English Version

THE NATIONAL REPORT UNDER THE CONVENTION ON NUCLEAR SAFETY

OF

THE PEOPLE'S REPUBLIC OF CHINA

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Content

1. INTRODUCTION

The Chinese government attaches high importance to nuclear safety. It had ratified and approved to participate in the “Convention on Nuclear Safety”, undertaken the safety responsibilities for nationwide nuclear power plants (NPPs), strictly implemented obligations of the Convention and made continual efforts to meet and keep a high level of nuclear safety standard accepted internationally.

1.1 Development and Policy of Nuclear Industry in China

The Chinese nuclear industry was initiated in 1955. From the late 1950s to the 1970s, it mainly served the national defense program. The related industrial systems of research, design, construction, education and nuclear fuel cycle were established during the period to lay down foundations for the later development of nuclear industry.

Since 1978, China has been carrying out reform and open-door policy. The nuclear industry has shifted to focus on economical construction and improvement of people’s life. At the early 1980s, the State Council decided to build Qinshan NPP and Guangdong Daya Bay NPP. Thus begins the era of the development of Chinese nuclear power industry. On December 15, 1991, Qinshan NPP designed and constructed by China itself was connected to the grid. On August 8, 1993, the Unit 1 of Guangdong Daya Bay NPP was connected to the grid, Unit 2 was connected to the grid on February 7, 1994. From 1996, there had been 4 NPPs to begin their constructions successively. Chinese government considers the safety of nuclear power to be the key problem in health development of nuclear power. At present, China endeavors to keep the safe operation of NPPs and, at the same time, does its best on the constructions of the constructing NPPs. “Safety First and Quality First” is always a policy that must be carried out in Chinese nuclear industry.

1.2 Current Nuclear Power Developing Policy

The current power developing policy of Chinese government is “To fully utilize the existing capacity in generating electricity, to actively develop hydroelectric power and fossil power of the big capacity units near pits, to reduce the small capacity’s fossil power units, and to moderately develop nuclear power”.

The current nuclear power developing policies are as follows:

(1) To implement the “Safety First” policy.

(2) To develop nuclear power steadily and develop nuclear power primarily in the coastal area where the economic development is relatively rapid.

(3) On the basis of our own, to cooperate with foreign countries, to introduce foreign technologies and to promote domestic manufacturing of equipment.

(4) To make great efforts achieve the target of design, manufacture, construction, and operation of the commercial NPPs by ourselves.

(5) Closely following-up the international developing trend of nuclear power technologies.

1.3 Nuclear Power Program before the Year 2005

The Chinese Qinshan NPP and Guangdong Daya Bay NPP whose total installed capacity is 2100 MW(e) have been put into operation for years. The nuclear generating capacity occupies about 1% of the Chinese total electricity generation.

Since 1996, four NPPs total 8 units whose total installed capacity is about 6600MW(e) have been put into construction in succession. They will be completed by the year 2001 to 2005. At that time, the installed nuclear power capacity is about 2.5% of the total electricity generation installed in China. At present, the relevant departments of the Chinese government are making a plan on developing nuclear power according to the policy of “to moderately develop nuclear power”.

1.4 Nuclear Safety Policy

China has paid great attention to nuclear safety from the beginning of nuclear industry development and clearly formulated the “Safety First” policy to protect personnel, publics and environment.

The National Nuclear Safety Administration (NNSA) was established in 1984 by the decision of the State Council. It then initiates the independent regulation for nuclear safety of civilian nuclear installations, establishes surveillance system of nuclear safety and at the same time defines clearly the responsibilities of governmental departments and operating organizations.

The nuclear safety regulations have been promulgated one after another from 1986 to regulate nuclear safety based on them. In order to make the requirements for

Chinese nuclear safety and the nuclear safety level keep consistent with the advanced international level, China has made some revisions for issued regulations and standards step by step. For the regulations that need longer period to revise, the related contents will be issued in advance in the form of "Statements on Nuclear Safety Policy".

The Chinese government attaches high importance to the international cooperation in the field of nuclear safety, it had actively taken part in the international legislation activities. China had ratified and approved "Convention on the Physical Protection of Nuclear Materials", "Convention on Early Announcement of Nuclear Accidents", "Convention on Emergent Assistance of Nuclear Accident or Radiation" and "Convention on Nuclear Safety", etc. and seriously implemented its obligations under the conventions.

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", generally and systematically described the work done in connection with the implementation of Chinese obligations under the convention up to the end of 2000. At the same time, the report reflects the important activities in the field of nuclear safety since the meeting on review of our first national report and the progress on regulatory activities of nuclear safety in China.

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

2. EXISTING NUCLEAR POWER PLANTS

2.1 List of Existing NPPs

In China, there are 2 NPPs in operation, 4 NPPs under construction, totally 11 units (the parameters of NPPs in Taiwan province of China is left open for the time being). For the listing of these units, see Appendix 1. The parameters of each nuclear steam supply systems (NSSS) are listed in Annex 1.

2.2 Safety Evaluation of Existing NPPs

2.2.1 NPPs in Operation

Qinshan NPP was designed and constructed by China in the 1980's. Its construction began in March 1985 and first connection to the grid was in December 1991. Guangdong Daya Bay NPP was introduced from France and began construction in 1987, its Unit-1 & 2 were connected to the grid in August 1993 and in February 1994, respectively.

Overall safety reviews of Guangdong Daya Bay NPP were performed by the NNSA. Although the Chinese nuclear safety regulations had not yet issued when Qinshan NPP was designed, however foreign design standards and rules were referred to in the design stage. After Chinese nuclear safety regulations were promulgated, a retrospective overall safety review for Qinshan NPP was conducted.

Qinshan NPP and Guangdong Daya Bay NPP accepted the safety reviews from IAEA OSART.

Safety barriers of the Chinese NPPs in operation have shown integrity through tests and monitoring. The integrity of fuel element cladding satisfies requirements of technical specifications. The leakage rates of the primary coolant system and the containment are far below the limits of technical specifications.

The occupational exposure dose of two operating NPPs is far below the limits of national standards. The discharges of radioactive effluents of the NPPs have been effectively controlled and monitored. The level of discharge volume per year of the NPPs is far lower than the state regulatory limits. There has been no undue dose release event occurred since the first fuel loading. The radioactivity level of the surrounding environment has been kept at the level of the ambient investigation.

In 2000, the unit capacity factors of Qinshan NPP and the Unit-1 & 2 of

Guangdong Daya Bay NPP were 76.80%, 86.07% and 88.0%, respectively. Detailed performance indicators for the two NPPs are listed in Appendix 2.

In Appendix 2, it can be found that, in 1998 and 1999 the capacity factors of Qinshan NPP is very low because of the damage of the bottom components of the core barrel. In August 1998, during the fourth refueling outage, the damage of the bottom components of the core barrel was found in the routine examinations. In September 1998, Qinshan NPP entrusted ABB Company to perform overall inspections, and in December 1998, Qinshan NPP entrusted Westinghouse Company to repair the damaged core barrel. On June 25, 1999, the repaired barrel was put back successfully. The results of various functional and performance tests were all satisfactory. The inspections, repairs and tests were supervised by the NNSA.

After passing the tests of the core barrel’s putting back, Qinshan NPP had experienced 11 months’ continuous commercial operation. The unit had been kept in a steady status, the integrity of safety barriers had been maintained, and the functions of the engineered safety systems had been satisfied. The development program (from 2001 to 2005) for Qinshan NPP has been prepared to perform planned technical and managing improvement. The periodic safety review (PSR) and the probability safety assessment (PSA) are being performed. At the same time, the training of the plant personnel, especially the personnel in top management level has been strengthened. The safety status of the plant, the management level, and the safety consciousness of the whole personnel are improved greatly.

