English Version

THE PEOPLE'S REPUBLIC OF CHINA

THE FOURTH 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 should 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) (Qinshan Phase II NPP, Qinshan Phase III NPP and Guangdong LingAo NPP have been put into commercial operation, while Jiangsu Tianwan NPP is still in the commissioning stage), 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. In 2005 and 2006, China successively approved four projects, of which unit 3 and unit 4 of Guangdong LingAo NPP and unit 3 and unit 4 of Qinshan Phase II NPP were started to construction. As of December of 2006, China had owned 4 nuclear power units under construction, 2 units in commissioning and 9 units in commercial operation. The total installed capacity was 12,538MWe, 6,958 MWe of which belonged to installed capacity of 9 commercial operated nuclear power units accounting for about 1.1% of the total electric installed capacity in China; and in 2006, the total electric energy generated by NPPs that had been put into commercial operation was 53.44 billion KWh, accounting for 1.89% of the total electric energy generated in China. Safe and steady operation of the nuclear power units relieved the electric tense situation of regions where NPPs were located, meanwhile relieved the local pressure of environmental protection and promoted development of the local economy.

Accompanying nuclear power development, the technologies 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 electric energy generated by NPPs in 2006 could be converted into electric energy that are produced by burning standard coals of about 15.81 million tons; thus the 'greenhouse effect' and the annual gas release that could result in acid rain were reduced. Since the first NPP was put into commercial operation 10 years ago in Mainland of China, discharges of radioactive effluents have been far below than limit of the national standards and brought no bad influence to the surrounding environment.

1.2 Policies and Objectives for Nuclear Power Development

In order to meet the rapid increasing of energy demand and maintain the sustainable development of economy, Chinese government has defined the policy of "developing nuclear power actively". In 2006, the State Council of the People's Republic of China passed "Long- and Medium-term Programme of Nuclear Power (2005-2020)", in which it clearly indicated that installed capacity of nuclear power operation would rise from 7 million KWe nowadays to 40 million KWe in 2020, accounting for about 4% of the total national installed capacity more or less. For the sake of implementing nuclear power programme, the following tasks should be done: first, boost system reform and mechanism innovation. Establish perfect modern enterprise system, drive reorganization of current domestic technical force and equipment manufacturing enterprise energetically, and gradually constitute development system of nuclear power together with construction and operation system of nuclear power that is consistent with the socialist market economy.

Second, improve safeguard system of nuclear power and quicken establishment of laws and regulations. Intensify safety supervision of nuclear power in accordance with the law, promote research and development of nuclear safety actively and strengthen the construction of nuclear emergency system. Third, well-establish operation and technical service system, quicken training of nuclear power personnel, and improve safety and steady operation of nuclear power plant completely. Fourth, enhance self-reliance to manufacture nuclear power equipments, succeed in design and manufacturing technique of key equipments emphatically, and strive to improve productive capacity of set equipments. Fifth, develop domestic resources reasonably, make use of foreign resources actively and establish steady supply and guarantee system of nuclear fuel. Sixth, increase policy support and guide, and advance the healthy development of nuclear power business.

By the end of 2006, China has utilized the advanced and mature second generation nuclear technology, started to construct unit 3 and unit 4 of Guangdong LingAo NPP and unit 3 and unit 4 of Qinshan Phase II NPP; besides, China would start to construct some new nuclear projects at Hongyanhe of Liaoning province, etc, and introduce advanced nuclear technique through international bidding to construct several modeling NPPs. With the guidance of the policy "self-centered, Sino-foreign cooperation, introducing technology and actively pushing on localization", China shall build NPPs towards the standardization continuously. Through batch construction of NPPs, China shall fully promote its independent ability of nuclear power design and construction, improve construction and installation ability as well as technical level of nuclear projects; and the standard system shall also be established and improved for design, manufacture and construction of nuclear power to promote the industrialization of nuclear power.

Along with quick development of the national economy, there is a great need for safe, proven, economical and advanced nuclear power units of high capacity; thus the nuclear power shall play an important role in promoting the pluralism of Chinese energy, improving the safety of energy, protecting the environment and so on. And it shall play a more important role in the supply of Chinese energy by means of actively developing advanced technologies of self-owned intellectual property rights, further improving the safety and economy of the nuclear power units.

1.3 Nuclear Safety Policy

When we make nuclear energy bring benefit to the human, we shall 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 safety operation, 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). In October of 2003, Chinese government enacted and implemented “Act of Prevention and Remedy of Radioactivity Contamination of the People’s Republic of China” to bring radioactive contamination control into a law-based regulation. 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.

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 specific 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 National Report under "Convention on Nuclear Safety" of the People's Republic of China to review meeting of "Convention on Nuclear Safety" respectively in October of 1998, 2001 and 2004. At the same time, China answered all the written questions to China from other contracting parties seriously.

The comments on Chinese National Report by the third review meeting of the "Convention on Nuclear Safety" held in Vienna in April of 2005 are as follows:

The Chinese National Report and afore-hand written responses for the 154 questions were fully affirmed. Representatives of each contracting party thoroughly discussed the detailed practices about Chinese nuclear safety supervision and management and concluded the good practices as follows:

— Chinese codes and guides of nuclear safety were enacted and amended based on IAEA safety standards and integrated Chinese practices of nuclear safety management;

— China paid attention to peer communication with partners in the domain of nuclear safety (such as IRRT and OSART of IAEA);

— China set regional office of nuclear safety in the regions where NPPs were located and strengthened nuclear safety supervision & management of NPPs;

— Occupational radiation dose of NPPs was far below the national regulatory limits;

— China attached importance to safety improvement of NPPs that were put into operation at early stage and reserved funds in advance to make sure that the safety improvement projects were performed effectively.

— Besides, contracting parties agreed that China had made progress in the following aspects:

— China improved Chinese law and regulation system of nuclear safety continuously based on IAEA safety standards and integrated Chinese practices of nuclear safety supervision & management;

— Functions of the regulatory body were further enhanced;

— Independence of the regulatory body on nuclear safety was further confirmed through IRRT tracking activities of IAEA;

— Financial resources and human resources of the regulatory body basically met the current demand; increased staffing plan had been established;

— Feedback system of operating experience was improved continuously;

— Probabilistic Safety Assessment (PSA) was applied;

— Periodic Safety Review (PSR) of early operated NPPs had been finished;

— Accident Emergency plan of NPPs was improved continuously;

— OSART of IAEA or other peer reviews were implemented.

In addition, all contracting parties expressed their persistent attentions to the following matters of China at the fourth review meeting of "Convention on Nuclear Safety" in 2008:

— "Atomic Energy Act" is still being drafted out;

— Laws and regulations on nuclear safety should be further improved;

— Chinese supervision of nuclear safety faces challenges of multi-reactor types and multi-national techniques at present;

— Various technical personnel are needed to face challenges of multi-reactor types and multi-national techniques at present;

— More professional human resources are needed for new nuclear power programme;

— Regulatory body needs more technical support;

— Technical renewal and aging management of NPPs;

— PSA is applied in operating and technical renewal of NPPs.

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 supervision and management from other contracting parts and found our deficiencies to be improved. China actively takes measures to resolve the issues mentioned by other contracting parts so as to make all Chinese NPPs achieve and keep a high level of nuclear safety.

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 on Nuclear Safety" by the end of 2006. The report also outlined the important activities in nuclear safety and the progress on regulatory activities of nuclear safety in China since the third review meeting.

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

2. EXISTING NUCLEAR POWER PLANTS

Each Contracting Party shall take the appropriate steps to ensure that the safety of nuclear installations existing at the time the Convention enters into force for that Contracting Party is reviewed as soon as possible. When necessary in the context of this Convention, the Contracting Party shall ensure that all reasonably practicable improvements are made as a matter of urgency to upgrade the safety of the nuclear installation. If such upgrading cannot be achieved, plans should be implemented to shut down the nuclear installation as soon as practically possible. The timing of the shut-down may take into account the whole energy context and possible alternatives as well as the social, environmental and economic impact.

2.1 List of Existing Nuclear Power Plants

By the end of 2006, there were nine units in commercial operation, 2 units in commissioning and 4 units under construction in China. The list of nuclear power plants is given in Annex 1 (Data of NPPs in Taiwan province is left open for the time being).

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 Pressurized Water Reactors (PWR) type. These NPPs were designed on the basis of some relative NPPs which had successful experience and good performance. Furthermore, some necessary improvements have been conducted to enhance the inherent safety characteristics of the NPPs.

Qinshan NPP and Guangdong Daya Bay NPP have commercial operated for about ten years. The two NPPs have accumulated the rich experience during the commercial 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 commercial NPP that is designed, constructed, managed and operated by China. Its design has referred to Guangdong Daya Bay NPP and adopted some improvements. Construction of unit 3 and unit 4 of Qinshan II NPP, which is being performed at present, is improved on the basis of relevant design, construction, commissioning and operating experience of unit 1 and unit 2.

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. Construction projects of unit 3 and unit 4 of Guangdong LingAo NPP, which are being performed at present, have referred to unit 1 and unit 2, which are equipped with two 1080 MWe PWR units.

Qinshan Phase III NPP, which is equipped with 2 sets of 700MWe 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 commercial 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 operating NPPs from 2004 to 2006 are listed in Annex 2. It presented a good macro trend in the three years, some of WANO performance indictors entered the best quartile.

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 shall 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 issuing 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). By the end of 2006, ten-year Periodic Safety Review (PSR) had been completed in Qinshan NPP and Guangdong Daya Bay NPP, it showed that the two NPPs maintained safe and steady operation. Aiming at the weakness discovered in the review, the two NPPs are adopting active corrective actions.

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 is no undue dose release event occurring, and adverse impacts on the environment due to the NPP's commercial operations are not discovered.

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.

Nuclear Industry Administration energetically impels operational assessment. From 2004 to 2006, Operational Assessment Committee for NPPs organized the first focus assessment on training to Qinshan NPP, and together with Paris Center of WANO, implemented a Peer Review for Guangdong Daya Bay NPP and LingAo NPP. In the past three years, Chinese NPPs also accepted 1 IAEA-OSART and 3 WANO

Peer Reviews. Results of the operational assessments showed that the reviewed NPPs' managements on operation, maintenance, training, technical support, radioactive protective, industry safety, 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 commercial operating NPPs in China are in the early stage 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 Structure of Legislation and Regulation

1. Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of nuclear installations.

2. The legislative and regulatory framework shall provide for:

- ***(i) the establishment of applicable national safety requirements and regulations;***
- ***(ii) a system of licensing with regard to nuclear installations and the prohibition of the operation of a nuclear installation without a licence:***
- ***(iii) a system of regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and the terms of licences;***
- ***(iv) the enforcement of applicable regulations and of the terms of licences, including suspension, modification or revocation.***

3.1.1 General Description of Nuclear safety Laws， Codes and Guides

Since 1982, China has collected extensively and studied carefully the laws and 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 safety operation of NPPs has been accumulated. According to the experience combined with the newest requirements of international nuclear industry, China continually improves 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 Council

The existing administrative regulations that applicable to nuclear safety field are "Regulations 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 Regulations for Nuclear 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.

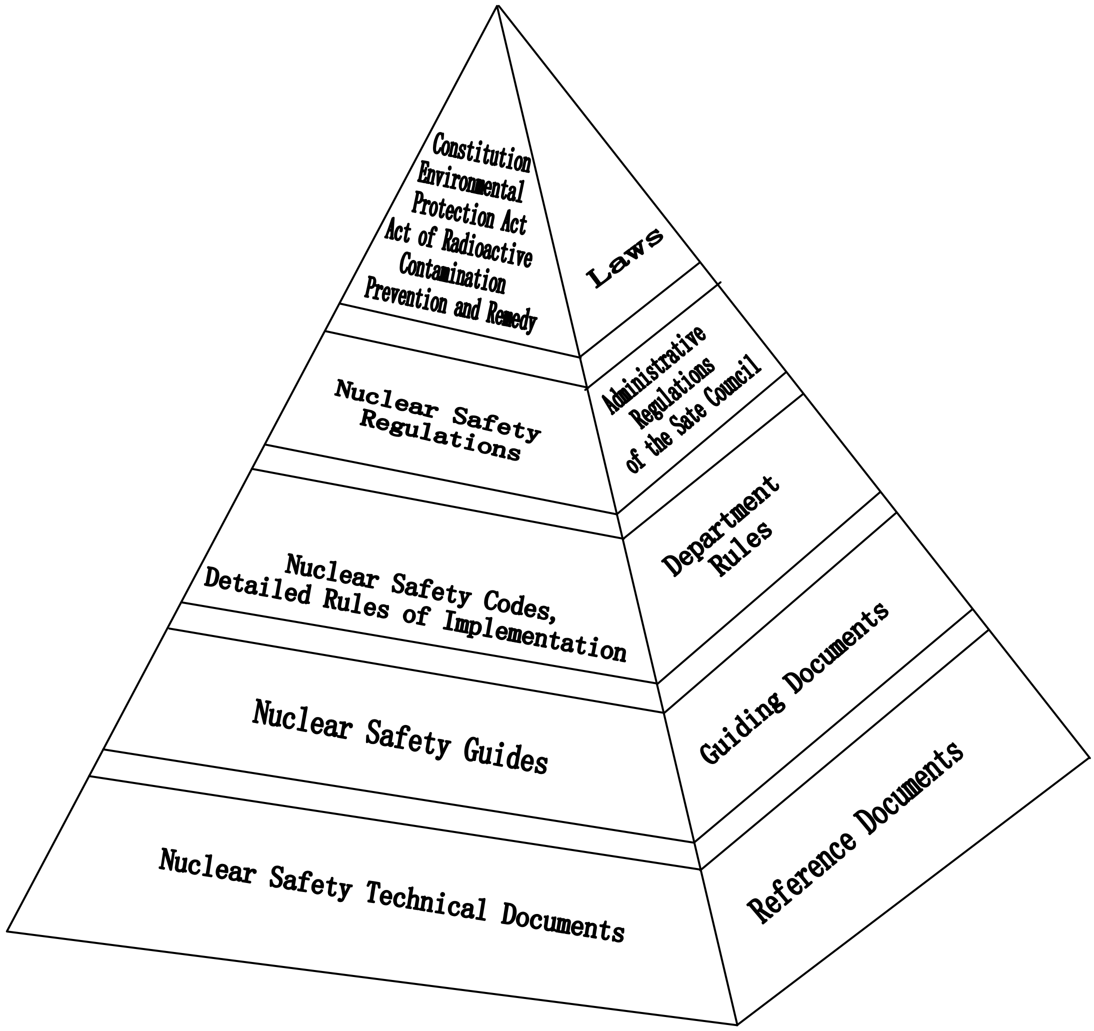

Figure 1 The hierarchical structure of laws, regulations and guides on nuclear safety of China

3.1.2 Issued 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 enacts 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 shall 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 specific 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.

