirming that these documents comply with the requirements of the national nuclear-safety regulations, the "Instrument of Ratification for the First Fuel Loading of Nuclear Power Plant" is issued to the applicant.

5.3.2.2 Licensing Process of "Operation License of Nuclear Power Plant"

The operating organization shall timely submit following documents to the SEPA (NNSA) after 12 month trial operation on full power of the nuclear power plant:

— "Revised Final Safety Analysis Report of Nuclear Power Plant";

— "Instrument of Ratification of the Environmental Impact Report of Nuclear Power Plant";

— "Reports of Commissioning and Trial Operation of Nuclear Power Plant After the Fuel Loading";

— "Quality Assurance Program of Nuclear Power Plant" (operation stage).

The SEPA (NNSA) organizes relevant experts to review the above mentioned documents. After confirming that these documents meet the requirements of the national nuclear-safety regulations, the "Operation License of Nuclear Power Plant" is issued to the applicant.

5.3.3 Measures Taken to Assure the Operation Safety

5.3.3.1 Safety Analysis and Commissioning

The trial operation of current nuclear power plants in China is based upon the proven fact that the constructed nuclear power plant is consistent with requirements of design, related safety analysis, and commissioning program.

(1) The scope of safety analysis includes

— verification of operation limits and conditions satisfying the requirements for normal operation of nuclear power plant;

— the postulated initiating events related to nuclear power plant design and its location;

— analysis and evaluation of event sequences resulted from postulated initiating events;

— comparison of the results of the analyses with the radiological acceptance criteria and design limits;

— establishment and confirmation of the design criteria;

— responses of automatic safety systems to anticipated operational incidents and accident conditions.

The applicability of the analysis methods should be verified prior to the safety analysis. The safety analyses of the nuclear power plant design are timely modified according to the significant changes and operational experience of nuclear power plant.

In addition to defining the design bases according to above processes, the probabilities and the consequences of the severe accidents are also considered to achieve following objectives:

— Confirm that the sudden escalation of the consequence of the postulated initiating events may not immediately lead to the design-basis accidents (DBAs).

— Determine those installations which may decrease the probabilities of the severe accidents or mitigate the consequence of the severe accidents.

— Provide suitable emergency procedures, and perform probabilistic safety analyses if necessary.

(2) Commissioning program and quality assurance program are drawn up by the operating organizations in order to ensure that the commissioning activities are safely and effectively implemented according to the written procedures. The commissioning program shall be approved by the SEPA (NNSA). All necessary tests and relevant activities are listed in the commissioning program to verify that the design and the construction of nuclear power plant are appropriate to ensure the safe operation of nuclear power plant. In the meantime, the opportunities are provided for the operational personnel to acquaint the operation of nuclear power plant.

The commissioning program of the operating organization is divided into several stages in order to indicate the tests required to be finished in the expected period of each stage and define the control points of reviewing the testing results before entering the next stage. The necessary tasks prepared for the next stage, especially the requirements of the availability of the systems used in the next stage, are included in each stage,

The next stage can not be started until the evaluation and the examination of the obtained results in current commissioning stage are finished and confirmed that all objectives have been achieved and all regulatory requirements of nuclear safety have been met.

All commissioning tests are implemented according to the approved written procedures. The safety important procedures and their modifications shall be reported to the SEPA (NNSA).

In order to achieve the target of safe commissioning, the whole commissioning work is completely managed, controlled and coordinated by the operating organizations. Practical working plans are stipulated to optimistically utilize the personnel, equipment, methods and time, etc.

From 2001 to 2003, the commissioning of five units has been carried out. Effective safety supervisions for the above nuclear power plants are performed by the SEPA (NNSA) according to the following documents:

— "Surveillance Program of Nuclear Safety in the Commissioning Stage of Nuclear Power Plant";

— "Items of the Specific Inspections of Nuclear Power Plant Commissioning";

— "Implementation Procedures of the Specific Inspections of Nuclear Power Plant Commissioning";

— "Implementation Procedures of the Surveillances and the Inspections of Nuclear Power Plant Commissioning".

The commissioning projects listed in the commissioning program have been finished for above units and are consistent with the safety requirements. Effective supervisions and the release of the selected control points are conducted by the SEPA (NNSA) to ensure the safe and reliable transition to operation. Among them, unplanned scram events didn't occur in Guangdong LingAo Nuclear Power Plant from the commissioning stage to the end of the first fuel cycle.

5.3.3.2 Establishment and Periodic Revision of Operation Limits and Conditions

The technical and managerial operation limits and conditions are prepared by all operating organizations and approved by the SEPA (NNSA). The operation limits and conditions which include requirements for all operational conditions (including the shutdown) form an important basis on which the operating organization is authorized to operate the nuclear power plant. The operational personnel who are directly responsible for operation are familiar with and strictly comply with the operation limits and conditions.

The operation limits and conditions are based on the analyses of specific nuclear power plant and its environment and are in accordance with the provisions in the final design. Some necessary amendments are made according to the results of tests in the commissioning phase, and the reasons and the necessities to adopt each operation limits and conditions are illustrated in the written form.

The operation limits and conditions are reviewed periodically throughout the operating life of the nuclear power plant in the light of accumulated experience and technological developments. The operating organization is responsible for preparing the working procedures to revise operation limits and conditions, and perform the revision of the operation limits and conditions according to the procedures.

Assessments and reports of anticipated operational incidents are important bases for determining whether or not the operation limits and conditions need to be revised. Any revision on operation limits and conditions made by Chinese nuclear power plants shall be reviewed and approved by the SEPA (NNSA).

From 2001 to 2003, the SEPA (NNSA) finished the reviews and the supervisions of the revision of operation limits and conditions as follows.

— Review of the 18-month refueling scheme and the revision of the Technical Specifications of Guangdong Daya Bay Nuclear Power Plant.

— Review of the AFA-3G fuel assembly scheme adopted in the first fuel reloading of LingAo Nuclear Power Plant.

— Several reviews of the technical specifications of Qinshan Phase III Nuclear Power Plant so as to ensure that the requirements of Chinese nuclear safety regulations were met.

5.3.3.3 Program of Operation, Maintenance, Inspection and Testing

Before the operation of nuclear power plant, the written operational procedures are worked out by the operating organizations in cooperation with the design institutes and the vendors. The compilation, review and revision of the operational procedures accord with the approved operation limits and conditions with adaptable safety margins. The necessary actions that should be taken in normal operation, anticipant operational incidents and design-basis accidents (DBAs) are included in the formulated operational procedures, and relevant items about severe accidents are also listed in them as far as possible. The operational procedures facilitate the operational personnel to perform the manipulations according to the correct sequence, and define the responsibilities and the communication means of the operational personnel in case of being forced to deviate from the written procedures.

The whole operational procedures are periodically reviewed, and any revisions are informed to the operational personnel and other holders. The revision of the operational procedures is performed according to the written processes.

Prior to the operation of nuclear power plant, the necessary programs for periodic maintenance, testing, inspection and verification of the structure, systems and components are prepared by the operating organization. The programs are re-evaluated according to the operational experience. The programs of the maintenance, testing, verification and inspection satisfy the operation limits and conditions, as well as the available regulatory requirements of nuclear safety.

Prior to the maintenance, testing verification and inspection of the structures, systems and components, the written procedures and programs which clearly define the standards and the periods of the maintenance, testing verification and inspection of the safety important structures, systems and components, are compiled by the operating organization of nuclear power plant in cooperation with the vendors of nuclear power plant and the equipment. After the maintenance, the inspections for the structures, systems and components are performed by the authorized personnel, and relevant verification experiments are performed if necessary.

For the in-service inspection (ISI) of nuclear power plant, some measures have already been taken in the design stage, and reviews have also been performed for the design of systems, components and their configuration for considering that the inspecting personnel can reach the components to be inspected so as to perform smoothly the required inspections and tests and to make the personnel exposure be as low as reasonably achievable (ALARA). The ISI program in which the systems and components need to be inspected and the frequency for the inspections are determined according to the safety importance and the rate of the equipment degradation, etc. has been worked out by the operating organization before the operation of nuclear power plant. In addition, the integrity of the pressure-retaining components has to be verified through the in-service inspections.

All inspection results are evaluated by the operating organization of nuclear power plant to determine whether or not the requirements of the standards are met. The components not suitable for further service through the assessment will be repaired or replaced.

From 2001 to 2003, Qinshan Phase II NPP, Qinshan Phase-III NPP and Ling'ao NPP went into the commissioning and operational stage successively. While the commissioning activities were implemented in these three nuclear power plants, the normalization of the operational management, equipment maintenance and the periodic tests was also actively promoted.