From 1998, the results of the overall evaluation of Guangdong Daya Bay NPP are satisfied. The plant performance indicators are at a better level; the times of automatic shutdowns in 7000 hours’ operation are between 0 and 0.5; no level 2 events occur; the unit operation status is steady; and the amount of three types of wastes is far below the limits of national standards.

2.2.2 NPPs under Construction

There are 4 plants under construction in China. Among them, Qinshan Phase II NPP was designed and constructed by China, the constructions of its Unit-1 & 2 were begun on June 2, 1996 and April 1, 1997, respectively. The two units will be planned to connect to the grid on February 1, 2002 and on December 1, 2002, respectively.

A part of the design for Guangdong Lingao NPP has been performed by China. The manufactures of NPP equipment are partly made in China too. The NPP is equipped with 2 sets of 984MWe PWR units. The constructions of its Unit-1 & 2 were begun on May 15, 1997 and on November 28, 1997, respectively. The two units will be planned to connect to the grid on February 1, 2002 and on November 1, 2002, respectively.

Qinshan Phase-III NPP was imported from Canada. It is equipped with 2 sets of 700MWe CANDU-6 units. The constructions of Unit-1 & 2 were begun on June 8, 1998 and on September 25, 1998, respectively. The two units will be planned to connect to the grid on November 10, 2002 and on June 15, 2003, respectively.

Jiangsu Tianwan NPP was imported from Russia. It is equipped with 2 sets of units of type of 1000MWe VVER-1000. The constructions of the Unit-1 & 2 were begun on October 20, 1999 and on October 20, 2000, respectively. The two units will be planned to connect to the grid on May 15, 2004 and on May 15, 2005, respectively.

In the stages of siting, design, construction, installation, and commission of above 4 NPPs under construction, the activities related to nuclear safety are all under control. Effective supervision and reviews are performed by the 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.

2.3 Views on Continual Operation of Existing NPPs

Qinshan NPP and Guangdong Daya Bay NPP of China are in the prophase of their design lifetime. It is shown that the safety of continual operation of Chinese NPPs is guaranteed through several years’ operational practices, in-service inspections, tests, analyses, and several safety reviews and assessments carried out by the NNSA and other competent departments of Chinese government.

3. LEGISLATION AND REGULATION

3.1 Laws, Regulations, Standards on Nuclear Safety

3.1.1 Legislation on Nuclear Safety

In 1989, the Standing Committee of the National People’s Congress promulgated “Environmental Protection Act of the People’s Republic of China” . China will enhance specific legislation in the field of nuclear safety, including preparing “Atomic Energy Act” and “Act of Prevention and Remedy of Radioactivity Contamination”.

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, was.

The NNSA issued Codes on the safety of siting, design, operation and quality assurance of the NPP in 1986. In 1990, the State Environmental Protection Administration (SEPA) issued the “Management of Radioactive Environment”. The SEPA and the Ministry of Health, etc. enacted the codes on radiation protection. In 1991, the NNSA promulgated “Codes on the Safety of the Management of Radioactive Waste from Nuclear Power Plants”.

The above-mentioned rules and regulations form the basic requirements on the safety of the NPP. In addition, based on implementation, supplement and revision have been made for the issued code and guides.

In addition, China Atomic Energy Authority (CAEA), the SEPA and the Ministry of Health consecutively formulated relevant implementing detailed rules and safety guides. Therefore, a relatively complete system of regulations and rules on nuclear safety has been formed.

3.1.2 Scope of Regulations on Nuclear Safety

At present, the nuclear facilities for which the regulations on nuclear safety in

China are applicable are:

(1) NPPs (electricity generating NPPs, nuclear thermo-electricity plants, nuclear heat and steam supply plants, etc.);

(2) Other reactors (research reactors, experimental reactors and critical assemblies, etc.);

(3) Installations for nuclear fuel production, processing, storage and reprocessing;

(4) Facilities for radioactive waste processing and disposal.

3.1.3 Nuclear Safety Regulation System

Since 1982, China has collected extensively and studied carefully the laws, regulations on nuclear safety used in advanced nuclear power countries, consulted the nuclear safety codes and guides of IAEA, established the Chinese nuclear safety regulation system that consists of state laws, administrative regulations of the State Council, department rules, nuclear safety guides, standards and specifications.

The nuclear safety regulation hierarchy is listed in figure 3.1.

(1) State laws

The state laws are enacted by the National People’s Congress and its Standing Committee and their legal effects are higher than administrative regulations and department rules.

The existing state laws that applicable to nuclear safety field are “ The Constitution of the People’s Republic of China” and “Environmental Protection Act of the People’s Republic of China”. The latter is special law that is enacted by the Standing Committee of the National People’s Congress. It is used for protecting and improving the living environment, preventing and governing contamination, guaranteeing human health and promoting social development. Recently, China will legislate the special laws such as “Atomic Energy Act” and “Act of Prevention and Remedy of Radioactivity Contamination”, etc.

(2) Administrative regulations of the State Council

Nuclear Safety Control Regulations are rules to stipulate the scope of management, regulatory body and its rights, principles and procedures of supervision and other important issues. They were promulgated by the State Council and have legal binding effect.