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 promulgated 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 third Review Meeting of "The Convention on Nuclear Safety" in 2004, China has promulgated a series of new laws, regulations and guides, the related activities are as follows:

In April, 2004, the SEPA (NNSA) promulgated the newly amended "Code on the Safety of Nuclear Power Plant: Design" and "Code on the Safety of Nuclear Power Plant: Operation". In addition, it successively promulgated the supporting nuclear safety guides, such as "Safety Important System Software of Nuclear Power Plant based on Computer", "Safety Assessment and Verification of Nuclear Power Plant" "Operation Limits, Conditions and Procedures of Nuclear Power Plant", "Organization and Safety Operation Management of Nuclear Power Plant Operating Organization", "Fire Protection Safety of Nuclear Power Plant Operation" and "Periodic Safety Review of Nuclear Power Plant".

Moreover, the related departments consecutively promulgated "Surrounding Intrusion Alarm System of Nuclear Installations", "Management Rules of Operating Experience Exchange for Nuclear Power Plant (For Trial Implementation)", "Supervision and Management Rules on Firefighting Safety of Nuclear Power Plants" and so on.

China has been making further revision and perfection of nuclear safety regulations.

3.2 Nuclear Safety Regulation

1. Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 7, and provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities.

2. Each Contracting Party shall take the appropriate steps to ensure an effective separation between the functions of the regulatory body and those of any other body or organization concerned with the promotion or utilization of nuclear energy.

3.2.1 Nuclear Safety Regulation System

The SEPA (NNSA) is Chinese regulatory body for nuclear safety. It is in charge of 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 sanction, 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 and Ministry of Health

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 registered 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 six regional offices are established in Shanghai, Shenzhen, Chengdu, Beijing, Lanzhou and Dalian 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 Radiation 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 inspect whether or not the construction is carried out in accordance with the approved design;

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

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

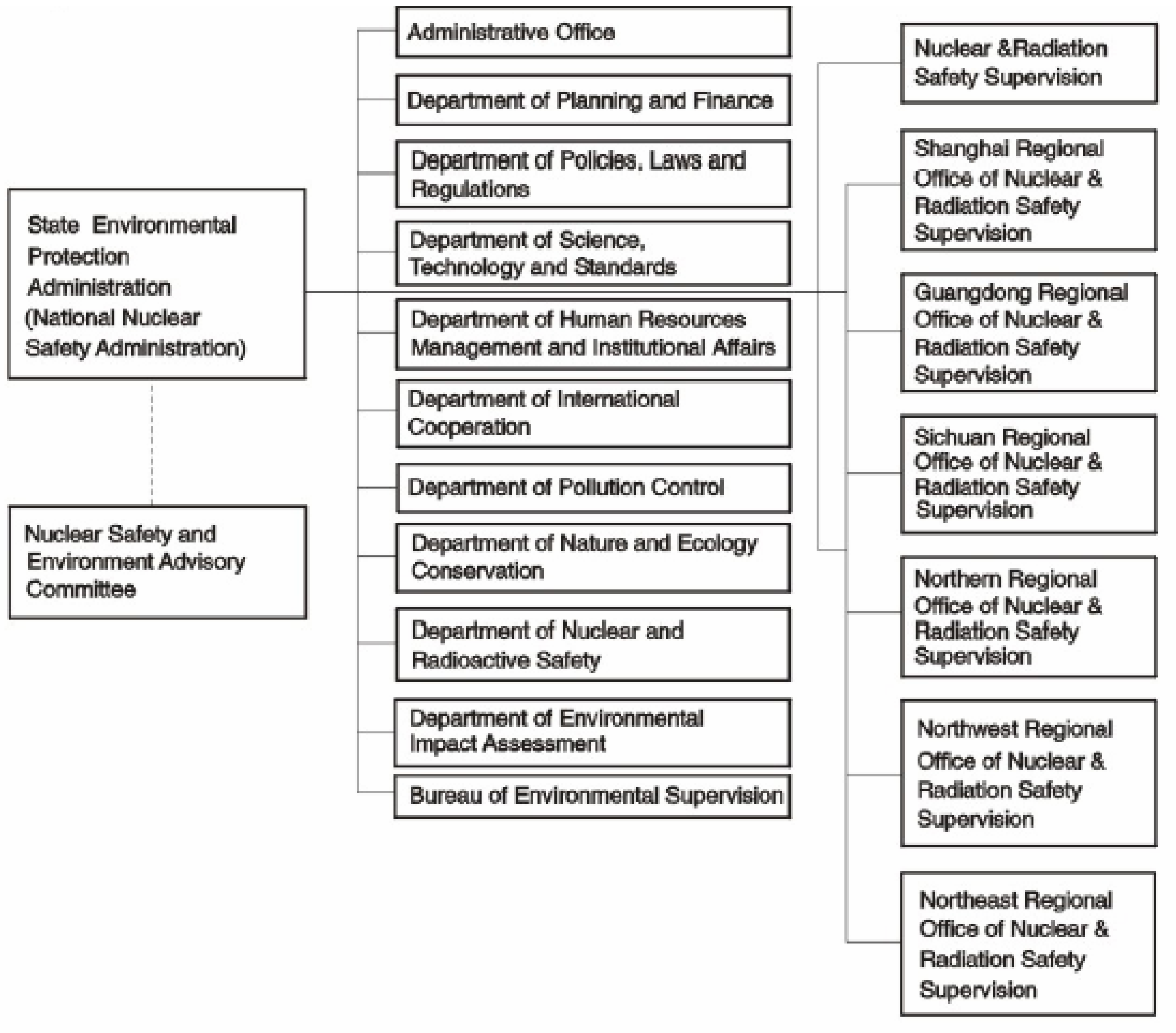

Figure 2 The organization structure of the SEPA (NNSA)

(5) to investigate whether or not the operating organization has a adequate capability for safety 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 Responsibilities of Licencee

Each Contracting Party shall ensure that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.

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.

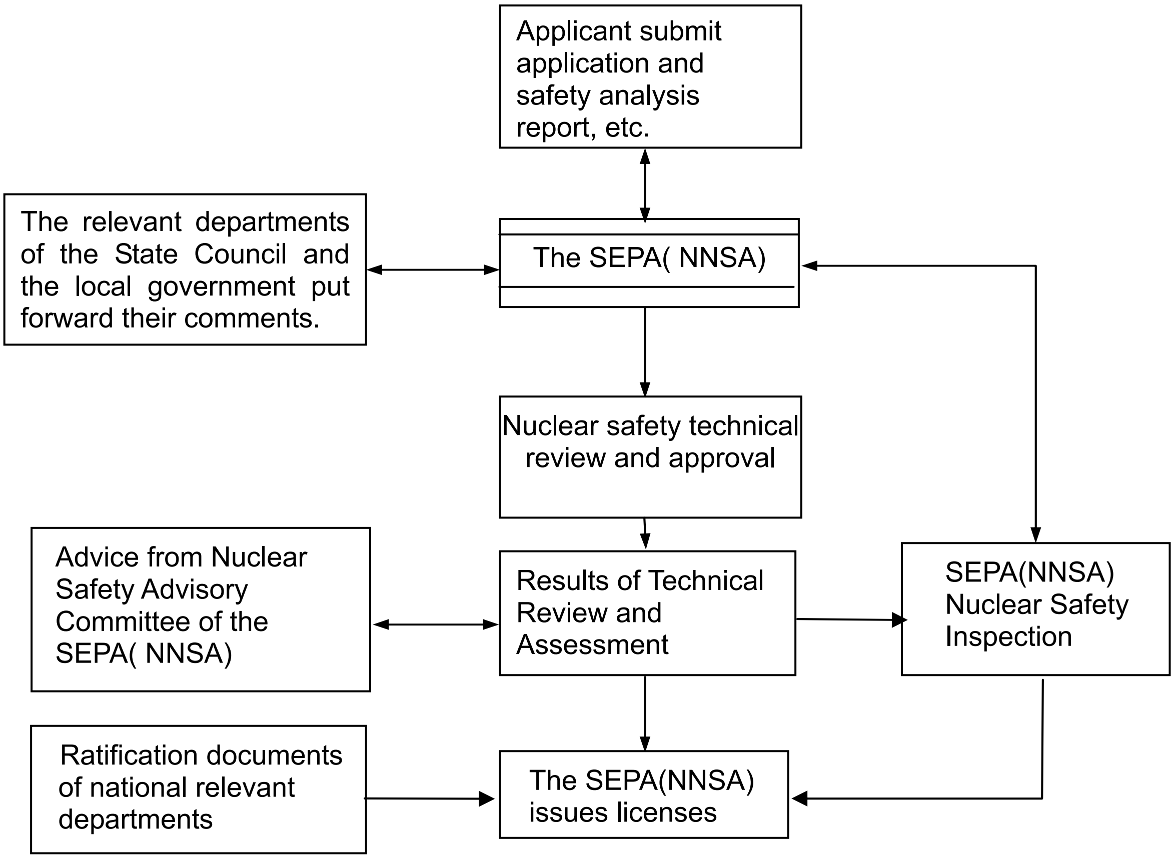

Figure 3 The procedures of application and issuance of licenses

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 third National Report review meeting of "Convention on Nuclear Safety" was convened, the SEPA (NNSA) has newly issued the following licenses and documents to NPPs:

(1) Siting review comments for Guangdong LingAo NPP unit 3 and unit 4 on Oct.15, 2004;

(2) Siting review comments for Qinshan Phase II NPP unit 3 and unit 4 on Oct.28, 2004

(3) Siting review comments for Zhejiang Sanmen NPP unit 1 and unit 2 on Jan.11, 2005;

(4) Siting review comments for Liaoning Hongyanhe NPP unit 1 and unit 2 on May 20, 2005

(5) Siting review comments for Shandong Haiyang NPP unit 1 and unit 2 on May 20, 2005;

(6) The instrument of ratification for the first fuel loading of Jiangsu Tianwan NPP unit 1 on Oct.17, 2005;

(7) Siting review comments for Guangdong Yangjiang NPP unit 1 and unit 2 on Oct.18, 2005,;

(8), Construction license for Guangdong LingAo NPP unit 3 and unit 4 on Dec.9, 2005;

(9), Construction license for Qinshan Phase II NPP unit 3 and unit 4 on Jan.24, 2006;

(10) Siting review comments for Fujian Ningde NPP unit 1 and unit 2 on Nov.8, 2006.

In addition, the SEPA (NNSA) has also reviewed and approved corresponding Environmental Impact Reports of the NPPs mentioned above.

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

Each Contracting Party shall take the appropriate steps to ensure that all organizations engaged in activities directly related to nuclear installations shall establish policies that give due priority to nuclear 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 shall 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 operating 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 operating experience feedback system: plant staff are encouraged to report any abnormal. Event investigation and analysis are implemented timely and corrective actions are taken. Management of NPP and reliability of equipment are improved effectively with the help of operating 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

The main management activities of China Atomic Energy Authority (CAEA) include the following:

(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) Boosting construction of operational assessment system of nuclear power industry, gradually developing comprehensive assessment and focused assessment of NPP, so as to strengthen industrial management, promote intercommunion among

NPPs and improve safety and reliability of NPPs;

(4) Improving operating experience exchange system of nuclear power industry step by step, establishing management rules and implementing instructions of operating experience exchange of NPPs, organizing compilation of "Annual Report on Operating Nuclear Power in China", "Quarterly Report on the Production of Operating Nuclear Power Plants", "Report on Key Performance Indicators of Chinese Nuclear Power Plants", "Annual Report on Operating experience Feedback" and other periodic reports, building platform for information exchange and promoting information exchange among NPPs;

(5) Strengthening the management of training and qualification for operators and senior operators of NPPs, issuing and implementing the new revision "Standard for License Examination of Operators of Nuclear Power Plants" based on the operating 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 of NPPs.

4.1.6 Good Practices Related to Safety

In the development of nuclear power industry, the Chinese nuclear regulatory body, the nuclear industry administration and the NPPs' Operators continue to track the international advanced experience and good practice on nuclear safety supervision and NPP operation, make great effort to keep nuclear safety of China consistent with international level and improve nuclear safety continuously.

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

(2) Qualification and certification system of registered nuclear safety engineers for professional technicians on key positions of nuclear safety is actively promoted, and continuing education system for registered nuclear safety engineers is implemented;

(3) Supervision personnel team building of nuclear safety is strengthened, and two new regional offices, i.e. Northwest Nuclear & Radiation Regional Office and Northeast Nuclear & Radiation Regional Office are set up. With increasing staffing

plan and outlay, and on the basis of strictly implementing various administrative permits, routine review and supervision are strengthened and supervision and management of important nuclear installations are enhanced;

(4) Supervision of nuclear pressure retaining components is strengthened, and Nuclear Equipment Office is set up in the nuclear safety regulation body. Reporting system for license holders of civilian nuclear pressure retaining components is established and the specific survey to 24 license holders of civilian nuclear pressure retaining components in the whole country has been completed

(5) Safety culture construction is promoted continuously, and, weakness on human factor of NPPs is identified by performing human-factor assessment and diagnosis. Through improving human behaviour, regulating management patrol and controlling human error risk, the basic principles and requirements of safety culture are put into effect, and safety culture improvement has been accepted as a daily and concrete work.