— Overall review and evaluation for all programs, managerial procedures and rules, instructions were performed to ensure the completeness, correctness and practicality and to normalize all activities affecting the safety and the quality of nuclear power plant.

— Organizing relevant personnel to study procedures, strengthening the skill trainings of the staff, emphasizing the manipulations strictly according to the procedures, and strictly enforced the work permit system.

— Positively preparing the maintenance equipment, tools and materials, and normalizing the inventory management of the tools and the spare parts.

— Suitably determining the maintenance projects, intervals and their priorities, and enlarge the proportion of preventive maintenance.

— Developing some management software to make the management of components and spare parts, the management of the work process and the periodic tests, etc more accurate and normalized.

From 2001 to 2003, besides performing the maintenance and the periodic tests successfully, both Qinshan NPP and Daya Bay NPP paid great efforts in the following fields:

— Developing a concept of the component-centered major component management that the departments of technical, production and maintenance jointly participate in. A series of institutions, which are related to the component functionary, the component tagging, early alarming and the system/component engineers, have been carried out. The management system of the component database of the NPP has been created and optimized.

— The reliability-centered maintenance (RCM) techniques were promoted with great efforts. The programs and activities of the maintenance have been optimized by using the results from the RCM analyses. A technical group for root-cause analyses (RCA) was established in each NPP to probe the root causes of the significant failures and problems occurring in the production and to seek the schemes and approaches to resolve the problems in the light of the probed root causes.

— Overall control and optimization of the outage maintenance activities have been performed on the organization management and the control of the safety, quality and progress, etc. During outage maintenance of NPPs, a command center for maintenance was responsible for the control and coordination of each activity, a safety group was responsible for the supervision of maintenance activities and unit conditions, and a quality control group was responsible for the follow-up check and the verification for the maintenance activities.

5.3.3.4 Management of the Design Modifications and the Equipment Transformations of the Operational Nuclear Power Plant

The modifications of the safety important structures, systems and components and the modifications of the operation limits and conditions affecting the bases of issuance of the operation license, as well as the modifications of the procedures and other documents originally approved by the SEPA (NNSA), shall be approved by the SEPA (NNSA) before the implementation.

Prior to the implementation of the design modifications, the procedures for stipulating and reviewing the modification schemes are prepared by the operating organization of nuclear power plant. The review of the modification schemes is the responsibility of personnel other than the stipulators of the modification schemes. All records in treating the modification schemes are kept in the archives so as to facilitate the examination from the SEPA (NNSA).

After implementing the modifications, all drawings and other documents are modified correspondingly to ensure that the drawings and the documents used by the relevant personnel of nuclear power plant are the latest version.

In processing each modification, the requirements of quality assurance related to the design, the purchase of materials and services, the construction, and the management of files, drawings and records, etc. are followed.

In order to strengthen the plan of modifying the engineering and equipment, the priority of the projects is determined to give prominence to the important tasks. The control and the management of the working process are strengthened, and all levels of reviews are rigorously performed to enhance the working quality. Continuous modifications and enhancements of the working procedures of the engineering modifications are performed to improve the availability of these procedures on the basis of summarizing the past experience and using the successful experience.

Since operation, Qinshan NPP has paid more attention to the technical modifications of the systems and components. The operational performance of the plant has been greatly improved by the continuous technical modifications. Based on summarizing the operational experience of more than ten years, the long-term plan for technical modifications has been developed to enhance comprehensively the operational performance. The important technical modifications planned to implement in the next several years are

— the modification of the head of the pressure vessel and its relevant components,

— the modification of physical protection system, and

— the modification of computer system, etc.

Guangdong Daya Bay NPP has continuously carried out the modifications of the design and the components. Its medium/long-term modification plan was stipulated in 2001. The objectives in improving the first ten-year maintenance are

— correcting the defects of the systems and components in the design, manufacture and installation, etc.,

— enhancing the safety level of the plant, and

— enhancing the availability of the plant.

According to the operational experience feedback and the results of ten-year periodic safety review, Guangdong Daya Bay NPP will put forward the further modification projects and make the analyses and evaluations on feasibility, expenses and profitability.

5.3.3.5 Accident Response Procedures

The response procedures for both anticipated operational incidents and accidents have been prepared and verified on full-scale simulator and/or in nuclear power plant as much as possible. The operational personnel are required to take trainings of these procedures.

The accident response procedures of Qinshan Nuclear Power Plant are designed by referrence to the relevant criteria of the similar foreign nuclear power plants. The procedures are composed of the event-oriented optimal recovery procedures, the status trees for judging the conditions of the critical safety function and the symptom-oriented function recovery procedures. The optimal recovery procedures cover the design basis accidents and the multi-failures with high probability. The function recovery procedures embody the conditions uncovered in the optimal recovery procedures. The optimal recovery procedures instruct the operational personnel to restore the plant from design-basis accidents and multi-failures. A set of systematic means are provided for the operational personnel to cope with the impact to critical safety functions by using the critical safety function recovery procedures and the status trees. By using these two procedures, the operational personnel may continuously monitor the critical safety functions of the plant, conduct the best-recovery operation, and systematically respond to the conditions uncovered in the optimal recovery procedures.

According to the principles for managing the design-basis accidents and the functions of engineered safety features, the accident response procedures of Daya Bay NPP and LingAo NPP are classified into two categories according to design methods:

— Single-event deterministic procedures are based upon the accident evolution premeditatedly studied in order to maintain the reactor in safe condition or lead it to safe condition. These procedures include Abnormal-Condition Handling Procedures (I), Design-Basis Accident Handling Procedures (A), and Beyond Design-Basis Accident Handling Procedures (H).

— Multi-failures of the equipment and/or human factors are possible. In order to deal with the difficulties caused by the combination of several events, the core-condition approaching methodology is selected to compile the accident response procedures including Severe Accident Handling Procedures (U), Continuous-Monitoring Procedures (SPI) of Abnormal Conditions, and Continuous-Monitoring Procedure of Severe Accidents (SPU).

The accident response procedures of Qinshan Phase III NPP, which include all kinds of event-oriented emergency operation procedures and a few symptom-oriented emergency operation procedures, are prepared by referring to the accident response procedures of the reference nuclear power plant.

5.3.3.6 Engineering and Technical Support

All operating organizations of Chinese NPPs have established specific technical support organizations.

China has set up a complete nuclear industry system after development of several decades. It possesses a capacity to provide engineering and technical supports in all fields related to operation safety of the NPPs. Some engineering and research organizations have become engineering and technical support organizations of Chinese nuclear power plants. In addition, some specific organizations have been founded in view of the operational safety of nuclear power plants. These organizations provide nuclear power plants with engineering and technical supports in the areas of operation research, safety analysis, radiation protection, in service inspection, plant modification, special tests, maintenance and safety reviews.

Through cooperation and exchange with foreign peers, the operating organizations of Chinese NPPs have established extensive cooperative relationships with them, and can get technical supports from the international peers if necessary.

5.3.3.7 Incident Reporting System

According to the requirements of the "Reporting System of Operating Organization", during commissioning and operation, the operating organizations of Chinese nuclear power plants must report the following incidents to the SEPA (NNSA), the national administration of nuclear industry and other related organizations.

(1) Any event that violates the Technical Specifications of the nuclear power plant.

(2) Any event that brings the characteristics of safety barriers or important equipment of the nuclear power plant to be seriously degraded, or one of the following conditions occurs:

— An unanalyzed working condition that would significantly endanger safety;

— A working condition beyond the design basis of the nuclear power plant;

— A working condition not taken into account by the operation procedures or emergency response procedures of the nuclear power plant;

(3) Any natural event or other external event that would pose actual threat to the safety of the nuclear power plant or clearly hinder site personnel on duty in their performance necessary for the safe operation of the nuclear power plant.

(4) Any event that would result manual or automatic activation of the engineered safety features and the reactor protection system (with the exclusion of the preplanned tests of this kind).

(5) Any event that would prevent the fulfillment of the three basic safety functions of structures or systems and the mitigation of the event consequences.

(6) Any common-cause event that would affect several independent systems, trains or channels with the three basic safety functions and the function of mitigating the event consequences to lose effectiveness simultaneously.

— the shutdown and the maintenance of the safe shutdown conditions,

— residual heat removal,

— the confinement of radioactivity, and

— the mitigation of the accident consequences.

(7) Any event that would result uncontrolled release of radioactivity.