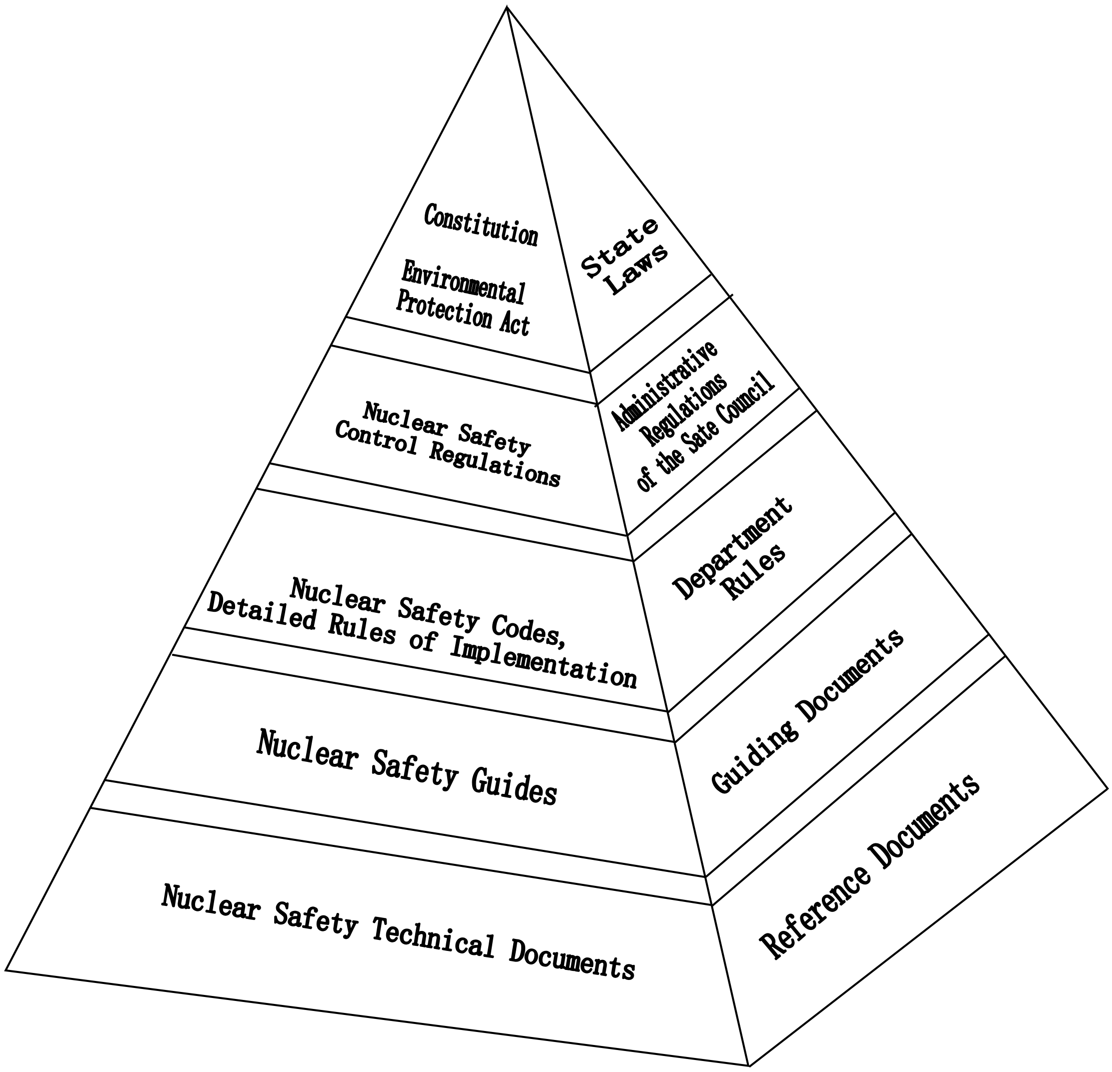

Figure 3.1 The hierarchical structure of nuclear safety regulations of China

(3) Department rules

— The detailed rules are departmental rules which stipulate specific implementing measures. They have been promulgated by the related departments of the Chinese government according to Nuclear Safety Control Regulations and have legal binding effect.

— Nuclear Safety Codes are departmental rules enacting nuclear safety objectives and basic safety requirements. They have been promulgated by the relevant departments of the Chinese government and approved by the State Council and have legal binding effect.

— Nuclear Safety Standards are standards and specifications related to nuclear safety enacted by the CAEA, the SEPA, the Ministry of Health and the NNSA, etc.

(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.

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

3.2 Nuclear Safety Surveillance and Management System

The NNSA is in charge of the right to exercise its unified and independent surveillance power over the safety of NPPs throughout the country. The licensing system is the main measure of surveillance and management of the NNSA. By means of the management of licenses, the NNSA supervises NPPs, nuclear materials and nuclear activities.

The SEPA is in charge of the surveillance and management 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 NNSA.

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

By means of license examination and approval, supervision, enforcement of laws, rewards and punishment, surveillance for implementation of nuclear safety related activity performed by licensee, the NNSA ensures that licensee can bear the responsibilities for nuclear safety and carries out nuclear activities in conformity with legal provisions.

3.3 Licensing System

China adopts licensing system for nuclear safety.

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

NPPs, possession, use, production, storage, transportation and disposal of nuclear materials, etc.).

3.3.1 Types of Licenses for NPP

Safety licenses that the NNSA is responsible for reviewing, approving and promulgating or checking and authorizing include:

(1) Construction permit of NPP;

(2) Operation permit 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.

The SEPA is responsible for approving instrument of ratification of environmental impact assessment of different phases of NPPs. Instrument of ratification of environmental impact assessment report is one of the necessary prerequisites before issuing a license.

3.3.2 Procedure of Application, Review and Approval of a License

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

During the process of appraisal, the 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.

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 NNSA decides independently whether the licenses are to be issued or not, meanwhile the NNSA enacts the essential requirements for licenses.

The procedures of application and issuing of licenses in China are listed in figure 3.2.

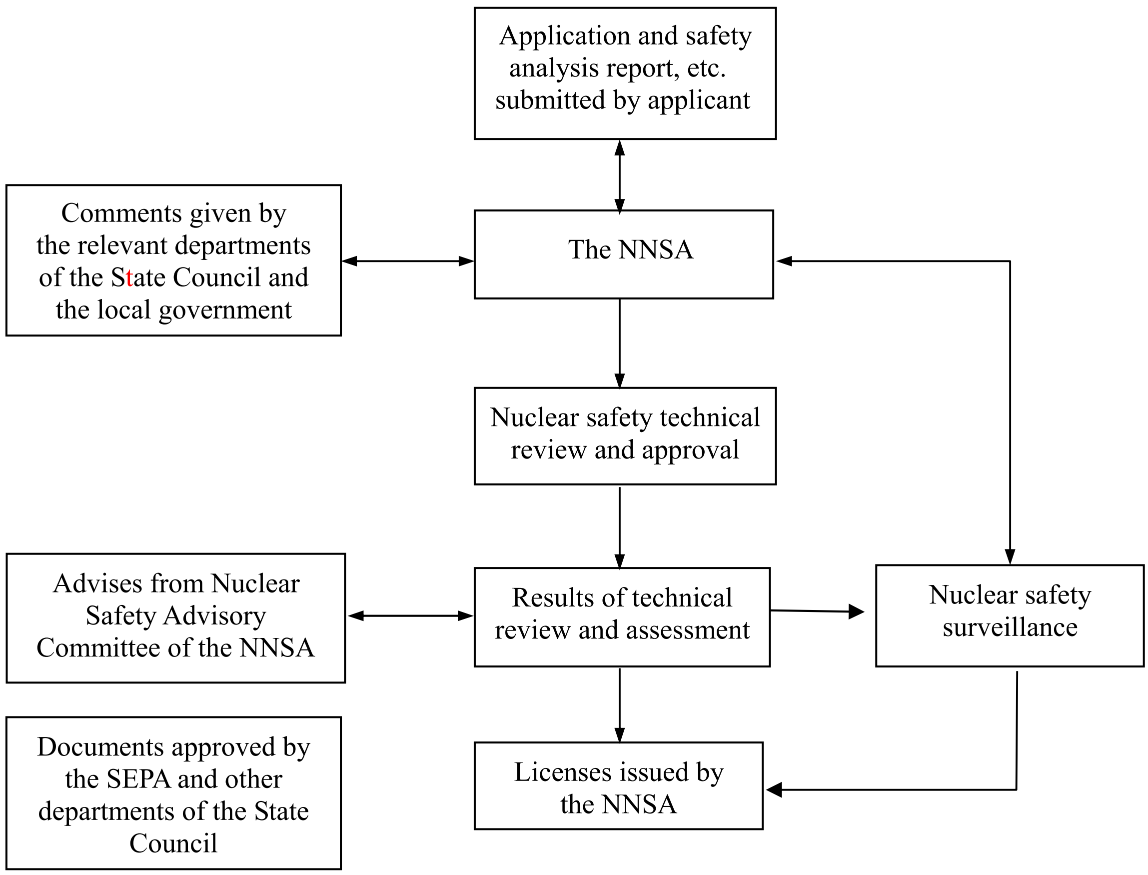

Figure 3.2 The procedures of application and issuing of licenses

3.4 Regulatory Body of Nuclear Safety

The NNSA, the SEPA 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.