(6) Focused assessment standards on personnel training of NPPs are established and the first domestic focused assessment on training for NPP operator is performed. Together with WANO Paris Center, a joint comprehensive assessment for Guangdong Daya Bay NPP and Guangdong LingAo NPP is completed with fruitful achievements. By the way of integrating comprehensive and focused assessment ,as well as combining domestic and international peer review together, the plants can share more resources and experience, and benefit more from these kinds of activities, and thus the operation safety of NPPs are continuously enhanced.

(7) Nuclear safety regulation, nuclear industry administration and all NPPs promote and involve in operation management and experience feedback practice actively at different levels, and always pay attention to experience exchange and information sharing among international and domestic peers.

(8) Probabilistic Safety Assessment 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

1. Each Contracting Party shall take the appropriate steps to ensure that adequate financial resources are available to support the safety of each nuclear installation throughout its life.

2. Each Contracting Party shall take the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety-related activities in or for each nuclear installation, throughout its life.

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 resource supplement of SEPA (NNSA).

All expenses for safety 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

Along with the rapid development of nuclear industry in China, the demand of human resource increases very quickly. Therefore, the Chinese government and NPP operators 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 personnel cultivation.

At present, the human resources needed by the nuclear power development in China are mainly supplied by the following ways:

(1) Chinese nuclear industry has fostered plenty of qualified nuclear engineering experts 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 operating NPPs transfer various qualified technical personnel and management personnel to the NPPs under construction and nuclear safety regulatory body continuously.

(3) Chinese government establishes qualification and certification system as well as registered nuclear safety engineers system for key positions on nuclear safety. For nuclear special occupation,, the government establishes national standards, strengthens professional skill qualification and carries out National Occupation Qualification and Certification System;

(4) Chinese government enhances professional personnel recruitment and introduction system, enlarges the amount of recruit students by colleges and universities, especially increases enrollment amount of, nuclear related majors. Outstanding personnel are selected to study relevant nuclear majors, the concerned

organizations are organized to recruit graduates from middle and higher colleges and universities, senior management leaders are selected within the scope of the country, professional technicians of conventional power plants and other relevant industries are recruited and introduced continuously by nuclear power industry.

(5) Chinese government also extends ways of personnel cultivation and enhances personnel cultivation by means of establishing nuclear energy institute in colleges and universities, joint educating and training with scientific research institutes, strengthening international communication and sending people abroad to study the advanced nuclear technology..

(6) Chinese government recruits overseas experts on nuclear power.

4.2.2.1 Training and Assessment of staff in NPPs

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 requirements 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.

With further development of Chinese nuclear power, Chinese NPPs energetically push Systematic Approach to Training(SAT), develop training demand analysis starting from the actual work requirements organize and implement various training and technical support activities effectively so as to increase personnel's knowledge and skills with focus on safety production of NPPs continuously. Moreover, they optimize training resources by standardizing training material preparation, adopt several measures to strengthen trainer management and cultivation, conduct internal and external evaluation and feedback in training areas, and improve current training system ceaselessly.

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 System

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, according to "Act of Prevention and Remedy of Radioactivity Contamination of the People's Republic of China", 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. Furthermore, Chinese government established and issued "Registration Management Rules for Qualification and Certification of Registered Nuclear Safety Engineers(on trial)" in 2004 and "Regulations on Continuing Education of Registered Nuclear Safety Engineers (on trial)" in 2005.

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. Continuing educational system shall be performed for registered nuclear safety engineers.

Professional scopes of registered nuclear safety engineer are: review of nuclear safety, supervision 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).

As of late 2006 from 2004, in which job qualification assessment and accreditation of the first registered nuclear safety engineers was made, three national job qualification examinations of registered nuclear safety engineers have been completed

4.3 Human Factors

Each Contracting Party shall take the appropriate steps to ensure that the capabilities and limitations of human performance are taken into account throughout the life of a nuclear installation.

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.

In accordance with the development of Chinese nuclear power plants and meeting the international safety requirements 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 requirements of human factor and man-machine interface were put forward. In April of 2004, the updated "Regulation on Safety Design of Nuclear Power Plants" addressed the requirements 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 operating experience are involved both in the simulator training and qualification.

(3) Nuclear power operating 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 operating management and safety regulation.

4.3.2 Measures in the Operation Management

(1) Be clear of organization and position responsibilities; by continuously strengthening responsibility system and surveillance system, establish and perform response and decision-making mechanism of unexpected incidents, put various interfaces and working process in order, reduce human-factor errors in the course of harmonizing management and decision-making.

(2) Continuously perfect various management systems; by establishing routine inspection and specific inspection system, introduce specific operation sheet, form methods including STAR, pre-job briefing, post-job briefing and three way communication, to improve management of NPPs.

(3) Strengthening work permit system. Operation, maintenance, periodic testing of NPPs as well as other safety- related activities are required to be done by certificated personnel and with work permit.

(4) Enhancing a system for root cause analysis of the events related to human factors, aiming at typical or recurring events related to human factors, carry out specific analysis thoroughly, strive to find the deficiencies in management policies and organization structures, etc, and adopt more effective preventive measures; regularly check the implementing conditions of human error prevention, and perform self-assessment to the implementing conditions of control measures.

(5) Strengthening internal and external experience feedback systems, making operating experience feedback systematical, organized, standardized and systematic as well as making experience feedback and incident education as daily work, analyze, compare and seek for managerial deficiencies and potential weakness in the human factor aspect from the internal, absorb and adopt advanced experience and lessons from the international peers, in order to avoid similar human errors recurring.

(6) Setting and using human error prevention cards, reminding staff to prevent human errors; popularize operators' behavior standards, control human error by improving human behavior and custom, make sure that the units operate safely, steadily and economically.

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 faithfully 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 shall 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 methods 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 operating experience, carefully investigate and study the human factor related safety important events, treat the errors as opportunities for learning and improving, systematically collect, screen, analyze, learn and apply the external operating 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

Each Contracting Party shall take the appropriate steps to ensure that quality assurance programmes are established and implemented with a view to providing confidence that specified requirements for all activities important to nuclear safety are satisfied throughout the life of a nuclear installation.

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 when 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 form, 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 safety important items 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, determining 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, Implementation, Assessment 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 specific 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.

From 2004 to 2006, the quality assurance organization of NPP performed its surveillance and evaluation functions mainly through the following activities:

(1) According to the requirements of nuclear safety codes, the newly-built NPPs established and built applicable QAP and corresponding quality assurance documents system in time, set up and perfect organization structure and functions to assure that the quality objectives of NPP were implemented;

(2) Operating NPPs effectively perform QAP. They independently reviewed, surveiled and evaluated preparation and implementation of important safety production activities, arranged specific person to follow up the whole process of important changes, prepared quality plan, set control points, implemented quality surveillance orderly, strengthened measures including metrologic management and contractor management, verified whether control requirements of various activities had been performed correctly and obtained the objective evidence which showed that various activities had met the quality standards, ceaselessly perfected QAP and its implementation effectiveness;

(3) Qualification review was performed in design, manufacture and installation of nuclear equipments, besides, surveillance was carried out to check whether the activities met the requirements in QAP, so as to strengthen quality management and process control to design, manufacture and installation of nuclear equipments.

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 assessment 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 safety important documents, 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 policies 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

Each Contracting Party shall take the appropriate steps to ensure that:

(i) Comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life. Such assessments shall be well documented, subsequently updated in the light of operating experience and significant new safety information, and reviewed under the authority of the regulatory body;

(ii) Verification by analysis, surveillance, testing and inspection is carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements, and operational limits and conditions.

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 shall be obeyed by the licensee.

Sitting－The applicant submits application documents of site review of nuclear installations, including "Environmental Impact Report of Nuclear Power Plant (at Siting Stage)" and "Safety Analysis Report of Site", to the SEPA (NNSA). 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 ratification of environmental impact report 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 Environmental Impact Assessment Report of Nuclear Power Plant", and the approval documents of the project, etc. 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), "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" and "Quality Assurance Programme of Nuclear Power Plant (at commissioning Stage)",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 "Instrument of Ratification of the Environmental Impact Assessment Report of Nuclear Power Plant" and "Quality Assurance Programme of Nuclear Power Plant (at Operation Stage)",etc. . 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", the "Report of the Environmental Impact of Decommissioning of Nuclear Power Plant" and "Quality Assurance Programme of Nuclear Power Plant (at decommissioning Stage)",etc.. 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 throughout 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

In accordance with Chinese safety regulation requirements，systematic safety re-assessments of the nuclear power plant shall be performed by the operating organization throughout its operational lifetime, with account taken of operating experience and new safety important information from all relevant sources. The strategy for the review and the safety factors to be evaluated shall be approved by or agreed to by SEPA (NNSA).

PSR is used to assess aging, modification, operating experience, the status of knowledge of NPPs and accumulative effect on siting. This kind of review includes assessment and comparing design and operation of NPPs according to current safety standards and practices; the purpose is to guarantee that the NPP bears high safety in the lifetime. By PSR, assessment the operating NPPs comprehensively and confirm the following matters: degree that the NPP meets the current safety standards and practices; degree that keep license permission still valid; sufficiency of arrangements that maintain safety of the NPP before the next PSR or at the end of lifetime; safety improvement to be implemented in order to solve the safety problems confirmed.

It shall be determined by means of the PSR to what extent the existing safety analysis report remains valid. The PSR shall take into account the actual status of the plant, operating experience, predicted end-of-life state, current analytical methods, applicable safety regulations, standards and the state of knowledge. The scope of the PSR shall include all safety aspects of an operating NPPs, including both on-site and off-site emergency planning, accident management and radiation protection aspects. In order to complement the deterministic assessment, consideration shall be given to the use of probabilistic safety assessment (PSA) for input to the PSR to provide insight into the relative contributions to safety of different aspects of NPPs. On the basis of the results of the systematic safety reassessment, NPPs shall implement any necessary corrective actions and any reasonably practical modifications for compliance with applicable standards. The first PSR is to be conducted after a ten-year's operation and after then once per ten years.

Qinshan NPP started its first PSR in 2001 after ten years' operation and submitted the PSR reports to the SEPA (NNSA) for reviewing at September of 2003. In 2005, the SEPA (NNSA) finished reviewing report of the first PSR of Qinshan NPP. The review showed that Qinshan NPP met Final Safety Analysis Report(FSAR) requirements and could continue to maintain safety operation. According to review comments, Qinshan NPP prepared and implemented corresponding corrective action plan. By the end of 2006, some corrective activities had been completed.

PSR was completed primarily in Guangdong Daya Bay NPP in early 2005. The review showed that after ten years' operation, Guangdong Daya Bay NPP met FSAR requirements and could continue to maintain safety operation. According to review comments, Guangdong Daya Bay NPP developed and implemented corresponding corrective action plan. By the end of 2006, some corrective activities had been finished.

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. In April 2004, the SEPA (NNSA) promulgated "Code on the Safety of NPP Operation" newly amended, it requires that a safety analysis of the NPPs design shall be performed, and the analysis shall adopt deterministic and probabilistic methodology. 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 operating experience in order to improve the operation safety.

Qinshan NPP started research of PSA in 2001, completed "PSA Main Report of Qinshan Nuclear Power Plant", and submitted it to the NNSA for review. Through the review, Qinshan NPP revised relevant reports and models, and gradually applied achievements that were obtained from PSA research to production and management of NPPs.

On the basis of completing Level-1 PSA, Guangdong Daya Bay NPP and Guangdong LingAo NPP continuously improved and perfected PSA model and data. Since 2004, they have successively accomplished upgrade of Level-1 PSA and task of simplified Level-2 PSA, collected, analyzed and applied credible equipment data of Guangdong Daya Bay NPP, developed and applied on-line risk appraisal and management system, and advanced the application of PSA technique in NPPs step by step, including risk appraisal and management of safety important items, plant modification and daily production activities together with risk analysis for plant modification.

Moreover, both Qinshan Phase III NPP and Jiangsu Tianwan NPP have completed Level-1 PSA, while Qinshan Phase II NPP is performing PSA.

4.5.2.3 Aging Management

In April, 2004, the SEPA (NNSA) approved and promulgated Code on the Safety of NPP Design which stipulated: there shall be adequate safety margins for safety important structures, systems and components (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 capabilities of carrying out their functions in the operating lifetime. In addition, the following factors shall be taken into account, that is, aging and wearing effect under all normal operation conditions, test, maintenance, outage, status of anticipated operational occurrences and NPP thereafter. It is requested to 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.

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 PSR, 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.

In the process of PSR, Qinshan NPP and Guangdong Daya Bay NPP performed corresponding aging mechanism analysis and aging management review to safety important equipments, and proposed relevant countermeasures aiming at weaknesses identified in aging management review. At present, Qinshan NPP and Guangdong Daya Bay NPP are developing aging analysis and research, establishing and implementing aging management program. They screen and determine aging management projects, establish relevant aging management database, make aging managing measures including policy and procedures, research the methods of detecting and mitigating the aging, as well as monitor, analyze, assess and track the actual status of structure, system and components, so as to keep the plants operate at a high safety level in the lifetime.

Qinshan Phase II NPP, Qinshan Phase III NPP and Guangdong LingAo NPP are also gradually developing and boosting aging management of equipments of NPPs.