(8) Any internal event that would pose actual threat to the safety of the nuclear power plant or clearly hinder site personnel in their performance of duties necessary for the safe operation of the nuclear power plant.

(9) Any event that is not covered by the above eight items and is defined by the SEPA (NNSA), nuclear industry administration, and the operating organization as a significant event important to safety, or the events that are commonly concerned by the public, according to the nature and consequence of the event.

The ways of reporting the events are

— oral notification which shall be submitted in 24 hours after the occurrence of the event;

— written notification which shall be submitted in three days after the occurrence of the event and in a given format;

— event report which shall be submitted in 30 days after the occurrence of the event and in a given format;

— accident report in the emergency condition (see 4.7.2.2).

The statistics of operational events of Chinese nuclear power plants from 1998 to 2000 are listed in Appendix 3.

5.3.3.8 Operation Experience Feedback

The plan for collecting and analyzing the operation experience of nuclear power plant has been formulated in China, and the operational-experience collection, analysis and feedback system has also been established.

The emphasis on operation experience feedback in China is put on the experience feedback of NPP operating organizations and its utilization. The main objectives of the operation experience feedback of the operating organizations are

— The practical and realistic attitude shall be taken in the routine tasks to ensure that all events can be detected and reported in time;

— Through the overall and comprehensive analyses for the events, trends and results, the internal and external experience shall be summarized and concluded, and the applications of good practices shall be popularized to improve the operational conditions and maintenance activities;

— The documents of the operation and maintenance procedures and the technical specifications, etc, shall be updated and perfected;

— The improvements of the organizational structure, operational practices and trainings, as well as systems, equipment and components, etc., shall be performed if necessary.

Exchanging and sharing operation experience are achieved by Chinese nuclear power plants mainly through the following ways.

(1) Establishment of the reporting systems on internal and external events and conditions

All information of abnormal operation conditions is collected, classified, screened and analyzed, and the corrective measures are defined and taken according to the systems of 24-hour event sheet, the notification of internal operational events, operational event report and condition report. When an event reaches a degree that it should be reported externally, it shall be reported to the SEPA (NNSA), the nuclear industry administration, etc., according to the requirements in the corresponding criteria on reporting events.

(2) Operational experience exchanges among nuclear power plants

In 2001, six domestic nuclear power plants made an agreement for jointly conducting a periodic activity of operational experience exchange each year. Until now, two sessions of the activities have been held, and good results have been obtained.

In addition, Chinese NPPs have conducted extensive technical exchanges and information sharing in many areas by establishing the sister-plant relations with some similar foreign nuclear plants.

(3) Positive participation in activities of international nuclear industry

As the members of some international organizations such as IAEA, WANO, COG, FROG, etc., China has actively taken part in all kinds of operational experience exchange activities including

— the application and implementation of the national and regional technical cooperative projects;

— all kinds of international training workshops and seminars;

— the peer reviews, personnel mutual visiting and specific technical exchanges of WANO;

— OSART and Pre-OSART, design safety review, personnel mutual visiting and specific technical exchanges of IAEA;

— the exchange and sharing of the information on events and performance indicators, etc.

(4) Extensive collection of the internal and external operation experience

Through various approaches, China has collected, screened and analyzed internal and external operation experience

— Abnormal operation conditions occurring in the plant;

— Suggestions on correction actions proposed in the meetings of the experience feedback engineers;

— Good practices of the plants;

— Reports on special topics and internal summary reports;

— Documents and Reports coming from the nuclear safety regulatory body and the nuclear industry administration of China;

— Important information from IAEA and WANO, etc.;

— Technical documentation provided by the equipment vendors;

— Information exchanged among the peers in electric industry;

— Information of the meetings, technical reports and the up-to-date technical feedback, etc.

(5) Propagation of the operational experience information by various ways

In order to spread, generalize and utilize all kinds of operational experience information timely and effectively, each plant propagates the information on operational experience within the plant by adopting the following vivacious and various means:

— The intranet and E-mail system of the plant;

— Bulletins, information notifications and reports;

— All propaganda pamphlets, periodic magazines and publications of the plant.

(6) Utilization of the operational experience in the routine jobs

Important experience and lessons are drawn from the discussion of the relevant operational experience in the routine tasks. The main ways include

— the hand-over meeting of the operational shifts;

— the working plan and the briefings;

— the regular meeting system of the managerial level;

— the formulation and the implementation of the maintenance plan.

(7) Application of the operational experience to training and examination

The operational experience has been used in the initial training, retraining and examination for each kind of staff. By using case analysis teaching, special topic lectures, simulator exercises, mockup/laboratory exercises, post training and examinations, the staff training has been combined effectively with the operational experience propaganda, hence the training quality and the personnel initiative to participate in prevention of accidents are enhanced.

Besides above activities of operational experience exchange, in order to achieve a broader exchange and share of the operational experience and information, the national nuclear safety regulatory body and the nuclear industry administration have made continual efforts to promote the operational experience exchanges in nuclear industry by various ways

— helping the plants apply for and obtain desired technical supports, exchanges and cooperation from the international society;

— promoting and performing the domestic peer reviews;

— organizing a variety of symposiums to conduct experience exchanges;

— disseminating the operational experience information in the form of publications or on the webs;

— supporting the research and development of the significant science and technical projects;

— positively promoting the construction of the system for operational experience exchange in the nuclear industry.

5.3.3.9 Control and Storage of the Radioactive Waste

The operating organizations of Chinese nuclear power plants have prepared and carried out the waste management program and a variety of measures for processing, storing and disposing the waste and effectively controlling the release of the effluents. The program shall be submitted to the SEPA (NNSA) for approval before the operation of nuclear power plant, and the approved discharge limits shall be included in the operational limits and conditions.

The operating organizations of nuclear power plants conduct the operation of the waste management systems by stipulating the detailed procedures and in terms of design intentions and assumptions. Through the adequate surveillance and the measures for training and quality assurance, all activities related to the operation and maintenance of the waste management systems are effectively controlled, hence the occurrence probabilities of the concerned abnormal events are decreased and the amount of the produced radioactive waste is kept as low as reasonably achieved (ALARA).

To effectively control and decrease the production amount of the radioactive waste, Chinese nuclear power plants have taken a series of measures.

(1) Taking the following measure to control the amount of the gas waste:

— Avoiding the damage of fuel assemblies through the proper operational modes of the reactor, and unloading the damaged fuel assemblies as soon as possible if practical;

— Decreasing the leakage of the pressure boundary of the reactor coolants;

— Keeping the impurities in the reactor coolant as the lowest as practically possible.

(2) Taking the following measures to control the amount of the liquid waste:

— Avoiding the damage of fuel assemblies, and unloading the damaged fuel assemblies as soon as possible if practical;

— Deceasing the leakage of the reactor coolant system and other systems;

— Elaborately planning and seriously carrying out the maintenance work, especially emphasizing the prevention measures to avoid enlarging the pollution;

— Taking measures to avoid the contamination of the equipment and the rooms to decrease the times of decontamination;

— Choosing the optimal decontamination procedures;

— Reducing the amount of the secondary waste by means of selecting appropriate waste disposal methods.

(3) Taking the following measures to control the solid waste:

— Meticulously planning and fulfilling the maintenance tasks;

— Carefully controlling the transportation of the radioactive substances;

— Effectively manipulating the disposal systems of gaseous and liquid waste;

— Providing procedures to control effectively the pollutions;

— Making isolations of the areas producing the waste.

The technological course producing the waste is monitored to provide the information about the sources and characteristics of the radioactive waste and to prove that it is consistent with the operational procedures. The monitor includes the measurement of the physical and chemical parameters, the discrimination of the radioactive nuclides and the activity measurement.

In order to ensure that the approved limits are not overshot, the measurement of the effluent discharge is conducted in each discharge point. The discharge amount of the radioactive effluents of Chinese nuclear power plants during the operation is far lower than the discharge limits stipulated by the national standards (see Appendix 2).

Chinese nuclear power plants have enough facilities to store the waste produced during the normal operation and the anticipated operational occurrences. Excess accumulation of the untreated waste is avoided during waste disposal. Records and documents of the amount of the stored waste are well kept in terms of the requirements of relevant regulations and quality assurance.

In order to ensure the integrity and subcriticality of the spent fuel, according to the written procedures, the operating organizations handle and store the spent fuel by using approved equipment inside the approved facilities. The underwater storage conditions of the spent fuel and the water quality are kept in accordance with the chemical and physical characteristics specified.