3.4.1 Duties and Responsibilities of Regulatory Bodies

3.4.1.1 Duties and Responsibilities of the 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; to issue or revoke nuclear safety licenses;

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

(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 surveillance 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.

3.4.1.2 Duties and Responsibilities of the SEPA

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

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

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

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

(5) to participate in emergency response activities.

3.4.1.3 Duties and Responsibilities of the Ministry of Health

(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.

3.4.2 Organizational Structure of Regulatory Bodies

3.4.2.1 The NNSA

The NNSA independently implements its right on surveillance of nuclear safety to conduct the nuclear safety surveillance of Chinese NPPs uniformly. It is a subordinate department of the SEPA.

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

The Nuclear Safety Advisory Committee is a consulting organization that assists the NNSA to enact nuclear safety regulations, to develop nuclear safety technology and takes part in review and supervision of nuclear safety.

The organization structure of the NNSA is listed in figure 3.3.

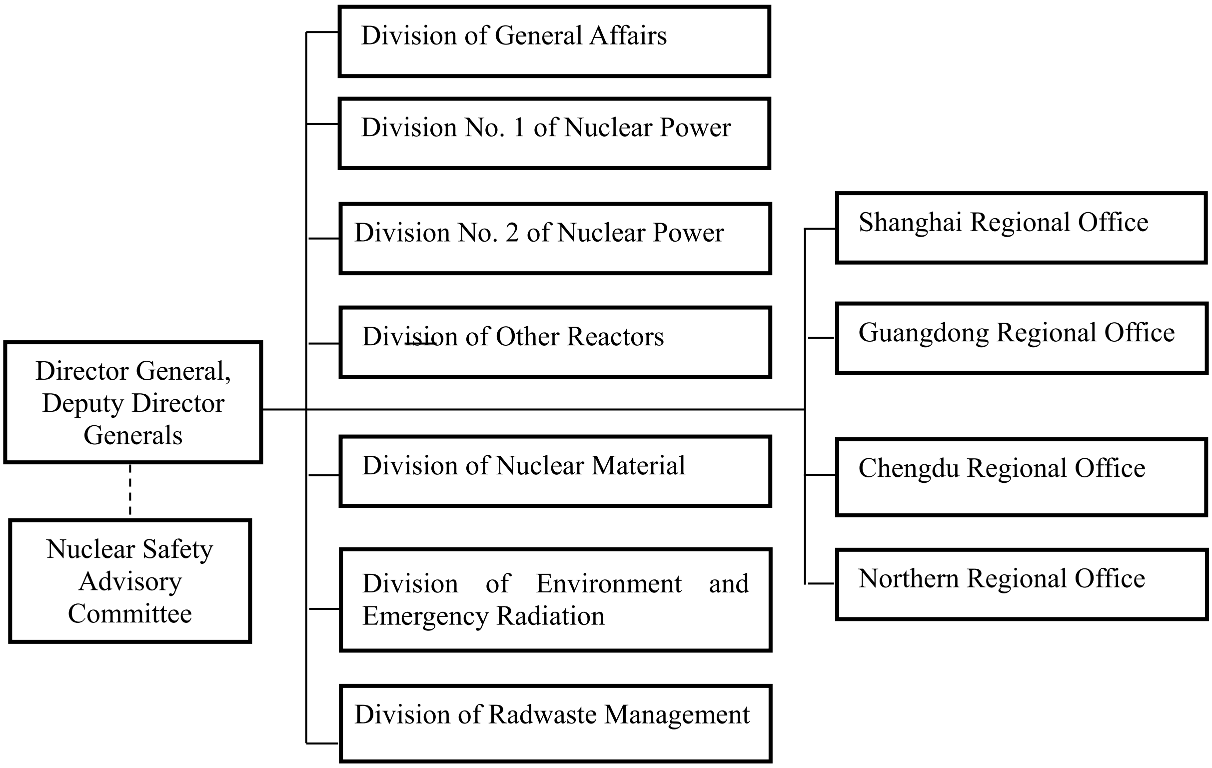

Figure 3.3 The organization structure of the NNSA

3.4.2.2 The SEPA

The SEPA is in charge of unified surveillance of environmental protection all over the country. The departments for environmental protection are established in all provinces and municipalities.

3.4.2.3 The Ministry of Health

The Ministry of Health performs an unified surveillance and management of the hygiene all over the country. There are also departments for hygienic monitoring affairs in all provinces and municipalities.

3.5 Nuclear Industry Administration

3.5.1 China Atomic Energy Authority

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

3.5.2 Duties and Responsibilities of the CAEA

(1) Investigating and drawing out policies and regulations for utilizing atomic energy peacefully in China, being in charge of making proposal, management and surveillance of important projects.

(2) Researching and establishing developing programme, planning and nuclear industry standard for utilizing atomic energy peacefully in China.

(3) Organizing discussion and appraisal, initial reviewing and approving for significant science and technology project on utilizing peacefully nuclear energy; monitoring and coordinating the implementation of significant science and technology project in nuclear energy.

(4) Conducting regulation for nuclear material; performing review and management for nuclear export.

(5) Promoting communication and cooperation among governments and also among international organizations in peaceful use of atomic energy; taking part in IAEA and its activities in the name of Chinese government; performing review for permit of nuclear import & export and governmental guarantee.

(6) Taking leader to organize national coordination committee for nuclear accident; researching and preparing emergency plan for nuclear accident and organizing its implementation.

(7) Safeguarding nuclear material and managing fire-fighting activities for the NPPs

3.5.3 Organizational Structure of the CAEA

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

3.6 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 NNSA, the SEPA and the Ministry of Health, etc.; to report the safety situation timely and faithfully and to provide relevant information;

(3) to be wholly responsible for the safety of NPPs under operation , the safety of nuclear materials and the safety of the site personnel, the public and the environment; and to provide enough resources for undertaking the responsibilities.

3.7 Nuclear Safety Surveillance

The 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 supervise whether or not the construction is carried out in accordance with the approved design;

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

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

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

4. GENERAL SAFETY CONSIDERATIONS

4.1 Priority to Safety

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

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

The general nuclear safety objectives are defined as follows: By establishing and keeping an effective defense of radiation jeopardy to protect site personal, public and environment. The general objectives is supported by two interrelated concrete safety objectives which are stated as follows:

Objective for radioactive protection: To ensure radioactive exposure and scheduled effluent of radioactive waste under all operation conditions of the NPP to be within the stipulated limits and be accordant with ALARA, to ensure to mitigate the radioactive effects of all accidents.

Objective for technical safety: To take all reasonable actions to prevent accidents in NPP and mitigate their effects. The effects of all possible accidents including accidents with very low probability considered in design of NPP are minimal and within the specified limits. To ensure that probability for accident with severe radioactive effects is very lower.

4.1.2 Safety Culture and its Cultivation

Chinese government always stress on and cultivate safety culture by organizing exchanges of safety culture among nuclear safety regulatory body, nuclear industry administration, and NPPs and taking part in the activities of international exchanges of safety culture.

In China, the promotion of nuclear safety culture was initiated in 1991. It has experienced several phases such as study and propagating, improvement of system and procedures, self-education mainly based on experience feedback, self-improvement mainly based on risk analysis and risk prevention within groups, etc. It stressed on incident report and analysis, persistence in an open attitude, emphasis on idea change of staffs. The basic requirements of safety culture for safety sense, quality sense and continuous improvement are concluded as easily understanding slogans such as “ One person is one barrier”, “No best but better”. These activities made the promotion of safety culture be effectively conducted in the basic units of NPP.