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 three years, Chinese NPPs have completed 21 in-service inspections during the outages. Any deficiency of equipment or component discovered in the inspection should be input into the in-service inspection database and compared with the previous results to forecast the trend. When necessary, widen the scope and increase frequency of inspection, repair the deficiencies or change the component. Qualified inspectors implement in-service inspection in accordance with approved inspection procedures, make use of qualified inspection equipments, and enforce strict quality assurance and quality surveillance in the process of inspection, in order to assure the effectiveness of the inspection results. Through previous in-service inspections, some deficiencies in NPPs have been discovered and corrected, which has guaranteed the integrity of three safety barriers and safety operation of NPPs. Besides, the results of in-service inspections are also 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 management 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 review 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.

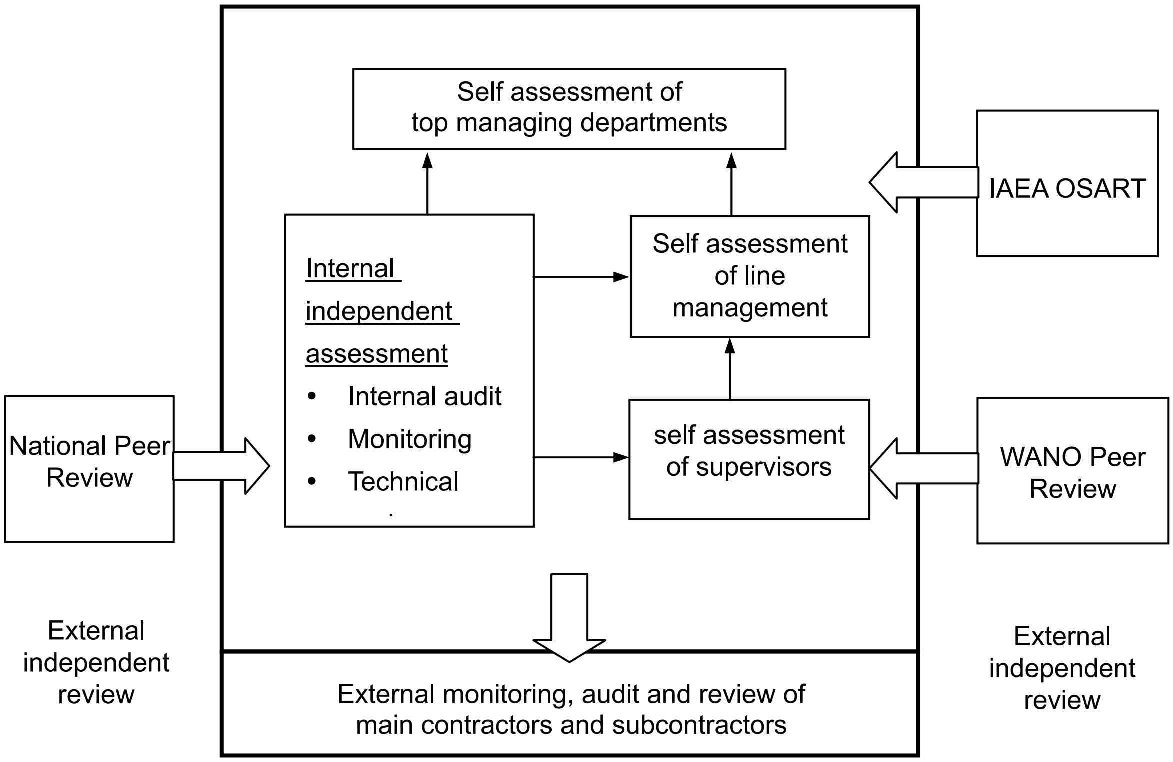

Figure 4 Assessment System of NPPs

During the recent three years, Operational Assessment Committee of the NPPs has continuously improved the domestic nuclear assessment system, actively developed domestic assessment activities and enhanced international communication. In 2004, in order to deepen assessment activities, Operational Assessment Committee of the NPPs started special assessment on training,, purpose of which was to evaluate the current situations of training system of NPPs, accelerate training system of NPPs to be improved and perfected continuously, and promote the effective application of the Systematic Approach to Training in NPPs. In December of 2005, the Assessment Committee completed training of relevant personnel and compiling of basic documents on focused assessment standards, etc.; in November of 2006, it performed the first focused assessment on training for Qinshan NPP.

In 2005, together with Paris Center of WANO, Operational Assessment Committee of the NPPs performed peer review to Guangdong Daya Bay NPP and

Guangdong LingAo NPP. The assessment team owned experience of both domestic and international peer experts, reduced communication barrier in culture and language, and took advantages of both domestic and international peer reviews. Therefore, the assessment results were highly agreed by the evaluated NPPs.

Besides, Chinese NPPs accepted reviews of IAEA-OSART and peer review of WANO.

The assessment results showed that the evaluated NPPs were in good safety condition overally. At the same time, assessment activities helped the evaluated NPPs realize their difference with high level performance and determine the improving objective and standards to be reached.

4.5.3 Control Activities of Regulatory Body

The SEPA (NNSA) conducts strict control over all key points in siting, construction, commissioning, operation and decommissioning 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.

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 operating 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.

In recent three years, the SEPA (NNSA) monitored and reviewed PSR activities of Qinshan NPP and Guangdong Daya Bay NPP, finished the review of PSA report of Qinshan NPP and Guangdong Daya Bay NPP, fulfilled nuclear safety review and supervision of important projects including the application for the instrument of ratification for the first fuel loading of Jiangsu Tianwan NPP unit 1, completed review of reports related with safety analysis of siting and appraisal of environmental impact, and eventually granted relevant licenses(referred to chapter 3.3.2 for details). Besides, aiming at quality deficiencies in important nuclear safety equipments including steam generator and main pump that occurred in construction and commissioning stages of Jiangsu Tianwan NPP, the SEPA (NNSA) has organized Chinese and foreign experts to review and propose relevant corrective action requirements.

From 2004 to 2006, operating safety of in-service NPPs and construction quality of NPPs under construction in China were controlled effectively.

4.6 Radiation Protection

Each Contracting Party shall take the appropriate steps to ensure that in all operational states the radiation exposure to the workers and the public caused by a nuclear installation shall be kept as low as reasonably achievable and that no individual shall be exposed to radiation doses which exceed prescribed national dose limits.

4.6.1 Principled Requirement of Radiation Protection

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

(1) "Act of Prevention and Remedy of Radioactive 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 administrative 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 administrative environmental protection department of the State Council and local governments.

— The operating organizations should minimize the effluent of radioactive waste. The airborne and liquid effluents shall be below the state standard of protection and remedy of radioactive contamination, and the operating organization shall periodically report the effluents survey result to administrative environmental 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, all the critical approaches which lead to public exposure should be determined, and the influence on 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 “Principal 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 effective 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 principal requirements are defined in series regulations on siting, design, operation and the others by the regulatory body. The requirements are as follows:

— 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 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, establish 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 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 shall follow the principle of low probability of accident with high radiation dosage or high radioactive substance release, and no or little radiation consequence of high probability incidents.

(5) The related requirements on the effective 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 NPP shall be less than 0.25mSv.

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

— Times and duration of personnel working in radiation area in the design are minimized..

— 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 moving 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 operating 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 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 reinforcing the control of entrance to and exit from radiative area, strengthening the periodical test and maintenance of instrumentation to ensure that all instrumentation is kept in good condition, and performing the oxygenation operation of primary system during cooldown and depressurization.

Because most of radiation exposure of NPP staff mainly occurs in the period of refueling outage, NPPs have attached high importance to radiation protection activities. The above-mentioned measures have been applied and strengthened effectively during the refueling outage, such as following up major projects by special person, enhancing contamination control on site, preparing and implementing ALARA plan as well as strengthening boundary management of radiation protection, item transfer control, contamination control, site shielding, regional isolation and simulation exercise, etc. By strictly performing these measures, NPPs have guaranteed the boundary integrity of radiation control zone during the refueling outage, effectively controlled radioactive substance in the course of transfer and reduced exposure dose of operators.

4.6.3 Personnel Exposure Control

4.6.3.1 The Occupational Exposure

The survey of the occupational exposure shows that 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 Appendix 1.

4.6.3.2 Radiation Exposure of the Public

The environment monitoring centers of the province in which Chinese NPPs are located have performed the monitoring of the environment around NPPs. The results indicate that 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 plant operation. The survey data of nuclear plant 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 a 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 and the investigation range of the other items is 20km. The analyzing and measuring contents include the radiation level in the environment and the radioactive nuclides related to NPPs.

Before put 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 environmental protection regulations and environmental radiation monitoring standards, the NPPs effectively monitor and evaluate the environment according to their environmental monitoring programs.

Through monitoring and analysis of living organisms, air, soil and sea and others in the ambient background, it indicated that in the past three years, operating NPPs in China brought no bad influence to the surrounding environment..

(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 2004 to 2006 of Chinese NPPs is listed in Appendix2.

(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 NPPs have established a monitoring plan for environmental emergency submitted to the provincial environmental protection department before the trial operation of NPPs. 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 NPPs have 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 used.

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

The NPPs evaluate the dose equivalent imposed upon the general public and the impact on the environment in the normal operation and in the accident of NPPs 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 codes and guiding documents related to the radioactive waste management.

— To stipulate codes, 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 of radioactivity.

The radiation environmental monitoring stations set up by local environmental protection departments in each province independently monitor 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 environmental protection administrations, and evaluate the effects of the effluence on environment. The SEPA (NNSA) and local environmental 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.

In addition, from 2004 to 2006, the regulatory body performed the following important activities on the radioprotection:

— Closely paid attention to development trends of the relevant international codes and standards, integrated Chinese supervision and management practice on nuclear and radiation safety, continuously improved regulation system of nuclear and radiation safety, organized to compile the supporting regulations of "Act of Prevention and Remedy of Radioactivity Contamination of the People's Republic of China";

— Established Technology Center for Radioactive Environmental Monitoring of the SEPA (NNSA), Technology Center for Nuclear and Radiation Accident Emergency of the SEPA (NNSA) as well as 33 provincial and civic monitoring stations of radioactive environment, and preliminarily formed the national monitoring network of radioactive environment to ceaselessly enhance monitoring and supervision on surrounding environment and effluence of NPPs.

— Set up Northwest regional office and Northeast regional office to strengthen supervision and management of regional nuclear and radiation protection;

— Completed review of environmental impact assessment reports of new NPPs Projects.

4.7 Emergency Preparedness

1. Each Contracting Party shall take the appropriate steps to ensure that there are on-site and off-site emergency plans that are routinely tested for nuclear installations and cover the activities to be carried out in the event of an emergency.

For any new nuclear installation, such plans shall be prepared and tested before it commences operation above a low power level agreed by the regulatory body.

2. Each Contracting Party shall take the appropriate steps to ensure that, insofar as they are likely to be affected by a radiological emergency, its own population and the competent authorities of the States in the vicinity of the nuclear installation are provided with appropriate information for emergency planning and response.

3. Contracting Parties which do not have a nuclear installation on their territory, insofar as they are likely to be affected in the event of a radiological emergency at a nuclear installation in the vicinity, shall take the appropriate steps for the preparation and testing of emergency plans for their territory that cover the activities to be carried out in the event of such an emergency

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 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;

— 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. In 2005, Sichuan and Gansu provinces also set up the provincial nuclear emergency commissions respectively.

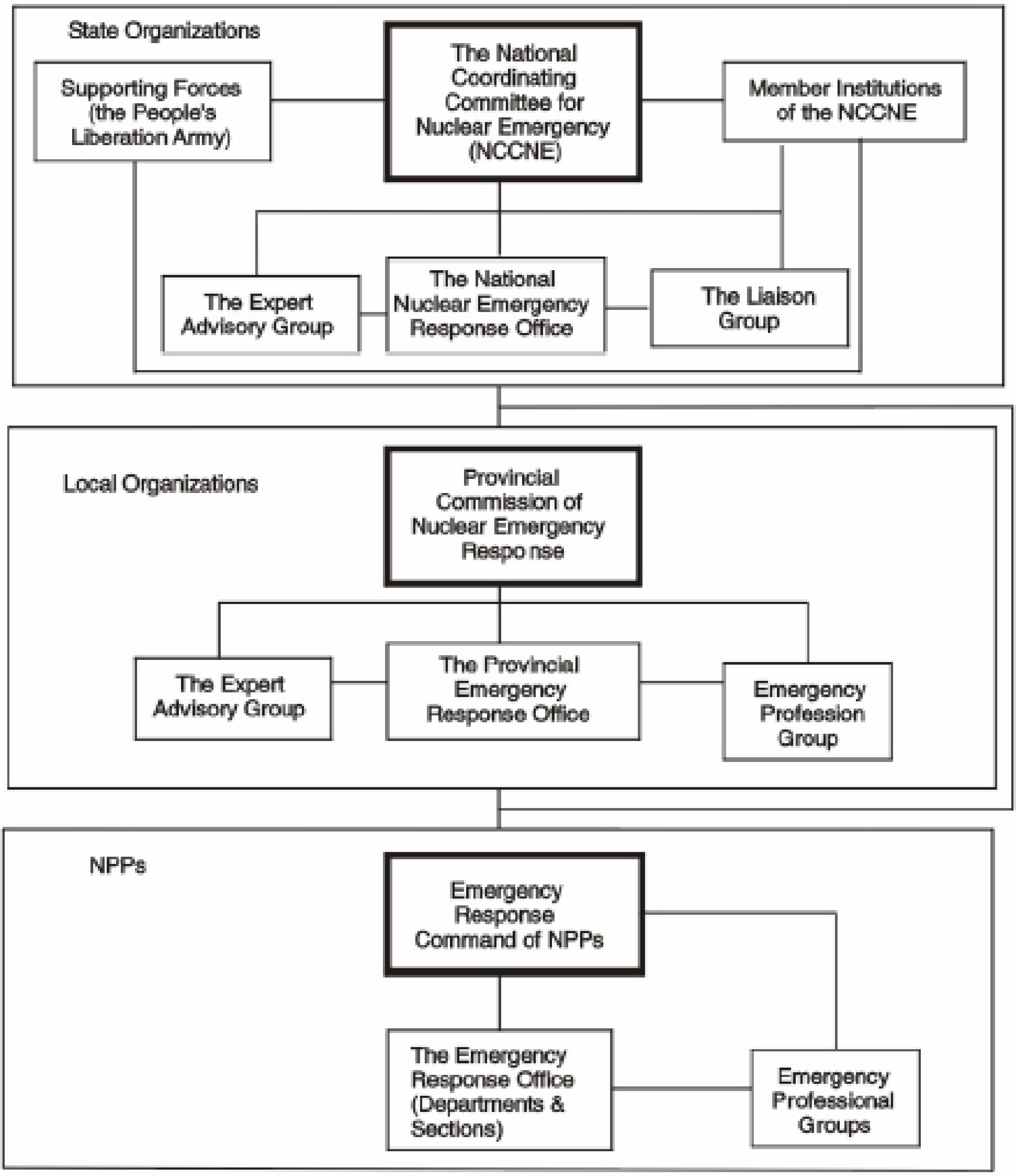

Figure 5 Organizational Structure of National Nuclear Emergency Response System

4.7.2.2 Classifying 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 are 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 at a higher level, 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 for 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 treatment, 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.