In June 2003, Chinese government promulgated the "Act of Prevention and Remedy of Radioactivity Contamination of the People's Republic of China", in which all requirements for managing the radioactive waste are further provided on the law bases, and the Act further promoted the realization of the management objects of the radioactive waste. In order to prevent and remedy the radioactive contaminations, China has implemented the policy of "Crucial Prevention, Prevention Combined with Remedy, Strict Management, Safety-First" and established a monitoring system of the radioactive pollution. The SEPA conducts the unified supervision and management for the prevention and remedy of the national radioactive pollution. According to the provided discharge modes, the operating organizations discharge the radioactive waste gas and waste liquid in terms of the requirements in the national standards on prevention and remedy of radioactive contamination. The operating organizations should submit their application for the discharge amount of radioactive nuclides to the SEPA (NNSA) which is responsible for reviewing and approving the reports of the environmental impacts, and periodically report the results for discharges. The radioactive waste liquid which cannot be discharged into the environment is processed and stored. A near-surface disposal is conducted for the medium-level radioactive solid waste in the regions provided by China. A concentrated deep-ground disposal is performed for the high-level radioactive solid waste.

5.3.3.10 Examination and License of the Operators

The "Rules for the Implementation of Regulations on the Safety Regulation for Civilian Nuclear Installations of the People's Republic of China" specifies that the persons who hold the licenses for operators or senior operators of Chinese nuclear power plants may operate the reactor control system of nuclear power plants. The valid period of the operator license is two years. The licenses of those who have left their duty-jobs for six months will be no longer valid.

The operators of nuclear power plants must receive strict training, and must pass the license examination and the qualification review organized by the "Review Committee on Qualification for Operators of Nuclear Power Plants" (RCQO). After the review and approval of the "Authorization Committee on Qualification for Operators of Nuclear Power Plants" of the SEPA (NNSA), the operator license or the senior-operator license will be issued by the SEPA (NNSA).

The examinations for applying operator license include paper examination, simulator test and oral test. The overall examination process is under the supervision and inspection of the SEPA (NNSA).

The license conditions of operators of Chinese operating nuclear power plants by the end of 2003 are listed in Appendix 4.

6. Planned Activities and Their Progress on Improving Nuclear Safety

China has achieved good performances in the construction and the operation of NPPs, and also made new progress on improving nuclear safety since the second review meeting of the Convention. The planned activities and their progress will be concisely introduced in this chapter.

6.1 Revision and Improvement of the Regulations on Nuclear Safety

Chinese Nuclear Safety Regulation System has been established for more than 20 years. In these years, China has accumulated a lot of experience on the design, construction, operation, and regulation of NPPs. In the meanwhile, the nuclear power countries and international organizations have kept on summarizing good experience and promulgating new regulations on nuclear safety. In order to make the Nuclear Safety Regulation System accord with the actual situation of China, learn duly domestic and foreign good experience, and consistent with the latest requirements accepted internationally as soon as possible, the revision and improvement of nuclear safety regulations have been listed in the routine plan.

From 2001 to 2003, nine items of laws, regulations and guides on nuclear safety, such as the "Act of Prevention and Remedy of Radioactivity Contamination of the People's Republic of China", the "Code on the Emergency Management of Nuclear Accidental Radioactive Influence Trans-Boundary", etc., was newly promulgated by China (see 3.1.3).

The revisions of the "Code on the Safety of Nuclear Power Plant Design" and the "Code on the Safety of Nuclear Power Plant Operation" were issued in 2004. In addition, the revisions of other regulations and guides on nuclear safety are in progress or in planning.

China will further strengthen the specific legislation on nuclear safety, including the stipulation of the "Atomic Energy Act" and the "Nuclear Safety Act". The administrative regulations, such as "Regulations on Safety Management of Transport of Radioactive Waste" and "Regulations on Safety Management of Radioactive Waste", etc., are planned to be established.

6.2 Further Enhancement of Nuclear Safety Culture

In recent years, all operating NPPs in China have achieved good performance on nuclear safety which is owing to NPPs' making a point of cultivating the safety culture and enhancing the safety culture of managing and general staff. Following measures have been adopted by Chinese NPPs to enhance the level of nuclear safety culture.

(1) Establishment of the rulers

All NPPs have established regular management rulers requiring that all personnel (including contractors) and all activities shall comply with the principle of "Safety First", and put the protection for the health of the plant personnel and the general public and the protection for the environment in the highest priority.

(2) Establishment of the organizations

Each NPP has founded its nuclear safety committee so as to promote the cultivation of safety culture and to enhance the safety culture of all personnel continuously.

(3) Standardization of the management

All departments in each NPP have defined behavior criteria corresponding to their jobs and embodied the requirements of the safety culture in the relevant programs and procedures.

(4) Training of personnel

Each NPP has established the training rule which requires that the training of the safety culture shall be an obligatory course for each person before taking jobs.

(5) Promotion of the nuclear regulatory body

The nuclear safety review and the inspection performed by the SEPA (NNSA) are helpful to promote further enhancement of the safety culture of Chinese NPPs. Moreover, the propaganda of nuclear safety regulations conducted by the SEPA (NNSA) in each NPP effectively enhances the consciousness and the level of nuclear safety culture of the plant personnel.

(6) Avocation of self-evaluation

In these three years, each NPP has conducted or planned to perform self-evaluation activities in its departments or in working groups so as to analyze the root causes and to put forward corrective measures focused on the safety problems found in the self-evaluation. Each NPP will foster the self-evaluation persistently and extensively and encourage all plant personnel to participate this activity so as to promote the sustaining improvement of nuclear safety culture.

6.3 Fulfilment of the System of the Professional Qualification of the Registered Nuclear Safety Engineers

On November 19, 2002, the Ministry of Personnel and the SEPA (NNSA) jointly issued the "Temporary Code on Professional Qualification of Registered Nuclear Safety Engineers" which requires that the professional qualification institution of the registered nuclear safety engineers should be established in the fields of nuclear safety or in the relevant fields. The implementation of this institution is helpful to enhance the level of the competence of nuclear technical personnel, to standardize the management of critical posts involving nuclear safety, to ensure nuclear safety and the safety of radioactive environment, and to protect the profit of the nation and the general public.

The descriptions about the qualification examination, the issuance and registration of certificates and the professional scope of the registered nuclear safety engineers are detailed in 4.2.2.3.

A registered nuclear safety engineer has the right to work at a critical post involving nuclear safety, and bears his own responsibilities. A registered nuclear safety engineer should unceasingly update his own knowledge, consciously accept occupational education, and take part in the professional training as required.

The "Temporary Code on Professional Qualification of Registered Nuclear Safety Engineers" has been implemented. In June 2004, the first group of registered nuclear safety engineers obtained the professional qualification through the examination and authentication.

The "Examination Program of the Professional Qualification of the Registered Nuclear Safety Engineers" and training materials are published in July 2004.

6.4 Further Reinforcement of Operation Experience Feedback System

The operation experience feedback system of China has been established for many years. In the prevention of the recurrence of human errors and each kind of operational events, in the revision of operational procedures, in the modification of the safety-important items and in the consummation of nuclear safety regulations, the system has played positive roles to ensure the safe and reliable operation of NPPs.

The operation experience feedback system of Chinese NPPs may be divided into three levels.

(1) In-house operation experience feedback of NPPs

The operation experience feedback system has been established by Chinese NPPs. The plan for collecting and analyzing internal and external operation experience, as well as the managerial and implementation procedures related to the operation experience feedback, has also been stipulated and implemented in order to decrease various errors and to prevent the recurrence of operational events by each kind of measures and methods.

(2) Operation experience feedback among domestic NPPs

The operation experience feedback system among domestic peers includes

— The periodic operation experience feedback and information exchange among six domestic NPPs.

— The activities of operation experience feedback organized by the administration department of nuclear industry, the nuclear safety regulatory body, Chinese NPPs and technical-support organizations.

A unified operational-information network of Chinese NPPs is under planning so as to realize the safe, handy and expeditious operational-experience exchange in more extensive fields and to facilitate the domestic peers to obtain the experience and to draw lessons in time.

(3) International Operation experience feedback

Good sister-plant relationships have been established among Chinese NPPs and the foreign similar-type NPPs (especially with the reference NPPs), and the regular or irregular experience exchange activities are conducted. In addition, all Chinese NPPs actively take part in the experience exchange and academic activities organized by international organizations such as IAEA, WANO, COG, FROG, etc., to endeavor to perform a better external operation experience feedback.