The IAEA document INSAG 4 “Safety Culture” for individuals engaged in nuclear power activities defines the following behavior standards:

— Questioning attitude;

— Rigorous and prudent working approach;

— Necessary communication.

Combined with our national culture traditions, we form three aspects of code of conduct from the decomposition of the connotation of the general concepts. The three aspects are:

— Good professional morality;

— High standard of knowledge and technique;

— Scientific working style.

In Chinese NPPs, following measures are taken to familiarizing safety culture:

(1) Establishment of safety goals of the NPPs. Management of safety operation is carried out in a quantification way. Safety goals are reviewed and revised every year.

(2) Establishment of organization structure with clearly defined responsibilities and independent quality assurance supervisory department.

(3) Development of systematical rigorous procedures as well as administrative rules and regulations. All operations and working practice should be carried out according to these procedures and rules.

(4) Establishment of “Event Report System” and “Event Analysis and Experience Feedback System”. Learning from experience is encouraged.

(5) Development and execution of the education program of safety culture. The education program is included in the plant's annual plan and the execution of this program is described in the plant's annual report.

(6) Conduction of self-assessment on safety culture.

Popularizing and cultivating of safety culture in the NPPs have received better results through propagandizing and cultivating safety culture these years. The safety performances of NPPs have been enhanced steadily. In Chinese NPPs, the leadership, managers, and ordinary workers not only bear related safety responsibilities they are responsible for, but also form an alliance to contribute to safety.

4.1.3 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 engineering, construction organization, suppliers should give their commitments to the corresponding part of safety duty, in which they are responsible. The commitment to safety is to be written in the policy statement of quality assurance programme and be inspected by operating organization and supervised by the NNSA. All organizations should fulfil the task of commitment down to its' 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 NPP staff, public, and environment from radioactive hazards.

4.1.4 Regulatory control

China has adopted a safety licensing system for NPPs. The NNSA is responsible for enactment and approving the issuing of safety licenses for NPPs. Before approving the issuing of safety licenses, the 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 NNSA is independent and compulsory. The NNSA has the right, when necessary, to take compulsory actions to order the operating organizations of NPPs to adopt safety measures or to stop any activities that endanger the safety.

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 nuclear industry Administration (CAEA) is responsible for safety management of NPPs, providing necessary support to NPP operating organizations and performing surveillance and inspection on NPP safety.

4.1.6 Good Practice Relating to Safety

Development of nuclear power in China was faster in recent years, nuclear safety level be enhanced in order to ensure no increase of risks to the public. For surveillance of nuclear safety and operation of NPP, China will continue to track the advanced experience or good practice in foreign countries of advanced nuclear power, in order to keep nuclear safety requirements and level of China consistent with international level.

(1) Preparation of nuclear safety regulations and codes in China widely refers to IAEA safety standards and relevant international standards.

(2) Nuclear safety regulatory body jointly with the nuclear industry system holds seminar to exchange experience of nuclear power operation every year in order to improve operation safety of NPP.

(3) The NNSA insists on utilizing original information and assessment results from the external to serve for improvement of nuclear safety management. In operating NPP, internal surveillance of nuclear safety by using risk-informed analysis is now being popularized.

(4) In the area where the NPPs are relatively centralized, regional offices for nuclear safety regulation have been established. Inspectors for nuclear safety regulation have been trained specifically and qualified.

(5) The nuclear industry administration has strengthened safety management and safety education for NPP operating organization. It organizes periodic safety inspections for NPPs, rigorously implements the rules for qualification and examination of the NPP operators, lays stress on training for NPP management and learning safety management experience from foreign peers.

(6) The emergency arrangements for nuclear accident were systemically evaluated to find something to improve and increase the effectiveness in order to ensure requirements for increasingly duty are satisfied.

(7) Nuclear industry administration, nuclear regulatory body, and NPP

operating organization always attach importance to effective exchange activities with international peers. These exchange activities include IAEA operation safety review, WANO performance index comparison and peer review, making agreements of sister plants with similar type of reactor and technology, periodic exchange and mutual visit. These activities are benefit to find difference between China and international level, to determine the target to seek and promote management level on nuclear safety continuously.

4.2 Financial and Manpower Resources

4.2.1 Financial Resources

In China, all expenses on safe operation and improvement of NPPs are borne by NPPs. After a NPP has been put into operation, a defined percentage of the benefit 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. Chinese government also allocates certain amount of funds for technical research and development of nuclear power and its safety.

In order to adapt demand on development of NPPs in China, Chinese government has increased financial budget and infrastructure to ensure implementation of the functions in nuclear safety regulation.

4.2.2 Manpower Resources

4.2.2.1 Manpower Resources in NPP

The qualified personnel required by the Chinese NPPs come from following resources:

(1) When drawing up nuclear power developing programme, Chinese government also makes target for cultivating personal. It creates good conditions for the growth of management personnel on nuclear safety and NPP operation.

(2) The nuclear industry of China fostered a batch of qualified nuclear engineering specialists and management personnel. They are rich of experience in design, construction and operation management and serve as the backbone of the scientific and technical team of the NPPs.

(3) The NPPs in operation and other civil nuclear facilities have fostered a batch of professional people for the NPPs under construction.

(4) There are many professional people specialized in conventional island and electrical engineering in Chinese electric power industry. The NPPs can choose persons from them.

(5) Graduates of universities and colleges every year are another human resources for NPPs.

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

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

The NPP personnel should pass special training courses before taking the job. Training centers are established and full-scope training simulators are installed in operating NPPs. They are used for training, retraining and examining of operating personnel and for training of managing personnel.

4.2.2.2 Nuclear Safety Regulatory Personnel

The NNSA undertakes safety evaluation and surveillance of the Chinese NPPs. The qualification requirements for the inspectors of nuclear safety are defined in the regulations on nuclear safety. They are: education level with bachelor degree or higher, five year’s engineering experience or more, three year’s nuclear safety regulatory experience or more. If necessary, the NNSA selects and recruits its staff among the persons on nuclear power technical management in China or the persons who accepted nuclear safety training abroad and came back to China.

4.3 Human Factors

4.3.1 Actions Taken to Prevent and Correct Human Errors

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

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

conditions. Multi-alarm indications occurring simultaneously or almost simultaneously are reduced as much as possible to avoid any confusion to operational personnel.

(2) Establishing operation experience feedback system to prevent and correct human errors: Nuclear power operation experience feedback system is established in operating organization, enterprises group, nuclear industry administration, the NNSA and technical support organization, respectively. Experiences 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 levels of operation management and safety regulation.

4.3.2 Measures in the Operation Management

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

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

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

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

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

4.3.3 Functions of the Regulatory Body and the Operating organization

The main tasks of the Chinese regulatory body in the field of human factors are: checking and examining the qualification of safety related personnel of the NPP or whether the licensees report deficiencies and abnormal situations in a timely and accurately manner.

The operating organization not only fulfills the above-mentioned tasks but also emphasizes on risk analysis and assessment activities prior to operation, maintenance and periodic testing. For important and risky work, the person who bears technical responsibility must be present on working site. Important operation and testing are assigned to qualified and experienced personnel. Safety and quality supervision on site is strengthened so as to put forward preventive measures and processing principles of human errors.

In 2001, the NNSA published "Statement on nuclear safety policy ---several important safety problems for design of the new NPPs". It stated that human errors should be taken into account during whole design process of the NPP and should be one of the important contents of safety evaluation for new NPP in the future.