In accordance with the National Nuclear Emergency Response Plan issued in 2005, relevant departments, provinces and NPP operators compiled and improved their nuclear emergency plans and implementing procedures respectively.

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 with 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 at 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 third review meeting of the convention on nuclear safety:

(1) Comprehensive on-site emergency exercise before the first fuel loading was organized by Jiangsu Tianwan NPP on March 20, 2004;

(2) Comprehensive on-site emergency exercise was organized by Guangdong Daya Bay NPP on April 20, 2004;

(3) Comprehensive on-site emergency exercise was organized by Guangdong LingAo NPP together with French EDF on Sept.16, 2004;

(4) The first multi-reactor linked on-site and off-site emergency exercise was organized by Off-site Accident Emergency Committee of Zhejiang Provincial NPP and base of Qinshan NPP on Dec.17, 2004;

(5) From May 11 to May 12, 2005, China first took part in the international nuclear emergency exercise (CONVEX3-2005) organized by IAEA;

(6) Comprehensive on-site emergency exercise was organized by Guangdong Daya Bay NPP and Guangdong LingAo NPP on May 26, 2005;

(7) Comprehensive on-site emergency exercise was organized by Guangdong

Daya Bay NPP and Guangdong LingAo NPP together with French EDF on Sept.13, 2005;

(8) Comprehensive on-site emergency exercise was organized by base of Guangdong Daya Bay NPP on June 13, 2006;

(9) Comprehensive on-site emergency exercise was organized by Qinshan Phase III NPP on Sept.15, 2006;

(10) Comprehensive on-site emergency exercise was organized by base of Guangdong Daya Bay NPP on Oct.26, 2006;

(11) Comprehensive on-site emergency exercise was organized by Qinshan Phase II NPP on Oct.28, 2006;

(12) Comprehensive on-site emergency exercise was organized by Jiangsu Tianwan NPP on Nov.2, 2006;

(13) Comprehensive on-site emergency exercise was organized by Qinshan NPP on Nov.22, 2006.

Moreover, in accordance with nuclear emergency regulations, Chinese NPPs had performed many drills from 2004 to 2006.

4.7.4 Progress of Emergency Preparedness Activities

(1) Improve the emergency plans and strengthen legal construction

Chinese government attaches high importance to various emergency activities, including nuclear emergency. In May of 2005, the Chinese government approved the revised the "National Nuclear Emergency Response Plan", which clarifies responsibilities and interfaces among different organizations. Member organizations of the NCCNE made the corresponding emergency plans, integrating their own responsibilities; the State Council Information Office of the People's Republic of China perfected information release mechanism of unexpected events including nuclear emergency; China Meteorological Administration revised the "National Meteorological Guarantee Response Plan for the National Nuclear Emergency"; Ministry of Information Industry of the People's Republic of China established "Emergency Response Plan for the National Communications Guarantee", in which nuclear emergency is included. People's governments of Jiangsu, Zhejiang and Guangdong provinces as well as nuclear power bases within their administrative areas also have revised or compiled nuclear emergency response plan and implementing procedures. In addition, the Chinese government is conducting revision activities of regulations related with nuclear emergency.

(2) Promote emergency ability by right of technological advancement

Scientific research on nuclear emergency has gained achievements in the domain of accident source analysis, radiation monitoring, aerial radiation monitoring, meteorology guarantee, accident result evaluation, emergency decision-making support, social psychological relief study and recovery of radiation harmed personnel etc, and further optimized Chinese technical support system of nuclear emergency.

(3) Boost the platform construction and enhance commanding ability

The National Nuclear Emergency Response Center was established and put into operation, followed which the following ones were also put into operation successively: relevant departments responsible for public security, sanitation, environmental protection, meteorological monitoring, transportation, information and army as well as NPP operators and nuclear emergency commanding and response facilities. Based on the national nuclear emergency commanding platform, commanding centers at different level are building or improving software platform, and intercommunion of nuclear emergency information is being implemented step by step. Many technical support centers or professional rescue teams are set up relying on existing scientific research institutes, hospitals and army by means of properly strengthening their current condition.

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 that nuclear accidents result 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. In May of 2005, China participated in the international nuclear emergency exercise organized by the IAEA for the first time, of which the participants included eight organizations of international inter-government and more than 50 countries. In November of 2006, China participated in the Annual Nuclear Emergency Exercise 2006 organized by IAEA again.

4.8 International Cooperation on Nuclear Safety

Chinese government pays great importance to 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, signing agreements for sister plants with the foreign NPPs, which adopted similar reactor type or technologies, 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 have been developed fruitfully in order to stimulate the improvement of nuclear safety regulatory level and ensure the operational safety of NPPs:

— In September of 2004, Chinese government invited experts of IAEA to carry out International Assessment on Radioactive Safety Infrastructure to the SEPA (NNSA) for the first time（RaSIA）.

— From November 23rd to December 3rd 2004, the IAEA carried out the follow-up review of International Regulatory Review Team (IRRT) to the SEPA (NNSA), and assessed the improvement progress proposed at the assessment in 2000.

— On April 29th 2006, Standing Committee of National People's Congress discussed and approved China to join in "Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management"(the "Joint Convention"), in May of 2006, Chinese government delegation participated in the second convention meeting of the contracting party.

— Chinese government keeps fruitful cooperation with the IAEA on nuclear safety continuously, entirely participates in the activities organized by IAEA and actively develops cooperation on nuclear safety code and standard, nuclear fuel cycle and management of radioactive waste and such aspects. In October of 2004, cooperating with the IAEA, Chinese government successfully co-organized the international meeting on safety of nuclear installations.

— Chinese government has further strengthened the bilateral and multilateral cooperation on nuclear safety with many countries, such as the US, France, Russia, Canada, Japan, South Korea, Pakistan and so on, developed cooperation at different level through various methods, such as high-profile visit, information communication and personnel training.

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

5. SAFETY OF NUCLEAR POWER PLANTs

5.1 Siting

Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented:

（i） for evaluating all relevant site-related factors likely to affect the safety of a nuclear installation for its projected lifetime;

（ii） for evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment;

（iii） for re-evaluating as necessary all relevant factors referred to in sub-paragraphs (i) and (ii) so as to ensure the continued safety acceptability of the nuclear installation;

（iv） for consulting Contracting Parties in the vicinity of a proposed nuclear installation, insofar as they are likely to be affected by that installation and, upon request providing the necessary information to such Contracting Parties, in order to enable them to evaluate and make their own assessment of the likely safety impact on their own territory of the nuclear installation.

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 Annex 3).

5.1.2 Licensing Process of Siting

According to the regulations of "Act of Prevention and Remedy of Radioactivity Contamination of the People's Republic of China", the siting of nuclear installations shall be carried through scientific demonstration and handled procedures of review and approval according to relevant national regulations. Before handling the review and approval procedures of siting nuclear installations, the report of environment impact shall be compiled, and reported to the SEPA (NNSA) for review and approval.

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 Defining 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 safety 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 methods are adopted to establish the design basis for natural events for some important natural phenomena. The methods 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 method shall 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 Defining 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 method is adopted for defining the design basis for man-induced events. The method 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 Impact 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 by which 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 Plan

(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 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 peripheral zone around a proposed site should be established in view of the potential radiation consequences to the public and the capability of implementing emergency response plans as well as any effect of external events which may hinder implementation of emergency response plan. Before starting construction of the NPP, it shall be affirmed that no basic problems exist in the peripheral 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 specific site 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 expected lifetime have been evaluated by the applicant.

5.1.4.1 Natural Events Affecting the NPPs 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 NPPs 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 that may cause 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 Continuous Monitoring Activities Related to the Siting

The system of radioactive contamination monitoring has been established in China according to the requirements in "Laws on the Environmental 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 safety operation of NPP. The SEPA (NNSA) is responsible for performing continuous supervisory 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 NPPs.

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 NPPs.

5.2 Design and Construction

Each Contracting Party shall take the appropriate steps to ensure that:

（i） the design and construction of a nuclear installation provides for several reliable levels and methods of protection (defense in depth) against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigating their radiological consequences should they occur;

（ii） the technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis;

（iii） the design of a nuclear installation allows for reliable, stable and easily manageable operation, with specific consideration of human factors and the human-machine interface.

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 have been established by the SEPA (NNSA), see Annex 3.

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 comply with the requirements of regulations on nuclear safety of China. If there are no such standards and specifications in China, the standards and specifications adopted 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 SEPA (NNSA) revised the "Code on the Safety of the Nuclear Power Plant Design" and implemented it in April of 2004. The new regulation clearly specified the safety objectives, safety management requirements, technical requirements and design requirements.

The nuclear safety objectives in the "Code on the Safety of the Nuclear Power Plant Design" are as follows:

Establish and keep effective defense to radioactive harm in NPP, so as to prevent personnel, society and environment from being harmed. The general nuclear safety objective is supported by radioprotection objective and technical safety objective, and these two objectives are supplement to each other. The technical measures and administrative and procedural measures work together to guarantee the defense of ionization radioactive harm.

The safety management requirements in the "Code on the Safety of Nuclear Power Plant Design" are as follows:

(1) Management responsibility

All responsibilities for safety are undertaken by the operating organization. Safety affairs shall be put at the top priority by all units engaged in safety important activities.

(2) Design management

The necessary reliability of SSCs shall be ensured to guarantee that the safety function of NPP is performed and NPP operates safely during its designed lifetime, and to prevent the occurrence of accidents to protect the site personnel, the general public and the environment.

(3) Verified project practice

If possible, the SSCs shall be designed based on the latest authorized or currently applicable standards and specifications; its design shall be verified before under the equivalent use condition, and the selection of these items shall accord with the reliability objective of NPP required by safety.

When unverified design or installations are introduced, or the design or installations deviate the existing project practice, their safety shall be proved reasonable by right of appropriate backup research plan or by checking operating experience obtained from other relevant applications.

(4) Operating experience and safety research

The results of relevant operating experience and research obtained from the operating NPP shall be given fully consideration.

(5) Safety assessment

The safety assessment shall be made comprehensively on design, so as to prove the design of manufacture, construction and completion delivered satisfies the safety requirements purposed at the beginning of the design.

(6) Independent verification of safety assessment

Before submitted to the National Nuclear Safety Supervision Department, the design shall be guaranteed by the operating organization to be verified independently by individuals or groups that have not participated in the relevant design.

(7) Quality assurance

The quality assurance programme, which specifies general arrangement of management, implementation and assessment of NPP design, shall be worked out and implemented. This programme shall be supported by more detailed plans of every SSC, so as to ensure the quality of design all the time.

The main technical requirements in the "Code on the Safety of Nuclear Power Plant Design" are as follows:

(1) Defense-in-depth

The concept of defense-in-depth is implemented in all safety-related activities, including related aspects with organization, personnel behavior and design, so as to provide a series of multi-level preventive measures, such as the inherent safety characteristic, equipment and procedures and so on, to prevent accident occurrence or provide appropriate protection when failing to prevent the accident occurrence. For details see the requirements of defense-in-depth in Section 5.2.3.

(2) Safety function

The following basic safety functions shall be implemented under any operating status and during and after the design basis accidents, or under the accident situation of selected beyond design basis accident:

— Reactivity control

— Heat removal from the reactor core

— Radioactive substance containment, operation discharge control and, accident release limiting.

(3) Accident prevention and safety characteristic of NPP

The design of NPP shall minimize the sensitivity of anticipated operational occurrence. Expected response to any anticipated operational occurrence shall be the following reasonably achieved situations (in order of importance) :

— Rely on the inherent characteristic of NPP to enable the anticipated operational occurrence not to cause safety-related impacts or only enable NPP to change towards safety status;

— Rely on the function of passive safety facilities or safety system operating continuously under this status in order to control this occurrence and enable NPP tend to safety when the anticipated operational occurrence happens;

— Rely on functions of safety system which shall be put into operation for the sake of response to this occurrence to make NPP tend to safety, when the anticipated operational occurrence happens;

— Rely on special procedures to make NPP tend to safety when the anticipated operational occurrence happens.

(4) Radiation protection

The design shall take the prevention or mitigation (when out of control) of radioactive exposure caused by design basis accident and selected serious accident as its objective. Measures shall be adopted to guarantee radioactive dose which may be received by the public and site personnel do not exceed the acceptable limits and reduce it as low as reasonably achieved. Probability of the NPP status, which may cause high radioactive dose or radioactive release, shall be controlled low, and NPP status with high occurring probability should be guaranteed to cause tiny potential radioactive result.

The main design requirements in the "Code on the Safety of Nuclear Power Plant Design" are as follows:

(1) Safety classification

All safety important SSCs shall be confirmed, including meter and control software, then classified according to the safe function and safe importance. Its design, construction and maintenance shall enable its quality and reliability consistent with such classification.