In order to ensure the normal and effective operation of the operation experience feedback system of China, the SEPA (NNSA), the CAEA, and the operating organizations of NPPs pay great attention to the establishment of the operation experience feedback system, and actively participate the activities of each level operation experience feedback system. The SEPA (NNSA) and the CAEA will cooperate to promote the improvement and consummation of the operation experience feedback system at all levels so as to make it be mutually promoted, compatible and service better for the enhancement of the integral safety performance of Chinese NPPs.

6.5 Significant Technical Improvement

At present, the NPPs put into operation for more than 10 years are Qinshan NPP and Daya Bay NPP. In recent years, these two plants performed lots of necessary technical improvement for some systems and components influencing the safe operation in order to enhance the safety and reliability. All these significant technical-improvement projects are required to consider fully the operation experience and the relevant research achievements, to accord with the requirements of the accepted regulations, standards and specifications on nuclear safety, and to submit to the SEPA (NNSA) for approval before implementation.

Qinshan NPP replaced the emergency refrigerator in the seventh refueling outage in 2003 and plans to replace its station computer in the eighth refueling outage. In addition, Qinshan NPP initiated the project for replacing the head of reactor pressure vessel for the sake of its long-term safe and steady operation. According to the plans, Daya Bay NPP finished the design and manufacture of the fifth diesel generator, the modification of the supporter of vibration damper in the nuclear island and the replacement of the head of reactor pressure vessel for unit two. The replacement of the head of reactor pressure vessel for another unit will be performed in the ten-year overhaul outage.

6.6 Reinforcement of the Development of Countermeasures Against the Severe Accidents of the NPPs

In August 2002, the SEPA (NNSA) promulgated "Technical Policy on Several Significant Safety Issues in the Design of Newly Constructed NPPs". Henceforth, the SEPA (NNSA) set up a specific group for study and management of severe accidents. This group is responsible for fully investigating the advancement and the status of the domestic and foreign researches on the phenomena and the management of the severe accidents of the NPPs, and putting forward suggestions about the research and the management of the severe accidents of the NPPs. On the basis of fully absorbing and referring to the international research fruits and mature experience, focused on the current status of Chinese NPPs under operation and construction, the SEPA (NNSA) will stipulate managerial requirements, regulations, guides and technical documents for severe accidents of NPPs in order to normalize and to direct the management of severe accidents of NPPs.

At present, Qinshan NPP and Daya Bay NPP plans to put forward the countermeasures for preventing and mitigating the severe accidents of NPPs on the basis of results of ten-year safety reviews.

6.7 Several Measures for Strengthening the Capabilities of the Regulatory Body

Following measures have been adopted by the SEPA (NNSA) to copy with the challenge imposed by the status of multi-type reactors and multi-nation technologies.

(1) Active promotion of the legislation on nuclear safety

The legislation on nuclear safety is actively promoted, and the hierarchy of nuclear safety regulations is continuously updated and consummated in order to make it more suitable for the current development of Chinese NPPs adopting multi-type reactors and multi-nation technologies and to provide complete law bases for the implementation of the nuclear safety supervision.

The revision and improvement of nuclear safety regulations are described in 3.1.3 and 6.1. Further legislation on nuclear safety, the revision and stipulation of regulations, guides on nuclear safety are being conducted in an orderly way.

(2) Proper selection of standards applicable for the design and construction of NPPs

The article 22 in the "Act of Prevention and Remedy of Radioactivity Contamination of the People's Republic of China" points out that the imported nuclear power plants should accord with the requirements of the national standards on the prevention and remedy of radioactivity contamination. If there are no corresponding national standards, foreign standards accepted by the SEPA should be adopted.

When a nuclear power plant is imported from the foreign country, in the prerequisite of meeting the requirements of Chinese nuclear safety regulations, the industry standards of the exporter's country approbated by the SEPA (NNSA) should be adopted.

(3) Enhancement of the regulatory capabilities

In order to improve the professional competence of the inspectors, the SEPA (NNSA) conducted the training and examination for the staff in its headquarters and regional offices in August and December 2001. In addition, the SEPA (NNSA) invited the IAEA experts to hold a training course for Chinese nuclear safety inspectors in August 2002.

In recent years, the SEPA (NNSA) unceasingly enlarged the investment in the construction of its capabilities including the increase of the staff, the intensification of the professional training, the establishment of the charging institution for nuclear safety review, the formation of a complete quality assurance system, etc.

(4) Performance of fundamental research in important fields

By fully using the technical force of nuclear safety centers, research institutes and universities, the SEPA (NNSA) conducts extensively the comparative researches and exploration in certain important fields such as the countermeasures against the severe accidents of NPPs, etc., so as to provide powerful technical support for the regulation on multi-type reactors and multi-nation technologies and for the improvement of nuclear safety regulation hierarchy.

(5) Positive support and promotion of operation experience exchange and technical cooperation among the domestic and foreign NPPs

The SEPA (NNSA) has recognized that Chinese NPPs with multi-type reactors and multi-nation technologies actually represent various challenges. The SEPA (NNSA)'s encouraging operation experience exchange and technical cooperation among the domestic and foreign NPPs has effectively promoted the enhancement of the overall level of nuclear safety.

(6) Reinforcement of the technical exchange and cooperation with the IAEA and foreign regulatory authorities

The SEPA (NNSA) has kept good relationships with the IAEA and many foreign regulatory authorities and conducted technical and experience exchanges in the field of nuclear safety regulation. The SEPA (NNSA) invited International Regulatory Review Team (IRRT) to China to evaluate the status of Chinese nuclear safety regulation. In 2003, the SEPA (NNSA) applied for a follow-up activity of the IRRT.

The IRRT experts affirmed the performance and the good practices in Chinese nuclear safety regulation, and they also pointed out some weakness which needs to be improved. The SEPA (NNSA) accepted the suggestions from IRRT and responded quickly.

6.8 Periodic Safety Review and Operation Assessment

6.8.1 Periodic Safety Review

According to Chinese regulations on nuclear safety, the NPP shall perform the Periodic Safety Review (PSR). The operating NPPs should conduct a comprehensive safety review involving all areas related to nuclear safety and systematical re-evaluation of NPPs by using applicable regulations and standards every ten years to assure a higher safety level in the life of NPPs.

In 2001, Qinshan NPP started the first ten-year PSR. In 2003, its self-assessment was finished and the related report was submitted to the SEPA (NNSA) for review. Guangdong Daya Bay NPP started its first ten-year PSR in 2002 and its self-assessment will be completed and submitted to the SEPA (NNSA) for review in 2004.

6.8.2 Operation Assessment

The operational safety assessment of Chinese NPPs has been conducted smoothly. The national peer reviews of six domestic NPPs will be entirely completed in 2007. In addition, Chinese NPPs have received or planned to receive the Pre-OSART and OSART from the IAEA and the peer reviews from WANO, and received the inspections, reviews and technical exchanges from the international peers. For example,

— Qinshan Phase III NPP accepted a WANO peer review in March 2003, and will accept a follow-up inspection in 2005.

— Tianwan NPP accepted IAEA Pre-OSART in February 2004.

— Qinshan Phase III NPP will accept IAEA OSART in 2005.

— Qinshan NPP will accept a WANO peer review in 2005.

— Daya Bay NPP and LingAo NPP plan to accept a joint peer review which will be conducted by the NOAC and WANO/PC at DNMC.

All these activities will be helpful to improve and perfect Chinese operation assessment system.

6.9 Spreading Application of the Probabilistic Safety Assessment

Chinese regulations on nuclear safety require that both deterministic and probabilistic should be used in safety analysis in the design of NPPs.

Qinshan NPP finished its level-1 PSA under full power condition in November 2003, and accepted a peer review on PSA conducted by IAEA in December 2003.

Guangdong Daya Bay NPP finished its level-1 PSA and accepted the SEPA (NNSA)'s review in 2000.

Guangdong LingAo NPP, Qinshan Phase III NPP, and Jiangsu Tianwan NPP have finished their level-1 PSA. Qinshan Phase II NPP's level-1 PSA is in progress.

6.10 Improvement of the Emergency Preparedness

Chinese government has been actively improving the emergency preparedness in past three years, e.g. the establishment of the "Program of Working Plan for National Emergency Preparedness for Nuclear Accidents", the revision of "National Emergency Plan", the improvement of regulations and standards of nuclear accident emergency, the improvement of emergency response system, the enhancement of communication facilities, the implementation of emergency exercises, the reinforcement of emergency training, the research and development of techniques for nuclear accident emergency, the elaboration of "National Technical Research Program for Nuclear Accident Emergency During the Tenth Five-Year Plan". In order to meet the needs of nuclear power development in China and to keep pace with the level of international emergency preparedness, Chinese government will further perfect its organizational hierarchy and decision-making system against nuclear accidents, and improve its hardware facilities at each level of emergency organizations.