4.4 Quality Assurance

4.4.1 Quality Assurance Policies

(1) The operating organization of the NPP has overall responsibility for ensuring the safety of its NPP. The operating organization shall establish and implement effectively the overall quality assurance programme and the partial programmes for each activity.

(2) The operating organization may entrust other organizations to establish and implement the programme wholly or partly but retains its responsibility for the effectiveness of the overall programme without reduction to the contractors' legal responsibilities or obligations.

(3) The quality assurance programme should involve the activities necessary for achieving the corresponding quality of items or services, the activities that are necessary for verification of the required quality having been achieved already and the activities for producing the objective evidence for above-mentioned activities.

(4) The contractor and the supplier related to the safety of unclear power plant establish their quality assurance programme according to the requirements in the contract in order to control their activities.

(5) The main responsibility for achieving quality rests with the persons who undertake the task, not with the persons who verify the quality.

(6) The persons having responsibility for verifying and inspecting the task should be independent of the persons or groups who directly perform the task, and the persons conducting the independent review and surveillance should be also

independent of the organizations that have responsibility for performing the task.

(7) The managing departments of the organizations participating in the programme shall carry out periodical review of status and adequacy of the quality assurance programme in order to assess its applicability and effectiveness. The overall quality assurance programme established by operating organization shall be submitted to the national nuclear safety regulatory body for approval.

4.4.2 Quality Assurance Programs at Each Stage of NPPs

The Chinese NPPs have established quality assurance programmes according to the requirements in nuclear safety regulations in each stage of the plant including siting, design, construction, commissioning and operation within the whole lifetime of the plant.

4.4.3 Implementation and Assessment of Quality Assurance Programes

The Chines NPPs use quality assurance as an important tool of effective management. Quality assurance progammes are effectively implemented through thorough analyses of the tasks to be performed, identification of the skills required, selection and training of appropriate staff, use of appropriate equipment and procedures, creation of a satisfactory working environment, recognition of the responsibility of the individual who is to perform the task, verifying if the activities are performed correctly and the production of documents proving that the required quality is achieved.

4.4.3.1 Quality Assurance Organization

Each NPP has established its quality assurance department that is directly leaded by the plant manager and independent of other plant departments. The responsibilities and activities of the quality assurance department are in the following:

(1) Establish and revise the quality assurance programme at each phase of the NPP.

(2) Perform planned internal and external surveillance and audit on quality assurance to all plant departments and contractors.

(3) Propose the requirements of corrective actions for findings identified during surveillance and audit on quality assurance, and take follow-up actions for conducting corrective actions. When necessary, issue stop-work order or notification and report to superior management organization.

(4) Participate in the examination of the supplier’s qualification and be

responsible for review and evaluation of quality assurance capabilities of suppliers.

(5) Review quality-related documents, including all management procedures of NPP, document package of design modification, quality plan, non-conformance report, procurement documents and quality assurance programmes of contractors, etc.

(6) Periodically submit the reports on quality activities, statistics reports of quality deficiencies, and analysis reports of quality trends to the management organization.

(7) Prepare programme and procedures on quality assurance training and perform education and training of plant personnel on subject of quality assurance.

4.4.3.2 Management Review

All management departments of the organizations participating in the implementation of quality assurance programme shall perform periodic review on the status and adequacy of quality assurance programme 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. When review the effectiveness of implementing quality assurance programme, each key element of the programme is evaluated and following aspects are emphasized during evaluation:

(1) Severe quality deficiencies existed before but having been resolved in the past year;

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

(3) Severe quality deficiencies unresolved;

(4) Overall evaluation for the effectiveness of implementing programme based on the applicability of programme.

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

The result of management review shall be documented.

Corrective action must be taken when programme deficiencies are discovered. Related organizations and units should be notified in written and timely manner. Quality assurance department should take follow-up action on implementation of corrective actions.

The quality assurance programme must be reviewed more frequently when following one or more situations exists:

(1) Regulations on nuclear safety revised or renewed.

(2) Significant problems occurred in the organization or unit responsible for certain activity.

(3) Trend for quality declines obviously.

When it is necessary to revise the programme, the programme should be revised according to the procedure for document change.

4.4.4 Regulatory Control Activities

(1) Draw up and promulgate the code on the NPP quality assurance and the related safety guides and technical documents.

(2) Review and approval the quality assurance programmes of the NPP.

(3) Supervise the implementation of the quality assurance programme of the NPPs from nuclear safety point of view.

4.5 Assessment and Verification of Safety

4.5.1 Licensing Process for Different Stages of a NPP

Control over safety on siting, construction, commissioning, operation and decommissioning of NPP is maintained primarily through the corresponding licenses approved by the NNSA which authorizes the correlative activities and places conditions to comply with by the licensee.

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

Construction－The applicant submits the “Application for the Construction of Nuclear Power Plant” to the NNSA, together with the “Preliminary Safety Analysis Report”(PSAR), the "Quality Assurance Programme of Nuclear Power Plant" at design and construction stages, the "Instrument of Ratification of the Feasibility Study Report for Nuclear Power Plant", and the "Instrument of Ratification of the Environmental Impact Statement for Nuclear Power Plant". After the design principles of NPP are reviewed and assessed by the NNSA, a conclusion is reached on whether the NPP is safe after it’s constructed. 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 NNSA, together with the “Final Safety Analysis Report of Nuclear Power Plant” (FSAR), the instrument of ratification of the “Environmental Impact Assessment Report of Nuclear Power Plant”, the “Commissioning Programme of Nuclear Power Plant”, the “Emergency Plan of the Operating Organization of Nuclear Power Plant”, etc. The 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 NNSA, together with revised the “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 Statement for Nuclear Power Plant”. The 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 NNSA, together with the “Decommissioning Report of Nuclear Power Plant” and the “Instrument of Ratification of the Environmental Impact Statement for Decommissioning of Nuclear Power Plant". The 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.

It should be mentioned here that the corresponding environmental impact assessment reports of the different stages e.g. construction, fuel loading, operation and decommission of the NPP are to be submitted to the SEPA. Instrument of ratification of environmental impact assessment reports are issued by the SEPA after examinations.

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

4.5.2 Main Results of Continuous Surveillance and Safety Assessment.

Up to December of 2000, the Qinshan NPP has experienced the trials of period of five fuel cycles. The two units of Daya Bay NPP have experienced the trials of period of six fuel cycles. The results of periodic testing, in-service inspection, and safety assessment of NPPs in China indicate that the safety performances of NPPs meet requirements of technical specifications and the integrity of three safety barriers is kept well. The results of monitoring carried out by the SEPA indicate that the annual radioactive liquid effluent releases and the annual radioactive airborne effluent releases are far below the release limits of national standard. The occupational exposures on the personnel of NPPs and the exposures on public are both far below the limits of the national standard.

During the fourth refueling outage of Qinshan NPP, failures of the components at the bottom of core barrel were found. The plant had been in the state of outage and overhaul NNSA established a expert group for review the problems on the core barrel of Qinshan NPP. The premise of their solving the problems of core barrel was to find direct and root sources of barrel failure. The control point of nuclear safety regulation is to determine making the repaired components be put back and fuel reload. The repair of the core barrel was supervised by the NNSA. No radioactive accidents occurred through strictly implementing the programme on radiation protection. Qinshan NPP has operated normally since its re-connection to the grid on 16 September 1999.

Since 2000, Guangdong Daya bay NPP has performed a systematic review by using probabilistic risk assessment (PSA) to enhance its level of operation safety.