(2) General design basis

The necessary capability of NPP shall be specified in the design basis, so as to adapt the confirmed operation status and design basis accident within the prescribed radioprotection requirement. The design basis shall contain the technical specification of normal operation, NPP status, safety classification and important assumption caused by anticipated operational occurrences together with special analysis methods at certain situations. Besides design basis, the design shall take into account the specific accidents beyond the design basis, including behaviors in the selected severe accidents.

(3) Reliability design of SSCs

Consider the malfunction of common factor, apply single malfunction standards, and adopt methods such as malfunction safety design to guarantee important safety items such as SSCs can endure all confirmed anticipated operational occurrences with sufficient reliability.

(4) Measures for in-service test, maintenance, repair, inspection and monitoring

In order to maintain the ability of implementing function of safety important SSCs, its design shall satisfy calibration, test, maintenance, repair or replacement, inspection and examination within the lifetime of NPP, to prove the satisfaction of reliability objective.

(5) Equipment qualification

The procedure of equipment qualification shall be adopted to affirm the safety important items can satisfy the requirement of implementation of safety function under the condition (such as vibration, temperature, pressure, impact of jet stream, electromagnetic interfering, radiation exposure, humidity and any possible combination of these factors) needed in the design and operation lifetime.

(6) Aging

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

(7) Design for optimizing operator performance

The working place and environment for site personnel shall be designed according to principles of human-machine engineering.

The human factor and human-machine interface shall be considered systematically at the beginning of the design, and carried through the entire process of design.

The design of human-machine interface shall be "friendly" to operators, and takes the limitation of man-made error as the objective. The human-machine interface shall be designed to not only provide complete and tractable information, but also comply with the time needed in making decision and adopting action.

(8) Safety analysis

The safety analysis shall be carried out to NPP and the analysis method of deterministic theory and probability theory shall be used. The nuclear power plant designed through safety analysis and argumentation shall meet all regulatory limits of various NPP status under radioactive release and the potential acceptable limits of radioactive dose, and demonstrate that the defense-in-depth makes sense.

(9) Other design considerations

The design code also specified many requirements on aspects such as SSCs, nuclear fuel and radioactive waste transport, package, evacuation route and communication manner as well as entrance and exit control of NPP and its decommissioning for the multi-reactor.

In addition, the "Code on the Safety of Nuclear Power Plant Design" has specified design of important NPP systems such as reactor core, reactor coolant system and containment I&C system, emergency control, emergency diesel generator and radiation protection.

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 for on site 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 "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 defense-in-depth is a basic principle for fulfillment of nuclear safety. The concept of defense-in-depth is implemented in all safety-related activities, including related aspects with organization, personnel behavior and design, so as to guarantee these activities are placed under the defense of overlapping measures, even if one kind of malfunction happens, it will be detected, compensated or corrected by appropriate measures.

Chinese NPPs have carried through the concept of defense-in-depth in the entire design, which embodies in the following aspects:

— Provide multiple physical barrier to prevent the radioactive substance from releasing to the environment without control;

— Conservatively design NPP and construct and operate it with high quality, so as to guarantee a minimal probability of malfunction and abnormal operation in NPP;

— Control the behavior of NPP during and after the anticipated operational occurrence by using inherent characteristic and specific safety facilities, try to minimize transient process without control, or even exclude it.

— Provide extra controls to NPP, these controls adopt automatic spring of safety system, so as to reduce the operator's interference at the early stage of anticipated operational occurrence;

— Provide equipment and procedures to control the development of accident and limits its result;

— Provide multi-means to guarantee each basic safety function to be fulfilled, that is, reactivity control, heat discharge and radioactive substances containing, so as to guarantee the effectiveness of every barrier and mitigate the result of anticipated operational occurrence.

In order to carry through the concept of defense-in-depth, Chinese NPPs try to prevent the following situations as reasonably as possible in design:

— The occurrence of affecting the integrality of barrier;

— The barrier loses its function when it is needed;

— Function failure of one barrier is caused by that of another barrier.

It is a basic requirement that every defense layer is prepared one by one according to different operation manners at any time. Continuous operation is no longer appropriate if one layer is lack.

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 purpose of the first layer defense is to prevent offsetting from normal operation and prevent function failure of the system. In order to obtain this purpose, Chinese NPPs have adopted the following measures in design:

— Adequate attention is paid to all aspects of quality, such as the selection of materials, specifications, the use of construction and operating 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) 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 Measures against Accident Prevention and Mitigation

5.2.4.1 Measures against Accident Prevention

Chinese NPPs mainly rely on conservative design, improving the reliability of system and equipment together with reasonable operating practice to prevent malfunction, rely on the quality assurance to check up whether the design purpose was achieved, and rely on monitoring to discover performance degradation or early malfunction and rely on certain measures to guarantee tiny trouble or that early malfunction will not become much more serious. Therefore, the following factors should be considered:

— 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 operating 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 against Accident Mitigation

Measures against 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 against Severe Accidents

(1) Requirements to the newly-built NPP

In April of 2004, the SEPA (NNSA) promulgated the amended "Code on the Safety of Nuclear Power Plant Design", which stipulated that countermeasures against severe accidents shall be considered in the design of newly-built NPPs.

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 operating 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 safety 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 shall 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) Design and design improvement of Chinese NPPs

On the basis of completely absorbing the experience related with design, construction, commissioning and operation of unit 1 and unit 2, unit 3 and unit 4 of Qinshan Phase II NPP have made 12 items of important improvement in design, such as the adoption of new type of AFA3G fuel assembly and digital I&C system, adding measure against hydrogen elimination under the situation beyond design basis accident and anti-boron mis-dilution and so on.

Unit 3 and unit 4 of Guangdong LingAo NPP referred to its unit 1 and unit 2 and carried out many technical improvements, of which there are 13 items of important improvement related with safety, including the adoption of advanced AFA3G fuel assembly, the adoption of integral forge piece in the active section of reactor core of reactor pressure vessel, extension of pressure relief function of pressurizer and so on.

Jiangsu Tianwan NPP imported from Russia is a WWER-1000 PWR which adopts mature technologies. According to the operating 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) During the past three years, the SEPA (NNSA) mainly regulated the following activities to the construction license of NPP, letter of ratification for the first fuel loading of NPP, design qualification certificate of nuclear pressure retaining components, qualification certificate of construction and qualification certificate of

installation:

— Organized and completed the review of conditions of the first fuel loading to unit 1 of Tianwan NPP, and issued the letter of ratification of the first fuel loading in October of 2005.

— Organized and completed the nuclear safety review of construction license application documents of unit 3 and unit 4 of Guangdong LingAo NPP, and issued the construction license in December of 2005.

— Organized and completed the nuclear safety review of construction license application documents of unit 3 and unit 4 of Qinshan Phase II NPP, and issued the construction license in January of 2006.

— Established reporting system for qualification licensee of civilian nuclear pressure retaining components; organized and completed survey to the 24 qualification licensees of civilian nuclear pressure retaining components, and gave 9 licensees notifications for correction within a specified time, and then ceased the qualification certificates of 2 licensees according to the situations of correction results.

(2) During the past three years, the SEPA (NNSA) has organized and completed the supervision of important project activities, important inconformity items and nuclear safety incidents to Qinshan Phase II NPP, Jiangsu Tianwan NPP and Guangdong LingAo NPP at the design and construction phases.

5.3 OPERATION

Each Contracting Party shall take the appropriate steps to ensure that:

(i) ***the initial authorization to operate a nuclear installation is based upon an appropriate safety analysis and a commissioning programme demonstrating that the installation, as constructed, is consistent with design and safety requirements;***

(ii) ***operational limits and conditions derived from the safety analysis, tests and operational experience are defined and revised as necessary for identifying safe boundaries for operation;***

(iii) ***operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures;***

(iv) ***procedures are established for responding to anticipated operational occurrences and to accidents;***

(v) ***necessary engineering and technical support in all safety-related fields is available throughout the lifetime of a nuclear installation;***

(vi) ***incidents significant to safety are reported in a timely manner by the holder of the relevant licence to the regulatory body;***

(vii) ***programmes to collect and analyse operating experience are established, the results obtained and the conclusions drawn are acted upon and that existing mechanisms are used to share important experience with international bodies and with other operating organizations and regulatory bodies;***

(viii) ***the generation of radioactive waste resulting from the operation of a nuclear installation is kept to the minimum practicable for the process concerned, both in activity and in volume, and any necessary treatment and storage of spent fuel and waste directly related to the operation and on the same site as that of the nuclear installation take into consideration conditioning and disposal.***

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 operating experience of years has proven that the formulated operational regulations and guides basically meet the actual operational needs.

In 2004, the SEPA referred to the nuclear safety standards of IAEA and amended the "Code on the Safety of Nuclear Power Plant Operation"; its basic requirements established are as follows:

(1) Operating organization of the NPP

As the license holder, the operating organization shall undertake all responsibilities for the safety operation of NPP. The organization structure and responsibilities shall be clearly specified, the competent management and sufficient qualified personnel shall be arranged. In order to guarantee safety operation, mitigate accident result and make correct response to the emergency status under any operation state of the NPP, the post responsibility, authorization level and liaison channel inside and outside shall be definitely prescribed.

In addition, the code has also specified definitely requirements to operating organizations in aspects of experience feedback, emergency preparation, quality assurance, practicality protection and fire protection safety operation and so on.

(2) Training and qualification of personnel

The operating organization shall define the qualification and experience necessary for personnel performing duties that may affect safety. Suitable qualified personnel shall be selected and given the necessary training and instruction to enable them to perform their duties correctly for the different operating status of the plant and in the event of an accident, in accordance with the appropriate operating or emergency procedures.

(3) Commissioning of NPP

Detailed commissioning programme and quality assurance programme, which specify the implementation and report responsibility, shall be established, the commissioning programme shall be approved by National Nuclear Safety Supervision Department. After the National Nuclear Safety Supervision Department ratified the first fuel loading, the operating organization can load nuclear fuel into reactor core for the first time, and carry out the NPP commissioning with nuclear fuel. The operating organization could carry through commissioning of the next phase only after finishing appraisal and inspection to the results of former phase's commissioning, fulfilling all goals and meeting all the management requirements of nuclear safety.

(4) Operational limits and conditions

Operating organization of NPP shall establish operational limits and conditions technologically and in management. The operational limits and conditions shall reflect the final design and be submitted to the National Nuclear Safety Supervision Department for assessment and approval before the operation of NPP. The operational limits and conditions shall contain the requirements for different operating status (including the reactor scram)

The operational limits and conditions shall form an important part of the basis on which the operation organization is authorized to operate the plant. The operators directly responsible for the operation shall be thoroughly familiar with the intent and content of the operational limits and conditions in order to comply with the provisions contained therein.

(5) Operating instructions and procedures

A comprehensive administrative procedure shall be established by NPP which contains the rules for the formulation, improvement, demonstration, acceptance, modification and withdrawal of operating instructions and procedures (hereinafter referred as "procedures").

Before the operation, operating organization of NPP shall establish operating procedures which are completely suitable for normal operation, anticipated operation incidents and accidents, in accordance with the policy of the operating organization and the requirements of the National Nuclear Safety Supervision Department.

A periodic review to the whole procedures shall be made. Any modification shall be informed to operators and holders of these files. The modification shall be according to the procedures of written instructions, and it only takes effect after approved by the authorized personnel. The operators shall have full knowledge for the procedures and their modified aspects.

Otherwise specified in the procedures, the operators cannot modify actual configuration of NPP (including the temporary modification) before receiving written instruction from the authorized personnel. This modification could deviate operational limits and conditions under no circumstance.

(6) Reactor core management and fuel handling

The operating organization shall be responsible and shall make arrangements for all the activities associated with reactor core management and on-site fuel handling in order to ensure the safe use of the fuel in the reactor and safety in its movement and storage on the site.

Management procedures of fuel and reactor core internals including the removal of new and used fuel, storage on the site and preparation for dispatch from the site, shall be established. Package, transportation and dispatch of the new and used fuel shall accord with related national codes and applicable international regulations

(7) Maintenance, test, surveillance and inspection

The operating organization shall prepare and implement a programme of maintenance, testing, surveillance and inspection of those SSCs. This programme shall take into account operational limits and conditions as well as any other applicable regulatory requirements and it shall be re-evaluated in the light of operating experience.

(8) Modification

Proposed modification to SSCs, which affect the bases on which the operating license was issued, to the operational limits and conditions, and to procedures and other documents originally approved by the National Nuclear Safety Supervision Department shall be submitted to SEPA(NNSA) for prior approval.

(9) Radiation protection

The operating organization of NPP shall work out and implement programme of radiation protection. The verification of correct implementation and fulfillment of the goal of radiological protection programme shall be carried out through supervision, review and inspection. The correction measures shall be adopted if necessary.

(10) Radioactive waste management

The operating organization of NPP shall establish and implement programme of radioactive waste management. The limit volume of effluent shall be established, and the discharge methods and procedures shall be monitored and controlled, so as to make discharge accord with regulations. The operating organization shall perform a safety analysis for radioactive discharges which demonstrates that the assessed radiological impacts and doses to the general public are kept as low as reasonably achievable.

(11) Periodic Safety Review (PSR)

Systematic safety reassessments of the plant in accordance with the regulatory requirements shall be performed by the operating organization throughout its operational lifetime. The scope of the PSR shall cover all safety aspects of an operational NPP, including emergency plan, accident management and radiological protection.

In addition, the newly-amended "Code on the Safety of Nuclear Power Plant Operation" has also made relevant regulations on records, reports and decommissioning of NPP and so on.