Annex 1 The List of Nuclear Power Plants in China (by December 31, 2003)

NPP Name	Unit No.	Location	Reactor Type	Nominal Power (MWe)	Date of the Construction	Date of the First Connection to the Grid
Qinshan NPP	CN-1	Haiyan, Zhejiang Province	PWR	310	1985-03-21	1991-12-15
Guangdong Daya Bay NPP	CN-2 CN-3	Shenzheng City, Guangdong Province	PWR PWR	984 984	1987-08-07 1988-04-07	1993-08-31 1994-02-07
Qinshan Phase II NPP	CN-4 CN-5	Haiyan, Zhejiang Province	PWR PWR	650 650	1996-06-02 1997-04-01	2002-02-06 2004-3-19
Guangdong LingAo NPP	CN-6 CN-7	Shenzheng City, Guangdong Province	PWR PWR	990 990	1997-05-15 1997-11-28	2002-02-26 2002-09-14
Qinshan Phase III NPP	CN-8 CN-9	Haiyan, Zhejiang Province	CANDU CANDU	728 728	1998-06-08 1998-09-25	2002-11-19 2003-06-12
Jiangsu Tianwan NPP	CN-10 CN-11	Lianyungang City, Jiangshu Province	PWR PWR	1060 1060	1999-10-20 2000-10-20	

Data of nuclear power plants in Taiwan province of China is left open for the time being.

Annex 2 Performance Indicators of Operational Units (from 2001 to 2003)

Performance Indicators of Operational Units (2001)

No.	Item (unit) / Unit / Year	2001		
		Qinshan NPP CN1	Guangdong Daya Bay NPP	
			CN2	CN3
1	Unit Capability Factor	93.90	88.02	90.89
2	Unplanned Capability Loss Factor	0.45	1.18	2.91
3	Automatic Scrams per 7000 Hours Critical (Times)	1.7	0.9	0.9
4	Collective Radiation Exposure (Man • Sv)	0.15	0.683	0.683
5	Safety System Performance: High-Pressure Safety Injection System Auxiliary Feed-Water System Emergency AC Supply System	 0.0009 0.0052 0	 0.001 0.001 0.001	 0 0.001 0.001
6	Fuel Reliability (Bq/g)	0.46	0.4	0.04
7	Chemistry Performance	1.31	1.00	1.00
8	Industrial Safety Accident Rate	0.20	0.129	

Performance Indicators of Operational Units (2002)

No.	Item (Unit) \ Year / Unit	2002		
		Qinshan NPP CN1	Guangdong Daya Bay NPP	
			CN2	CN3
1	Unit Capability Factor (%)	67.80	89.74	82.02
2	Unplanned Capability Loss Factor (%)	2.8	0.24	14.84
3	Automatic Scrams per 7000 Hours Critical (Times)	0	1.7	1
4	Collective Radiation Exposure (Man • Sv)	1.24	0.366	0.366
5	Safety System Performance: High-Pressure Safety Injection System Auxiliary Feed-Water System Emergency AC Supply System	 0.0003 0.0005 0	 0 0.001 0	 0 0 0
6	Fuel Reliability (Bq/g)	0.64	0.04	0.8
7	Chemistry Performance	1.11	1.05	1.03
8	Industrial Safety Accident Rate	0	0.12	

Performance Indicators of Operational Units (2003)

No.	Year / Unit / Item (Unit)	2003				
		Qinshan NPP	Guangdong Daya Bay NPP		Qinshan Phase II NPP	Guangdong LingAo NPP
		CN1	CN2	CN3	CN4	CN6
1	Unit Capability Factor (%)	89.15	90.13	84.79	79.69	90.44
2	Unplanned Capability Loss Factor (%)	0.2	0.06	1.13	2.33	5.46
3	Automatic Scrams per 7000 Hours Critical (Times)	0	0	0	0.97	0
4	Collective Radiation Exposure (Man • Sv)	0.798	0.924	0.924	0.3168	0.761
5	Safety System Performance: High-Pressure Safety Injection System Auxiliary Feed-Water System Emergency AC Supply System	 0.0004 0.00183 0.00042	 0 0.002 0.002	 0.001 0.001 0.002	 0.00056 0.00545 0.00007	 0.001 0 0.001
6	Fuel Reliability (Bq/g)	0.57	0.04	1.01	0.037	0.16
7	Chemistry Performance	1.07	1.01	1.00	1.939	1.12
8	Industrial Safety Accident Rate	0.1	0.216		0.250	0

Annex 3

Laws, Regulations and Guidelines of China on Nuclear Safety (By the end of December 31, 2003)

. National Laws

1. Constitute of the People's Republic of China
   (Promulgated in the Fifth Meeting of the Fifth National People's Congress，December 4, 1982)
2. Laws on the Environmental Protection of the People's Republic of China
   (Issued by the Standing Committee of the National People's Congress, on December 26, 1989)
3. Act of Protection and Remedy of Radioactive Contamination of the People's Republic of China
   (Promulgated in the Third Meeting of the Standing Committee of the Tenth National People's Congress, on June 28, 2003)

. Decrees of the State Council

1. Regulations on the Safety Regulation for Civilian Nuclear Installations of the People's Republic of China
   (Promulgated by the State Council on October 29, 1986)
2. Regulations on Nuclear Materials Control of the People's Republic of China
   (Promulgated by the State Council on June15, 1987)
3. Emergency Management Regulations for Nuclear Accidents of Nuclear Power Plant
   (Promulgated by the State Council on August 4, 1993)

. Department Rules

1. Rules for the Implementation of Regulations on the Safety Regulation for Civilian Nuclear Installations of the People's Republic of China
   — Part One: Application and Issuance of Safety License for Nuclear Power Plant (HAF001/01)
   (Issued by NNSA on April 1, 1987; Revised on December 31, 1993)

2. Rules for the Implementation of Regulations on the Safety Regulation for Civilian Nuclear Installations of the People's Republic of China — Part One
   Appendix one: Issuance and Management Procedures for Operator License of NPP (HAF001/01/01)
   (Issued by NNSA on December 31, 1993)
3. Rules for the Implementation of Regulations on the Safety Regulation for Civilian Nuclear Installations of the People's Republic of China
   — Part Two: Safety Surveillance of Nuclear Installations (HAF001/02)
   (Issued by NNSA on April 14, 1988; Revised on June 14, 1995)
4. Rules for the Implementation of Regulations on the Safety Regulation for Civilian Nuclear Installations of the People's Republic of China—Part Two
   Appendix One: The Reporting System for Operating Organization of Nuclear Power Plant (HAF001/02/01)
   (Issued by NNSA on January 3, 1992; Revised on June 14, 1995)
5. Rules for the Implementation of Regulations on Emergency Management of Nuclear Accident for Nuclear Power Plant
   — Part One: Emergency Preparedness and Response for Operating Organization of Nuclear Power Plant (HAF002/01)
   (Issued by NNSA on May 12, 1998)
6. Code on the Safety of Nuclear Power Plant Quality Assurance (HAF003)
   (Promulgated by NNSA on July 7, 1986; Revised on July 27, 1991)
7. Code on the Safety of Nuclear Power Plant Siting (HAF101)
   (Promulgated by the National Nuclear Safety Administration on July 7, 1986; Revised on July 27, 1991)
8. Code on the Safety of Nuclear Power Plant Design (HAF102)
   (Promulgated by NNSA on July 7, 1986; Revised on July 27, 1991)
9. Code on the Safety of Nuclear Power Plant Operation (HAF103)
   (Promulgated by NNSA on July 7, 1986; Revised on July 27, 1991)
10. Code on the Safety of Nuclear Power Plant Operation (HAF103)
    Appendix One: Management of Refueling, Modifications and Accidental Shutdown of Nuclear Power Plant (HAF103/01)
    (Issued by NNSA on March 2, 1994)
11. Code on the Safety of Civilian Nuclear Fuel Cycle Installations (HAF301)
    (Promulgated by NNSA on June 17, 1993)