In a word, the Chinese NPPs in operation are kept in a better safe condition and the environmental radiation around the NPPs is kept in the background level. The construction quality of the NPPs under construction is under controlled conditions.

4.5.3 Verification Programme and its Implementation

Work programmes and plans of preventive maintenance, in-service inspection and periodic testing during normal operation and shutdown for refueling have been prepared by NPPs in operation in China according to requirements of nuclear safety regulations.

Nowadays, based on experience feedback, preventive maintenance programme has been revised and optimized by NPPs for further improvement of preventive maintenance. Qinshan NPP attaches high importance to preventive maintenance and obtained good results. Guangdong Daya Bay NPP is promoting a management strategy based on reliability-centered maintenance (RCM).

Pre-service inspection is implemented before operation and in-service inspection is implemented during the period of shutdown for refueling according to the in-service inspection programme. In 2000, during the outage for refueling, Qinshan NPP performed its fifth in-service inspection. Guangdong Daya Bay NPP performed its sixth in-service inspection. The results of inspections and tests shown that all equipment and components that were inspected are in good condition and fully meet the needs for safe operation in the next cycle.

4.5.4 Control Activities of Regulatory Body

The NNSA conducts strict controls to all key links in construction, commissioning, fuel loading, and operation of the NPPs. For example, the NNSA sent inspectors to the NPP site to conduct surveillance and witness for water pressure tests of primary loop, gas-tight tests of containment, etc. and to organized integrated examinations before first fuel loading. The NNSA defined the conference points for all stages of first fuel loading, first criticality, and power escalation in the license conditions of “Instrument of ratification of the first fuel loading”. The NNSA also set the control points for re-criticality after maintenance outage of NPP.

The NNSA always regards the routine inspections of NPPs as its principal tasks. In view of Chinese operating NPPs’ shorter operation history and less operation experience, and the problems on component reliability not fully emerged, the NNSA has strengthened its routine inspections and inspections of refueling outage, actively conducted the activities on analyses of operation incidents and feedback of operation experience, effectively guaranteed the safety of the NPPs.

According to “Programme on nuclear safety inspections at construction phase of

NPPs”, the NNSA made a further perfection of the modes in safety inspection during construction of NPPs. Meanwhile, the NNSA invited the experts from IAEA and related countries for consults of nuclear safety reviews, time after time, thus guaranteed the safety of the NPPs in construction.

4.6 Radiation Protection

4.6.1 Regulations and Standards on Radiation Protection of NPPs

(1) The principled requirements on design of radiation protection and radiation protection in NPP operation are established by nuclear safety codes, the “Code on the Safety of Nuclear Power Plant Design”(HAF102) and the “Code on the Safety of Nuclear Power Plant Operation” (HAF103) respectively.

(2) The related requirements on the dose equivalent limits are stipulated by the national standard, “Rules on the Radiation Protection” (GB8703-88) as follows:

— The annual effective dose equivalent limit of the occupational exposure is 50mSv. The annual dose equivalent limit for the eye crystal and for the other single organ or tissue is 150mSv and 500mSv, respectively.

— When a few staff are needed to accept the radiation exposure overstepping the annual dose equivalent limit, the individual effective dose equivalent should not be more than 100mSv in one event and 150mSv in the whole life, respectively. In the meanwhile it should be restricted by the annual dose equivalent limit in above item concerning single organ or tissue.

— The annual effective dose equivalent limit of any members of the general public is 1mSv. The annual dose equivalent limit for the skin and the eye crystal of any members of the general public is 50mSv.

(3) The related requirements on the dose equivalent limits and the annual discharge limits are stipulated by the national standard, “Rules on the Environmental Radiation Protection of Nuclear power Plant” (GB6249-86) as follows:

— The annual effective dose to any members (adults) of the general public caused by the discharge of the radioactive substance of each NPPs shall not exceed 0.25mSv.

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

The Annual Discharge Limits of Each NPPs 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 Implementation of Regulations and Standards Related to Radiation Protection

4.6.2.1 Dose Limits

(1) The occupational exposure

The annual average dose equivalent for the site personnel in two operating NPPs of China (Table 1 of Annex 2) is far below the dose equivalent limit set by the national standards.

(2) Radiation exposure on the public

The environment monitoring centers of the province in which the Chinese NPPs are located have performed the monitoring of the environment around NPPs. The results indicated that the radioactivity of the surrounding environment keeps at the level of the ambient background investigation. The maximum individual dose equivalent to the general public by the discharge of the radioactive effluents in the operation period is far below the dose equivalent limit set by the national standards.

4.6.2.2 Amount of Radioactive Waste

The discharge of the radioactive effluents in the operation period of Chinese NPPs (Table 2 of Annex 2) is far below the discharge limits set by the national standards.

The amount of radioactive solid waste is listed in Appendix 2.

4.6.3 Measures Taken to Ensure that the Radiation Exposure is Kept As Low As Reasonably Achievable (ALARA)

4.6.3.1 Application of ALARA Principle in Design

(1) General design considerations

— General design considerations and methods used for keeping ALARA of in-plant radiation exposures have two objectives:

- To minimize the amount of personnel time spent in radiation areas;
- To minimize radiation levels in routinely occupied plant areas and in the

vicinity of plant equipment expected to require attention of personnel.

— Equipment and facility designs are considered in maintaining exposures ALARA during plant operations including: normal operation, maintenance and repairs, refueling operations and fuel storage, in-service inspection and calibrations, radioactive waste handling and disposal, and other anticipated operational occurrences.

— Experiences and data from operating plants are evaluated to decide if and how equipment or facility designs could be improved to reduce overall plant personnel exposures. Methods to mitigate such exposures are implemented wherever possible and practical.

— In designing radioactive systems, important considerations are to reduce the need for equipment maintenance, to minimize necessary maintenance times, and to lower the radiation levels at which maintenance and other operational activities are performed.

(2) Equipment design considerations

— Equipment design considerations to minimize the duration of personnel staying in a radiation area include:

• Reliability, durability of the selected equipment, components, and materials to reduce or eliminate the need for repair or preventive maintenance;

• Servicing convenience for anticipated maintenance or potential repair, including easy disassembly and modularization of components for replacement or removal to a lower radiation area for repair;

• Redundancy of equipment or components to reduce the need for immediate repair when radiation levels may be high and when no feasible method is available to reduce radiation levels;

• Provisions, where practicable, to remotely or mechanically operate, repair, service, monitor, or inspect equipment.

— Equipment design considerations directed toward minimizing radiation levels proximate to equipment or components requiring personnel attention include:

• Provisions to flush, if necessary, by means of remote control, to clean the equipment containing radioactive material;

• Design of equipment piping, connections and valves to minimize the build up of radioactive material;

• Provisions to isolate equipment from radioactive working fluid;

• Provisions to minimize the contamination seeping in the service areas of equipment including drain piping;

• Utilization of high quality valves, valve backings, and gaskets to minimize leakage and spillage of radioactive materials;

• External surfaces are coated with easily decontaminated paint.

— Corrosion products carried by the reactor coolant and activated when passing through the core are one of the main sources of radiations in a plant, the attention is paid to reduce the production of such products as well as to deal with their distribution and retention throughout the circuits as follows:

• Choice of alloys in contact with reactor coolant. They are corrosion resistant and as far as possible have a low cobalt content;

• Chemical specifications for reactor coolant;

• Surface condition and surface cleanliness.