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 operating 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 safety operation of nuclear power plant. In the meantime, the opportunities are provided for the operating 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 2004 to 2006, Jiangsu Tianwan NPP has performed commissioning to two units. According to the following files, the SEPA (NNSA) implements effective safety supervision to NPP:

— "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 SEPA (NNSA) has carried out effective supervision to NPP, and authorized unit 1 of Jiangsu Tianwan NPP to load fuel after a series of safety review and site inspection. On October 18th of 2005, unit 1 began fuel loading for the first time, on May 12th of 2006, it connected to grid for the first time.

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).

5.3.3.3 Program of Operation, Maintenance, Inspection and Test of NPP

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.

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 operating experience. The programs of the maintenance, test, verification and inspection satisfy the operation limits and conditions, as well as the available regulatory requirements of nuclear safety.

Prior to the maintenance, test 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, test 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 2004 to 2006, except for the activities on safety operation, maintenance and periodic test, Chinese operational NPP has also made efforts as follows:

— Actively explore Reliability-centered Maintenance Technology（RCM）and Technology-centered I&C Maintenance Technology（TCM）, meanwhile, strengthen the management of crucial sensitive equipment which can directly cause turbine and reactor trip (CCM).

— Actively promote the work of equipment aging and lifetime management, work out the layout of aging and lifetime management, establish aging and lifetime management programmes and improve the system of aging and lifetime management system. Reinforce the inspection of key equipments, improve the reliability of units and optimize the scope and period of maintenance after systematic aging analysis.

— Conduct screening and key supervision to high risk activities, improve the effectiveness and practicability of site safety supervision management, reduce and eliminate all kinds of procedure violation, so as to prevent the happening of personnel hurt and equipment damage.

— Aiming at the outage, set performance indicator and implement goal management. The set performance indicator of outage involves nuclear safety, radiological protection, industry safety and fire protection, quality control, management of three wastes, planning management, management of examination and repair, operation and equipment management and such important aspects.

5.3.3.4 Management of the Design Modifications and the Equipment Transformations of the Operating NPP

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 always paid much attention to the technical innovation of system and equipment. Since 2004, it has continuously upgraded some items such as relay protection system for electricity power service, electrical system of emergency diesel oil generator and generator excitation system. The two important technical modification programs, that is, "replacing of pressure vessel closure head and relevant components system" and "I&C comprehensive modification（reactor protection and relevant equipments）", have also made essential progress, and their upgradation is expected to be completed in 2007.

The Guangdong Daya Bay NPP has completed ten-year outage on schedule, the chief achievements of which are: improvement of preventing mis-dilution, bareness of reactor core and refueling machine and so on.

The other operational NPPs of China have also made necessary improvement on design according to operating experience feedback and guarantee safe and stable operation of NPP through the continuous technical improvement.

5.3.3.5 Accident Response Procedures

The NPP has worked out relevant response procedures on anticipated operation events and accidents, tried to verify accident procedure at full scope simulator and/or on site, and performed training to operators.

At present, the accident response procedures chiefly include two kinds of methods: incident-oriented method and symptom-oriented method.

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 method 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).

Qinshan Phase II NPP and Qinshan Phase III NPP have amended their accident procedures respectively.

According to upgradation of NPP system, research results of PSR and PSA, operating experience of accident procedures and research on accident evolvement, Chinese NPPs actively followed the international development to assess and modified accident procedures.

With active researches and development on severe accident countermeasures, on the basis of PSA work, combining relevant safety research and practice of NPPs of the same kind, Chinese NPPs determined the order of chief events which may cause serious accidents, adopted necessary prevention and mitigation measures on the reasonable and feasible basis, and explore management guideline of serious accidents.

5.3.3.6 Project 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 shall 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 safety 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 safety 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).

Except the above-mentioned accidents which need to be reported to nuclear safety supervision departments and nuclear departments in charge, Chinese NPPs should submit relevant accident reports to IAEA and WANO according to the requirements and guideline of accident report of IAEA and WANO.

The statistics of operational events of Chinese nuclear power plants from 2004 to 2006 are listed in Appendix 3.

5.3.3.8 Operating Experience Feedback

The plan for collecting and analyzing the operating 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 operating experience feedback in China is put on the experience feedback of NPP operating organizations and its utilization. The main objectives of the operating 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 operating 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.

From 2004 to 2006, under the support of every NPP, Nuclear Operating Experience Exchange Committee of NPP has established the database of Chinese NPPs operation occurrence, which has sorted out the important occurrences of all operating NPPs and formed the information bank of nuclear industry, shared through the inner website. Meanwhile, the Committee has analyzed the three years' operation occurrences and internal occurrences from 2003 to 2005, found out the common issues which deserve attention of all NPPs, chosen typical occurrences and analyzed in detail, and then formed the first "Operating Experience Feedback Report of Chinese Nuclear Power Plants from 2003 to 2005" and published within the industry.

(2) Operating experience exchanges among nuclear power plants

Chinese six NPPs shall fulfill experience exchange activities of operation periodically every year according to their agreement. Moreover, the NPPs often held activities of various specific experience exchanges, inviting relevant research institutions to join in and strengthening the experience feedback with design organization.

Form 2004 to 2006, aiming at the common issues, the Chinese NPPs have mainly developed the following inter-plant experience exchange activities:

— Workshop on root cause analysis of NPP's incident;

— Workshop on industrial safety of NPP;

— Workshop on SAT of NPP;

— Workshop on Performance Indicators newly published by WANO ;

— Workshop on experience feedback training of NPP;

— Workshop on existent problems of NPP's seawater system;

— Workshop on corrective action, recommended by SOER/SER of WANO;

— Workshop on WANO Peer Review PO&Cs.

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 operating 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, exchange visiting and bench marking under WANO;

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

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

In addition, the Chinese NPPs have organized or participated in activities of sub-groups of IAEA Asian Nuclear Safety Network (ANSN), IAEA PRIS/IRS and other relevant activities.

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

Through various approaches, China has collected, screened and analyzed internal and external operating 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 operating experience information by various ways

In order to spread, generalize and utilize all kinds of operating experience information timely and effectively, each plant propagates the information on operating 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 operating experience in the routine jobs

Important experience and lessons are drawn from the discussion of the relevant operating 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 operating experience to training and examination

The operating 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 operating experience propaganda, hence the training quality and the personnel initiative to participate in prevention of accidents are enhanced.

Besides above activities of operating experience exchange, in order to achieve a broader exchange and share of the operating experience and information, the national nuclear safety regulatory body and the nuclear industry administration have made continual efforts to promote the operating 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 operating 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 operating experience exchange in the nuclear industry.

— Positively promoting the establishment of the system for operating experience exchange for NPPs under construction.

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 management of the Operators

The "Application and Issuance of NPP's Safety License", the detailed rules for implementation of "Safety Regulations on Civilian Nuclear Installations" prescribed that those who hold the Reactor Operator License or the Senior Reactor Operator License of the People's Republic of China can operate the reactor control system of NPP, the validity period of the license is two years; if the operator leaves this post for more than six months, his license will be expired automatically. In addition, the detailed rules for implementation of "Issuance and Management Procedures of Operator License of Nuclear Power Plants" have made definite requirements to the issuance and management of operator's license.

— According to the requirement of nuclear safety regulations, the nuclear departments in charge issued "License Management Methods for Nuclear Power Plant Operators" and "License Examination Rules for Nuclear Power Plant Operators", organized experts to constitute and issue the "Standards for License Examination of Nuclear Power Plant Operators", which has further specified the activities of assessment and license management of NPP operators. In addition, Ministry of Health of the People's Republic of China issued the "Specification of Health Standards and Medical Surveillance for Nuclear Power Plant Operators" in December of 2004, which definitely specified the health requirements for operators and specific requirements for medical surveillance to operators.

The operators of nuclear power plants shall receive strict training, and shall 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 2006 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 third 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 in the design, construction, operation, and management of NPPs. In order to make the Nuclear Safety Regulation System accord with the actual situation of China and learn domestic and foreign good practice timely, the revision and improvement of nuclear safety regulations have been listed in the routine plan.

From 2004 to 2006, the issued and emendatory laws and regulations on nuclear safety included "Code on the Safety of Nuclear Power Plant: Design" and "Code on the Safety of Nuclear Power Plant: Operation"; the recently published nuclear safety guides include "Safe and Important System Software of Nuclear Power Plant Based on Computer, Safety assessment and Verification for NPP", "Fire Protection Safety of Nuclear Power Plant Operation", "Organization and Safety Operation Management of Nuclear Power Plant Operating Organization" and so on, see 3.1.3 for details. Other regulations and guides on nuclear safety are planed to be or being amended and perfected.

China will further enhance the specific legislation on nuclear safety, and is establishing "Regulation on Supervision and Management of Civilian Nuclear Safety Equipments" and the "Compensation Regulation of Nuclear Damage".

The legislation on "Atomic Energy Act" has achieved some progresses.

6.2 Enhancement of Nuclear Safety Surveillance

Aiming at surveillance of present situation of China's multi-reactor types and multi-national technique, the SEPA (NNSA) has adopted the following measures:

（1） Enhance surveillance in accordance with the law

Continuously perfect the establishment of law and code of nuclear safety, on the basis of several years' practice, the SEPA (NNSA) and its technical support unit have established interior quality assurance system of nuclear safety supervision and management institute by referring to international practice and the safety standard of IAEA, which can guarantee the effectiveness of nuclear safety supervision and management.

（2） Further improvement of regulatory capabilities

The northwest and northeast surveillance stations of nuclear and radiation safety are added to adapt the development of Chinese nuclear power. Up to now, we have established six surveillance stations of nuclear and radiation safety performed as the dispatching institutions for nuclear safety regulation, and matched with competent human resources. The committee of safety and environmental experts of SEPA act as the expert decision-making &consultancy of nuclear safety and environment, the technical support unit such as safety centers of nuclear and radiation safety of SEPA provides relevant technical support to nuclear safety regulation, which enables a further strengthening of china's nuclear safety regulatory ability.

（3） Enhance regulation to the license holder for nuclear facility

Strengthen the qualification review to the license holder, improve the original review model, establish the review system of presiding unit, and increase the consultation and consideration sections of expert committee and so on. Strengthen the surveillance and review for manufacture and installation of nuclear equipment. Meanwhile, we are establishing Regulation on Supervision and Management of Civilian Nuclear Safety Equipments to implement the supervision and management for design, manufacture, installation, no-destructive test of civilian nuclear safety equipment..

6.3 Perfection of Nuclear Emergency Response System and Improvement of Emergency Response Capabilities

The "National Nuclear Emergency Response Plan" enacted by the Chinese government in May of 2005 has made a unified arrangement to Chinese nuclear emergency and created condition for further improvement of nuclear emergency management capability in NPP. Meanwhile, Zhejiang, Guangdong and Jiangsu provinces had built provincial nuclear emergency system for NPP, on the basis of which Sichuan and Gansu provinces succeeded to establish such system. In May of 2005, the Chinese government first took part in the international nuclear emergency exercise organized by the IAEA, through this exercise, China's capability for emergency preparation and response has been reviewed.

By combining the requirements of development of nuclear emergency work, the Chinese government is planning to amend the "Regulations on Emergency Measures for Nuclear Accidents of Nuclear Power Plants".

6.4 Use of PSA in Operating NPPs

The SEPA (NNSA) is zealously promoting the application of PSA in the operating NPP. Since 2004, the tracking and assessment of risk, risk of NPPs' operational status, risk analysis of project reforming and risk analysis of safety important items of NPPs' operating status and such aspects have provided effective technical support for safety operation management of NPPs. The PSA technology has been used in technical improvement and the maintenance of safety equipment by some NPPs. The PSA has brought positive function in improving the safety operation management of NPPs.

6.5 Human resources

In order to meet the requirements of Chinese nuclear power development, Chinese government has strengthened the cultivation of human resources on nuclear safety surveillance and nuclear power construction. In March of 2005, the SEPA (NNSA) and Tsinghua University signed an agreement for joint education of master on radioactive protection and environmental protection; the SEPA (NNSA) continuously develops training to nuclear safety supervisors and grants relevant qualification to qualified personnel. Meanwhile, Chinese government will cooperate with the IAEA to train senior personnel of China nuclear safety surveillance.

Chinese government continuously improves the professional system, enhance technical training and cultivation work of related personnel on nuclear power and provide professional security for the persistent development of nuclear power through various kinds of models to run a united school formed by foreign and domestic research institutions and universities, work out united training talent plan, found nuclear energy academes at certain university, develop training class for all kinds of personnel and so on. Meanwhile, strengthen the knowledge renovation of nuclear technical personnel and establish a batch of continuing education bases rely on existing resources to meet the requirements of technical development of nuclear power.

6.6 Technical improvement and aging management of Chinese NPPs

6.6.1 Technical improvement of NPP

In 2005, four units in total of Qinshan Phase II NPP and Guangdong LingAo NPP began to be constructed. According to the operating experience feedback from foreign and domestic NPPs and the requirements in the newly-revised "Code on the Safety of Nuclear Power Plant Operation", a few items of important technical improvements have been implemented.

On the basis of operating of unit 1 and unit 2, the unit 3 and unit 4of Qinshan Phase II NPP have adopted 12 items of technical improvements such as on main feed-water system isolation improvement, digital I&C system, combined pump room and so on. Whereas, on the basis of operating unit 1 and unit 2, the unit 3 and unit 4 of Guangdong LingAo NPP have adopted 13 items of technical improvements such as on digital I&C system, advanced fuel assembly and so on. All of these technical improvements will further improve safety performance of NPP.

Additionally, during the construction of Qinshan Phase III NPP, we combine the operating experience feedback from CANDU－6 type NPP and refer to the successful experience of Chinese NPPs' construction, 21 items of technical improvements which were made by joint effort of China and Canada have been first used in CANDU-6 of Qinshan Phase III NPP, which enabled the safety and reliability a further improvement.