12. Code on the Safety Regulation for Radioactive Waste (HAF401)
    (Promulgated by NNSA on November 5, 1997)
13. Rules for the Implementation on Regulations on Nuclear Materials Control of the People's Republic of China(HAF501/01)
    (Promulgated by NNSA, the Ministry of Energy and the China Atomic Energy Authority on September 25, 1990)
14. Code on the Safety Regulation for Civilian Nuclear Pressure Retaining Components (HAF601)
    (Issued by NNSA, the Ministry of Machine Building and Electronics Industry and the Ministry of Energy on March 4, 1992)
15. Rules for the Implementation of Code on the Safety Regulation for Civilian Nuclear Pressure Retaining Components (HAF601/01)
    (Issued by NNSA, the Ministry of Machine Building and Electronics Industry and the Ministry of Energy on March 5, 1993)
16. The Management on the Training, Examining and Certificating of the Personnel Undertaking Non-destructive Examination of Civilian Nuclear Pressure Retaining Components (HAF602)
    (Issued by NNSA on June 6, 1995)
17. The Management on the Training, Examining and Certificating of the Welders and the Welding Operators of Civilian Nuclear Pressure Retaining Components (HAF603)
    (Issued by NNSA on June 6, 1995)
18. Standard of Surveillance of Environmental Radiological Health and Public Health Survey
    (Issued by Ministry of Health, 1985)
19. Management Rules of the Health of Radiological Working Personnel
    (Issued by the Ministry of Health in 1988, Revised in 1997)
20. Management Methods for Radioactive Environment
    (Issued by the NEPA on June 22, 1990)
21. Criteria of the Safety Class Electric Power System of NPP (GB 12788-91)
22. Management Rules of the Radiological Health Protection of Nuclear Facilities
    (Decree by Minister, Issued by the Ministry of Health, 1992)
23. Surveillance and Evaluation Standard of the Public Dose During Normal Operation and Accident Condition of Nuclear Installation

(Issued by Ministry of Health, 1992)

24. Management Rules of the Medical Emergency Response Under Nuclear Accident
(Decree by Minister, Issued by the Ministry of Health, 1994)
25. Intervention to the Public Protection and the Derived Intervention Level During Nuclear Accident or Radiation Emergency
(Issued by Ministry of Health, 1995)
26. Management Rules of the Safety of Electricity Production of NPP Connected to the Grid
(Issued by the Ministry of Electric Power Industry on April 28, 1997)
27. Codes on the Radiation Protection of NPP Environment (GB6249-86)
(Issued by the National Environmental Protection Administration on April 23, 1986)
28. Management Methods for License Examination of Operators of NPP (tryout)
(Issued by Chinal Atomic Energy Authority on September 6, 1999)
(Issued by National Atomic Energy Organization on January 19, 2001)
29. Management Rules for Review and Approval for Transfer and Transit Transportation of Nuclear Products
(Issued by China Atomic Energy Authority on January 27, 2000)
30. The Basic Standard on the Ionization Radiation Protection and Radioactive Source Safety(GB18871-2002)
(Issued by the NNSA, the Ministry of Health and the General Bureau for Quality Inspection)
31. Reporting System of Nuclear Accident Emergency for NPP
(Issued by China Atomic Energy Authority on December 11, 2001)
32. Specifications on Medical Treatment of Radiation Damage
(Issued by the Ministry of Health, China Atomic Energy Authority on May 22, 2002)
Management Rules of Emergency Crossing the Boundary for Radioactive Influence due to Nuclear Accident (Issued by China Atomic Energy Authority in 2002)
33. Management Methods for Operation Assessment of NPP (tryout)
(Issued by China Atomic Energy Authority on June 4, 2002)
34. Management Rules of Nuclear Accident Emergency Exercise for NPP

(Issued by China Atomic Energy Authority on February 28, 2003)

. Guiding Documents (Safety Guideline)

Series for General

1. Emergency preparedness for the operating organization of nuclear power plant (HAD002/01)
   (Issued by NNSA on August 12, 1989)
2. Emergency Preparedness of Local Government for Nuclear Power Plant (HAD002/02)
   (Issued by NNSA, the National Environmental Protection Administration and the Ministry of Health on May 24, 1990)
3. Interfering Principles and Levels for Public Protection During the Emergency of Nuclear Accidental Radiation (HAD002/03)
   (Issued by NNSA, the National Environmental Protection Administration on April 19, 1991)
4. Levels of Derived Intervention of Public Protection During the Emergency of Nuclear Accident Radiation (HAD002/04)
   (Issued by NNSA, the National Environmental Protection Administration on April 19, 1991)
5. Emergency Preparedness and Response of Medicine During Nuclear Accident (HAD002/05)
   (Issued the Ministry of Health and NNSA on June 24, 1992)
6. Preparation of the Quality Assurance Program for Nuclear Power Plants (HAD003/01)
   (Issued by NNSA on October 6, 1988)
7. Quality Assurance Organization for Nuclear Power Plants (HAD003/02)
   (Issued by NNSA on April 13, 1989)
8. Quality Assurance in the Procurement of Items and Service for Nuclear Power Plants (HAD003/03)
   (Issued by NNSA on October 30, 1986)
9. Quality Assurance Record System for Nuclear Power Plants (HAD003/04)
   (Issued by NNSA on October 30, 1986)
10. Quality Assurance Audit for Nuclear Power Plants (HAD003/05)
    (Issued by NNSA on January 28, 1988)

11. Quality Assurance in the Design of Nuclear Power Plants (HAD003/06)
    (Issued by NNSA on October 30, 1986)
12. Quality Assurance During the Construction of Nuclear Power Plants (HAD003/07)
    (Issued by NNSA on April 17, 1987)
13. Quality Assurance in the Manufacturing of Items for Nuclear Power Plant (HAD003/08)
    (Issued by NNSA on October 30, 1986)
14. Quality Assurance During Commissioning and Operation of Nuclear Power Plants (HAD003/09)
    (Issued by NNSA on January 28, 1988)
15. Quality Assurance in the Procurement, Design and Manufacture of Nuclear Fuel Assemblies (HAD003/10)
    (Issued by NNSA on April 13, 1989)
16. Guide for Nuclear Emergency—Protective Actions and Recovery Decision for Post-Emergency of Serious Accident
    (Issued by National Atomic Energy Authority on September 28, 2000)
17. Technical Document of Nuclear Emergency Management —Emergency Preparedness and Response for Transportation Accident of Radioactive Materials
    (Issued by National Atomic Energy Authority on September 28, 2000)

Series for NPP

18. Earthquakes and Associated Topics in Relation to Nuclear Power Plant Siting (HAD101/01)
    (Issued on April 17, 1987 by NNSA and the National Seismic Administration, Revised on April 6, 1994)
19. Atmospheric Dispersion in Relation to Nuclear Power Plant Siting (HAD101/02)
    (Issued by NNSA on November 20, 1987)
20. Site Selection and Evaluation for Nuclear Power Plant with Respect to Population Distribution (HAD101/03)
    (Issued by NNSA on November 20, 1987)
21. External Man-induced Events in Relation to Nuclear Power Plant Siting (HAD101/04)
    (Issued by NNSA on November 28, 1989)

22. Hydrological Dispersion of Radioactive Material in Relation to Nuclear Power Plant Sitting (HAD101/05)
(Issued by NNSA on April 26, 1991)
23. Nuclear Power Plant Sitting - Hydrogeological Aspects (HAD101/06)
(Issued by NNSA on April 26, 1991)
24. Site Survey for Nuclear Power Plants (HAD101/07)
(Issued by NNSA on November 28, 1989)
25. Determination of Design Basis Floods for Nuclear Power Plants on River Sites (HAD101/08)
(Issued by NNSA on July 12, 1989)
26. Determination of Design Basis Floods for Nuclear Power Plants on Coastal Sites (HAD101/09)
(Issued by NNSA on May 19, 1990)
27. Evaluation of Extreme Meteorological Events for Nuclear Power Plant Sitting (HAD101/10)
(Issued by NNSA on April 26, 1991)
28. Design Basis of Tropical Cyclone for Nuclear Power Plants (HAD101/11)
(Issued by NNSA on April 26, 1991)
29. Safety Aspects of the Foundation of Nuclear Power Plants (HAD101/12)
(Issued by NNSA on February 20, 1990)
30. General Design Safety Principles for Nuclear Power Plants (HAD102/01)
(Issued by NNSA on July 12, 1989)
31. Seismic Analysis and Testing of Nuclear Power Plant (HAD102/02)
(Issued by NNSA on May 13, 1996)
32. Safety Functions and Component Classification for BWR, PWR, and Pressure Tube Reactor (HAD102/03)
(Issued by NNSA on October 30, 1986)
33. Protection against Internally Generated Missiles and Their Secondary Effects in Nuclear Power Plants (HAD102/04)
(Issued by NNSA on October 30, 1986)
34. External Man-induced Events in Relation to Nuclear Power Plant Design (HAD102/05)
(Issued by NNSA on November 28, 1989)
35. Design of the Reactor Containment Systems in Nuclear Power Plants