6.6.2 Aging management of NPP

Up to now, Qinshan NPP and Guangdong Daya Bay NPP have been put into commercial operation for more than 10 years. On the basis of ten years' periodic safety review, aging management is gradually materialized. The NPP has worked out aging management programme according to the essentiality of safety, factors such as the replacement of equipments or structures and changeable economy and so on. Combining the international experience of aging management, the key items of aging management were determined from the safety related important equipments or structures. The collection of needed data in aging management and aging trend analysis of equipments and structures were started.

Annex 1 The List of Nuclear Power Plants in China (by December 31, 2006)

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 CN-14 CN-15	Haiyan, Zhejiang Province	PWR PWR PWR PWR	650 650 650 650	1996-06-02 1997-04-01 2006-04-28 2007-01-28	2002-02-06 2004-03-11
Guangdong LingAo NPP	CN-6 CN-7 CN-12 CN-13	Shenzheng City, Guangdong Province	PWR PWR PWR PWR	990 990 1080 1080	1997-05-15 1997-11-28 2005-12-15 2006-06-15	2002-02-26 2002-09-14
Qinshan Phase III NPP	CN-8 CN-9	Haiyan, Zhejiang Province	CANDU CANDU	700 700	1998-06-08 1998-09-25	2002-11-19 2003-06-12
Jiangsu Tianwan NPP	CN-10 CN-11	Lianyungang City, Jiangsu Province	PWR PWR	1060 1060	1999-10-20 2000-09-20	2006-05-12

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 2004 to 2006)

Performance Indicators of Operational Units (2004)

No.	Item \ Unit / Year	2004							
		Qinshan NPP	Guangdong Daya Bay NPP		Qinshan Phase II NPP	Guangdong LingAo NPP		Qinshan Phase III NPP	
		CN1	CN2	CN3	CN4	CN6	CN7	CN8	CN9
1	Unit Capability Factor (%)	99.81	87.77	73.91	80.17	88.54	80.43	76.16	92.85
2	Unplanned Capability Loss Factor (%)	0.10	0.00	16.56	2.68	1.32	1.72	1.66	3.08
3	Automatic Scrams per 7000 Hours Critical (Times)	0.00	0.00	1.05	0.97	0.88	0.00	0.00	0.00
4	Collective Radiation Exposure (Man • Sv)	0.06	0.91	0.91	0.57	0.50	0.50	0.40	0.40
5	Safety System Performance: High-Pressure Safety Injection System Auxiliary Feed-Water System Emergency AC Supply System	0.0002 0.0003 0.0006	0.0000 0.0002 0.0000	0.0001 0.0002 0.0000	0.0000 0.0000 0.0001	0.0009 0.0010 0.0000	0.0003 0.0000 0.0000	0.0003 0.0044 0.0027	0.0006 0.0000 0.0027
6	Fuel Reliability (Bq/g)	9.58E-02	3.70E-02	7.44E-02	3.70E-02	3.70E-02	3.70E-02	8.29E+00	8.84E+00
7	Chemistry Performance	1.05	1.00	1.00	1.43	1.00	1.02	1.22	1.39
8	Industrial Safety Accident Rate	0.10	0.07	0.07	0.24	0.00	0.00	0.08	0.08
9	Forced Loss Rate	0.10	0.00	0.28	3.24	0.98	1.26	2.13	3.21

Performance Indicators of Operational Units (2005)

No.	Item \ Unit \ Year	2005								
		Qinshan NPP	Guangdong Daya Bay NPP		Qinshan Phase II NPP		Guangdong LingAo NPP		Qinshan Phase III NPP	
		CN1	CN2	CN3	CN4	CN5	CN6	CN7	CN8	CN9
1	Unit Capability Factor (%)	87.02	99.95	79.76	90.57	82.82	83.10	91.22	82.34	79.61
2	Unplanned Capability Loss Factor (%)	0.46	0.03	0.02	0.02	1.34	1.05	0.82	1.86	0.75
3	Automatic Scrams per 7000 Hours Critical (Times)	1.81	0.00	0.00	0.00	0.00	0.93	0.86	0.00	0.98
4	Collective Radiation Exposure (Man • Sv)	0.93	0.65	0.65	0.37	0.37	0.54	0.54	0.59	0.59
5	Safety System Performance: High-Pressure Safety Injection System Auxiliary Feed-Water System Emergency AC Supply System	 0.0000 0.0005 0.0003	 0.0000 0.0002 0.0008	 0.0000 0.0002 0.0008	 0.0207 0.0000 0.0002	 0.0100 0.0000 0.0002	 0.0000 0.0002 0.0004	 0.0000 0.0003 0.0004	 0.0000 0.0000 0.0023	 0.0000 0.0000 0.0023
6	Fuel Reliability (Bq/g)	6.73E-02	7.40E-02	2.15E-01	3.70E-02	3.70E-02	2.08E-01	3.70E-02	7.17E+00	5.66E+00
7	Chemistry Performance	1.01	1.00	1.00	1.10	1.17	1.00	1.02	1.00	1.02
8	Industrial Safety Accident Rate	0.54	0.14	0.14	0.00	0.00	0.00	0.00	0.07	0.07
9	Forced Loss Rate	0.53	0.03	0.02	0.02	1.59	1.25	0.89	2.21	0.93

Performance Indicators of Operational Units (2006)

No.	Item \ Unit \ Year	2006								
		Qinshan NPP	Guangdong Daya Bay NPP		Qinshan Phase II NPP		Guangdong LingAo NPP		Qinshan Phase III NPP	
		CN1	CN2	CN3	CN4	CN5	CN6	CN7	CN8	CN9
1	Unit Capability Factor (%)	91.84	80.32	99.88	55.24	88.78	90.08	92.44	96.34	86.73
2	Unplanned Capability Loss Factor (%)	0.29	0.87	0.05	10.11	0.00	0.18	0.03	0.07	0.22
3	Automatic Scrams per 7000 Hours Critical (Times)	0.00	0.00	0.00	1.40	0.00	0.00	0.85	0.00	0.00
4	Collective Radiation Exposure (Man • Sv)	0.54	0.60	0.60	0.36	0.36	0.36	0.36	0.26	0.26
5	Safety System Performance: High-Pressure Safety Injection System Auxiliary Feed-Water System Emergency AC Supply System	0.0001 0.0016 0.0002	0.0000 0.0000 0.0010	0.0009 0.0002 0.0010	0.0001 0.0000 0.0002	0.0000 0.0003 0.0002	0.0001 0.0000 0.0006	0.0000 0.0000 0.0006	0.0000 0.0000 0.0018	0.0000 0.0000 0.0018
6	Fuel Reliability (Bq/g)	3.70E-02	3.70E-02	1.49E-01	3.70E-02	3.70E-02	3.70E-02	3.70E-02	3.70E-02	3.70E-02
7	Chemistry Performance	1.00	1.00	1.00	1.05	1.02	1.00	1.00	1.08	1.004
8	Industrial Safety Accident Rate	0.00	0.07	0.07	0.00	0.00	0.00	0.00	0.00	0.00
9	Forced Loss Rate	0.05	1.08	0.05	15.47	0.001	0.20	0.03	0.07	0.25

Annex 3

Laws, Regulations and Guidelines of China on Nuclear Safety (By the end of December 31, 2006)

Ⅰ. 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, and amended in accordance with the amendments to the Constitution of the People's Republic of China adopted at the Second Session of the 10th National People's Congress on March 14, 2004)
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)

Ⅱ. 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)

Ⅲ. 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 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 27, 1991)
7. Code on the Safety of Nuclear Power Plant Siting (HAF101)
   (Promulgated by the NNSA on July 27, 1991)
8. Code on the Safety of Nuclear Power Plant Design (HAF102)
   (Promulgated by NNSA on April 18, 2004)
9. Code on the Safety of Nuclear Power Plant Operation (HAF103)
   (Promulgated by NNSA on April 18, 2004)
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 Rules of the Radiological Health Protection of Nuclear Installations
    (Decree by Minister, Issued by the Ministry of Health, 1992)
21. Surveillance and Evaluation Standard of the Public Dose During Normal Operation and Accident Condition of Nuclear Installation
    (Issued by Ministry of Health, 1992)
22. Management Rules of the Medical Emergency Response Under Nuclear Accident

(Decree by Minister, Issued by the Ministry of Health, 1994)

23. Intervention to the Public Protection and the Derived Intervention Level During Nuclear Accident or Radiation Emergency
    (Issued by Ministry of Health, 1995)
24. 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)
25. Management Methods for License Examination of Operators of NPP (tryout)
    (Issued by China Atomic Energy Authority on September 6, 1999)
    (Issued by National Atomic Energy Organization on January 19, 2001)
26. Management Rules for Review and Approval for Transfer and Transit Transportation of Nuclear Products
    (Issued by China Atomic Energy Authority on January 27, 2000)
27. 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)
28. Reporting System of Nuclear Accident Emergency for NPP
    (Issued by China Atomic Energy Authority on December 11, 2001)
29. Specifications on Medical Treatment of Radiation Damage
    (Issued by the Ministry of Health, China Atomic Energy Authority on May 22, 2002)
30. Management Rules of Emergency Crossing the Boundary for Radioactive Influence due to Nuclear Accident (Issued by China Atomic Energy Authority in 2002)
31. Management Methods for Operation Assessment of NPP (tryout)
    (Issued by China Atomic Energy Authority on June 4, 2002)
32. Management Rules of Nuclear Accident Emergency Exercise for NPP
    (Issued by China Atomic Energy Authority on February 28, 2003)
33. Management Rules of Operating Experience Exchange for NPPs(for Trial Implementation)
    (Issued by China Atomic Energy Authority on April 4, 2005)
34. Supervision and Management Rules on Firefighting Safety of NPPs
    (Issued by China Atomic Energy Authority on December 20, 2006)

Ⅵ. 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)
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Appendix 1 Occupational Exposure of NPPs in China (From 2004 to 2006)

Plant	Item （unit） Year	Annual Man Average Effective Dose (Man·mSv)	Annual Maximum Individual Effective Dose (mSv)	Annual Collective Effective Dose (Man·Sv)	Normalized Collective Effective Dose (Man·mSv/GWh)
Qinshan NPP	2004	0.11	3.53	0.064	0.024
	2005	0.69	10.3	0.932	0.396
	2006	0.40	8.05	0.538	0.217
Guangdong Daya Bay NPP	2004	0.674	12.14	1.817	0.13
	2005	0.486	8.146	1.307	0.085
	2006	0.436	5.921	1.205	0.078
Qinshan Phase II NPP	2004	0.353	5.443	0.590	0.068
	2005	0.362	7.210	0.738	0.073
	2006	0.335	6.318	0.713	0.086
Guangdong LingAo NPP	2004	0.417	8.05	1.006	0.069
	2005	0.433	8.910	1.088	0.072
	2006	0.284	7.155	0.722	0.046
Qinshan Phase III	2004	0.369	8.015	0.81	0.077
	2005	0.594	9.350	1.368	0.135
	2006	0.272	5.990	0.519	0.045

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 2004 to 2006)

Type / Item / plant / Year		Gaseous Effluents			Liquid Effluents	
		Noble gas	Halogen	Aerosol	Tritium	Other Nuclides
Qinshan NPP	2004	3.44 E-04	0	0	1.63 E+00	8.05E-03
	2005	1.80E-04	0	0	4.13 E+00	5.64E-02
	2006	2.70E-04	0	0	2.06 E+00	2.91E-02
Guangdong Daya Bay NPP (Unit 1 and Unit 2)	2004	5.04E-01	1.65E-01	5.90E-04	3.21E+01	1.96E-01
	2005	9.16E-02	1.67E-02	2.74E-03	4.16E+01	1.70E-01
	2006	9.36E-02	2.25E-02	2.56E-03	3.81E+01	1.19E-01
Qinshan Phase II NPP (Unit 1)	2004	9.08E-07	5.00E-02	2.69E-03	7.07E+00	3.00E-01
	2005	4.72E-06	7.00E-03	1.37E-03	1.38E+01	2.40E-01
	2006	4.88E-08	1.35E-03	1.81E-03	1.79E+01	4.12E-01
Guangdong LingAo NPP (Unit 1 and Unit 2)	2004	4.44 E-01	8.79E-02	6.75E-04	2.65E+01	4.27E-02
	2005	7.2E-02	9.85E-03	3.78E-03	2.85 E+01	3.47E-02
	2006	7.60E-02	8.00E-03	3.20E-03	3.34 E+01	3.88E-02
Qinshan Phase III (Unit 1 and Unit 2)	2004	1.30E+00	Below the Detecting Limit Values	Below the Detecting Limit Values	*	1.60E-01
	2005	2.35E+00	2.02E-02	Below the Detecting Limit Values	*	1.93E-01
	2006	1.08E-02	0	8.25E-04	*	2.20E-01

Notes:

1. The discharge of radioactive effluents is related to the power level of nuclear unit.
2. In calculating gaseous effluents 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. * At present, there is no release 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 2004 to 2006)

Operational Events in 2004

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 2	Unit 1	Unit 2	Unit 1	Unit 2
0	3	3	5	4	3	1	4	9	5
1	1	0	2	0	1	0	0	0	0
≥2	0	0	0	0	0	0	0	0	0
Total	4	3	7	4	4	1	4	9	5

Operational Events in 2005

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 2	Unit 1	Unit 2	Unit 1	Unit 2
0	5	2	1	0	0	3	1	4	3
1	0	0	1	0	0	1	0	0	1
≥2	0	0	0	0	0	0	0	0	0
Total	5	2	2	0	0	4	1	4	4

Operational Events in 2006

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 2	Unit 1	Unit 2	Unit 1	Unit 2
0	1	1	0	2	0	0	1	1	0
1	0	1	0	0	0	0	1	0	1
≥2	0	0	0	0	0	0	0	0	0
Total	1	2	0	2	0	0	2	1	1

Appendix 4 Licensed Reactor Operators and Senior Reactor Operators (By the End of 2006)

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	7	38	31	39	37
Senior Reactor Operators (SRO)	Number of SRO	28	68	60	63	27