(HAD102/06)
(Issued by NNSA on May 19, 1990)

36. Design for Reactor Core Safety in Nuclear Power Plants (HAD102/07)
(Issued by NNSA on July 12, 1989)
37. Reactor Cooling Systems and Their Related Systems in Nuclear Power Plants (HAD102/08)
(Issued by NNSA on April 13, 1989)
38. Ultimate Heat Sink and Directly Associated Heat Transport Systems for Nuclear Power Plants (HAD102/09)
(Issued by NNSA on October 30, 1986; Revised on April 17, 1987)
39. Protection System and Related Facilities in Nuclear Power Plants (HAD102/10)
(Issued by NNSA on October 6, 1988)
40. Fire Protection in Nuclear Power Plants (HAD102/11)
(Issued by NNSA on October 30, 1986, Revised on May 13, 1996)
41. Design Aspects of Radiation Protection for Nuclear Power Plants (HAD102/12)
(Issued by NNSA on May 19, 1990)
42. Emergency Power Systems at Nuclear Power Plants (HAD102/13)
(Issued by NNSA on October 6, 1988; Revised on February 13, 1996)
43. Safety-related Instrumentation and Control Systems for Nuclear Power Plants (HAD102/14)
(Issued by NNSA on October 6, 1988)
44. Fuel Handling and Storage Systems in Nuclear Power Plants (HAD102/15)
(Issued by NNSA on February 20, 1990)
45. Operation Limits and Conditions for Nuclear Power Plants (HAD103/01)
(Issued by NNSA on April 17, 1987)
46. Commissioning Procedures for Nuclear Power Plants (HAD103/02)
(Issued by NNSA on April 17, 1987)
47. Core and Fuel Management for Nuclear Power Plants (HAD103/03)
(Issued by NNSA on November 28, 1989)
48. Radiation Protection During Operation of Nuclear Power Plants (HAD103/04)
(Issued by NNSA on May 19, 1990)
49. Staffing, Recruitment, Training and Authorization for Personnel of Nuclear Power Plants (HAD103/05)
(Issued by NNSA on April 17, 1987, Revised on February 13, 1996)

50. Management of Nuclear Power Plants for Safe Operation (HAD103/06)
    (Issued by NNSA on February 20, 1990)
51. In-service Inspection for Nuclear Power Plants (HAD103/07)
    (Issued by NNSA on October 6, 1988)
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    (Issued by NNSA on April 13, 1989; Revised on June 1, 1993)
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    (Issued by NNSA on July 10, 1998)
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    (Issued by NNSA on July 10, 1998)

Series for Radioactive Waste Management

57. Management of Radioactive Effluents and Wastes in Nuclear Power Plants (HAD401/01)
    (Issued by NNSA on May 19, 1990)
58. Design of Radioactive Waste Management System for NPP (HAD401/02)
    (Issued by NNSA on January 16, 1997)
59. Design and Operation of Incinerators of Radioactive Waste (HAD401/03)
    (Issued by NNSA on February 15, 1997)
60. Classification of Radioactive Waste (HAD401/04)
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61. Siting for Near Global Surface Disposal Site of Radioactive Waste (HAD401/05)
    (Issued by NNSA on July 6, 1998)
62. Siting for Geology Disposal Warehouse of Radioactive Waste (HAD401/06)
    (Issued by NNSA on July 6, 1998)

Series for Regulation of Nuclear Material

63. Guide on Physical Protection of Nuclear Power Plant (HAD501/02)
    (Issued by NNSA on April 8, 1998)

Appendix 1 Occupational Exposure of NPPs in China (From 2001 to 2003)

Plant \ Year \ Item （unit）		Annual Man Average Effective Dose (Man·mSv)	Annual Maxium Individual Effective Dose (mSv)	Annual Collective Effective Dose (Man·Sv)	Normalized Collective Effective Dose (Man·mSv/GWh)
Qinshan NPP	2001	0.19	4.97	0.15	0.06
	2002	1.03	15.76	1.25	0.70
	2003	0.71	10.37	0.798	0.31
Guangdong Daya Bay NPP	2001	0.61	36.3	1.37	0.09
	2002	0.37	6.78	0.73	0.05
	2003	0.704	8.098	1.848	0.123
Qinshan Phase II NPP	2001	/	/	/	/
	2002	/	/	/	/
	2003	0.158	4.242	0.316	0.0686
Guangdong LingAo NPP	2001	/	/	/	/
	2002	/	/	/	/
	2003	0.62	11.331	1.53	0.11
Qinshan Phase III	2001	/	/	/	/
	2002	/	/	/	/
	2003	0.185	3.274	0.171	0.0193

Notes: For Guangdong Daya Bay NPP, Guangdong LingAo NPP and Qinshan Phase III, the annual collective effective dose is the sum of two units' data, respectively.

Appendix 2 Percent (%) of Radioactive Effluents to the Annual Discharge Limits Set by National Standards

(From 2001 to 2003)

plant \ Year \ Item \ Type		Gaseous Effluents			Liquid Effluents	
		Noble gas	Halogen+Aerosol		Tritium	Other Nuclides
Qinshan NPP	2001	3.0E-4	0		6.7E-1	1.5E-2
	2002	5.88E-3	2.00E-3		1.73	2.70E-2
	2003	3.0E-3	0		1.7	3.3E-2
Guangdong Daya Bay NPP (Unit 1 and Unit 2)	2001	1.36	1.8E-1		8.56E+1	3.1E-1
	2002	1.22	2.3E-1		2.92E+1	3.3E-1
	2003	9.9E-1	2.5E-1		4.38E+1	2.0E+1
Qinshan Phase II NPP (Unit 1)	2001	/	/		/	/
	2002	1.77E-6	3.17E-3		1.08	1.83E-1
	2003	5.24E-6	1.7E-2		6.3	6.9E-1
Guangdong LingAo NPP (Unit 1 and Unit 2)	2001	/	/		/	/
	2002 Unit 1*	5.8E-1	1.0E-1		8.11	2.0E-2
	2003	4.8E-1	1.3E-1		2.28E+1	1.5E-1
Qinshan Phase III (Unit 1 and Unit 2)	2001	/	/		/	/
	2002	/	/		/	/
	2003	7.72E-3	Radioactive Iodine	2.96E-4	**	Total ß－γ 1.57E-4
			Aerosol	2.15E-8		

Notes:

1. The discharge of radioactive effluents is related to the power level of nuclear unit.
2. In calculating gaseous effuluents and liquid effluents, for a value below the detectable limit, each NPP may use different analysis methods. For example, Qinshan NPP assumes it 0, but Guangdong Daya Bay NPP and Guangdong LingAo NPP assume it the detectable limit.
3. * The unit started commercial operation in 2002.
4. ** At present, there is no realease limit of tritium set by the national standards for CANDU reactor, so the percentage of tritium is not listed here.

Appendix 3 Operational Events (From 2001 to 2003)

Operational Events in 2001

Plant / INES Level	Qinshan NPP	Guangdong Daya Bay NPP	
		Unit 1	Unit 2
0	2	8	5
1	0	1	1
≥2	0	0	0
Total	2	9	6

Operational Events in 2002

Plant / INES Level	Qinshan NPP	Guangdong Daya Bay NPP		Qinshan Phase II NPP	Guangdong LingAo NPP
		Unit 1	Unit 2	Unit 1	Unit 1
0	8	6	2	20	14
1	1	1	2	1	0
≥2	0	0	0	0	0
Total	9	7	4	21*	14*

Operational Events in 2003

Plant / INES Level	Qinshan NPP	Guangdong Daya Bay NPP		Qinshan Phase II NPP	Guangdong LingAo NPP		Qinshan Phase III NPP	
		Unit 1	Unit 2	Unit 1	Unit 1	Unit 2	Unit 1	Unit 2
0	3	5	6	7	6	3	11	10
1	0	0	0	0	1	2	0	0
≥2	0	0	0	0	0	0	0	0
Total	3	5	6	7	7	5	11	10

Appendix 4 Licensed Reactor Operators and Senior Reactor Operators (By the End of 2003)

Items \ Plant		Qinshan NPP	Guangdong Daya Bay NPP	Qinshan Phase II NPP	Guangdong LingAo NPP	Qinshan Phase III NPP
Reactor Operators (RO)	Number of RO	10	39	42	40	26
Senior Reactor Operators (SRO)	Number of SRO	24	55	26	36	17