(3) Facility layout design considerations

— Facility design considerations to minimize the duration of personnel staying in a radiation area include:

• Equipment, instruments, and sampling stations that need routine maintenance, calibration, operation, or inspection, are designed for easy access and minimum stay time in radiation areas;

• Laying out plant areas to allow remote or mechanical operation, service, monitoring, or inspection of highly radioactive equipment;

• Providing, where practicable, for transportation of equipment or components requiring service to a lower radiation area.

— Facility design considerations directed toward minimizing radiation levels in plant access areas and in the vicinity of equipment requiring personnel attention include:

• Separating radiation sources and occupied areas where practicable;

• Providing adequate shielding between radiation sources and access and service areas;

• Where appropriate, separating equipment or components in service areas with permanent shielding;

• Locating equipment, instruments and sampling points in the lowest practicable radiation zone;

• Providing means and adequate space of utilizing movable shielding for sources within the service area when required;

• Providing means for decontamination of service areas;

• Providing means to control contamination and to facilitate decontamination of potentially contaminated areas.

4.6.3.2 Application of ALARA Principle in Operation

(1) Achievement of radiation protection objective

The implementation of the ALARA principle is closely related to the modes of activities and control of behavior in the plant, mainly involving entering and exiting controlled areas, work preparation and operation in controlled areas, and radiation supervision and protection of staff as well as decontamination. Therefore, the site personnel will, through such measures as education on radiation protection and administrative control, be asked to strictly execute work plans and observe the operation procedures so as to fulfill self-protection and to protect others.

The radiation protection workers equipped by the operating organizations are conversant with the radioactivity-related operational equipment, systems and processes of the plant, the locations, types and levels of various radioactive sources in the plant and radiation protection design features. They also know well the radioactive hazards on working system and the corresponding protective requirements and stipulations, and are capable of undertaking radiation exposure planning by applying the theoretical knowledge and practical experience on radiation protection.

The radiation protection departments periodically perform radiation surveys to evaluate radiation exposures to staff and understand the tendency of radiation variations in order to provide a radioactivity basis for the managing departments of the plant to modify the design details, to perfect the operation procedures and to improve the operation skills.

(2) Implementation of radiation protection procedures

To achieve the ALARE principle, the radiation protection departments focus their studies on all operations related to radiation exposures in controlled areas and work out detailed protective procedures. In view of working tasks, they study the radioactive information of the plant, investigate the existing working conditions on the site, estimate the dangers of radiation and contamination and determine the protective measures and alternative approaches. Especially for operations likely to be subject to high radiation exposure, brief explanations about operations in working areas, simulative training and guidelines in the field of radiation protection technology are provided to operators in advance. These are helpful to lower the doses of exposure to individuals and the working population. During operation, the data of doses to operators are evaluated for the purpose of reducing them in similar events in the future.

(3) Control of radiation exposures

Throughout the operation of the Chinese NPPs, the radiation protection departments take the following measures to ensure that the occupational radiation exposures are ALARA.

— Technical considerations:

• To reduce the external exposure with the help of minimizing contamination shielding, remote control and operation, and by shortening exposure times;

• To reduce the internal exposure by means of isolation, ventilation, decontamination and use of protective clothing and respiratory equipment;

• To demarcate the plant areas in accordance with radiation and contamination levels and restrict access to controlled areas;

• To classify the site personnel in accordance with different working conditions and to implement corresponding control and supervision;

• To monitor individuals and work areas.

— Management considerations:

• To strengthen the training, retraining and qualification review of all staff;

• To establish the allowable limits of radiation exposures applicable to Chinese NPPs;

• To implement the system of radiation work permits;

• To approve as few as possible personnel for working in controlled areas;

• To forbid smoking, drinking or eating in controlled areas;

• To forbid unnecessary stay in radioactive areas;

• To avoid getting close to radioactive sources;

• To provide radiation protection staff with procedures for the radioactive work and the related documents;

• To establish and keep permanent records of dose equivalent for all site personnel;

• To keep investigation records on radiation and contamination in the plant, results of monitoring processes and zones, and other radioactive information;

- To investigate and report any radioactive accidents and take actions to prevent their recurrence.

4.6.4 Environmental Radioactivity Monitoring

4.6.4.1 Monitoring Objectives

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

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

— To ensure that the related stipulations of the national regulations are obeyed;

— To appraise the long-term tendency of environment radioactivity;

— To assess the transportation and diffusion of radioactive substance in the environment.

4.6.4.2 Working Scope of the Environment Monitoring

The environmental monitoring programme has been established according to critical nuclides, critical path of exposure (transportation) and critical public groups defined in the environment impact report (EIR) by the operating organization. The items and frequency of the environment monitoring are provided in the related procedures.

(1) The environment investigation of pre-operation

— The operating organization of NPP fulfills two-year investigation of the ambient radioactivity and the ocean ecosystem.

— The operating organization obtains the information of critical nuclides, critical path of exposure (transportation) 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 and soil, etc..

— The investigation range of γ radiation in the environment is 50km, the investigation range of other items is 20km.

— The analyzing and measuring contents include the radiation level in the environment and the radioactive nuclides related to NPPs.

(2) The routine environmental radiation monitoring

— The operating organization of NPP has established an environmental monitoring programme which includes the monitoring range, the types of the monitored environment media, the sampling and measuring period, the nuclides to be analyzed and measured and the monitoring methods, the quality assurance for the monitoring, records of monitoring data and the reporting system, etc..

— In order to satisfy the environmental evaluation needs, the operating organization of the NPP adequately uses 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.

(3) The effluent monitoring

The operating organization and the local environmental protection department monitor all types of airborne and liquid radioactive effluents after the NPP is in operation. The measuring contents include the total discharge quantity, the discharge concentration and the main nuclides to be analysed.

(4) The meteorological monitoring

The operating organization has equipped with the meteorological monitoring instruments and worked out the meteorological monitoring programme to monitor the conditions for air diffusion and the related statistical parameters. The contents of the meteorological monitoring are:

— Direction and speed of the wind and temperature of the air in different elevation above the ground;

— The rain amount and the air pressure, etc..

The selected monitoring place can represent the discharge point. In addition, the communication connection has been established between the operating organization and the local provincial meteorological department to exchange the related meteorological data.

(5) The environmental emergency monitoring under accident

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

— The operating organization has equipped with 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 when necessary to make sure that these emergency response facilities are available when they are to be used.

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

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

4.6.5 Control Activities of the Regulatory body

(1) The SEPA

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

— To review the environmental impact report (EIR) submitted by the operating organization of the NPP. After reviewing the EIR, the SEP issues the "Instrument of Ratification of the Environmental Impact Report" to the operating organization.

— 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.

From 1998 to 2000, the main activities of the SEPA in regulating the radiation environment are:

— Strengthening the regulation of the radiation environment, re-evaluating the monitoring capability of radiation environment in China, planning to establish a network for radiation environment monitoring, and founding the monitoring technology center for radiation environment, the nuclear and radiation accident emergency center and the quality monitoring networks of the SEP.

— Reviewing work of the EIR of Tianwan NPP, and ratifying the EIR at design stage of Tianwan NPP.

(2) The NNSA

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

— To evaluate whether the NPP conforms 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 rectificative measures for the items discordant with the requirements of the related regulations and standards.

From 1998 to 2000, the main activities of the NNSA in regulating the radiation protection and the radioactive waste are:

— Sending inspection groups to inspect the situation of the radiation protection and radioactive waste management of the NPPs, and putting forward opinions about improving the management work.

— Stipulating the ALARA evaluation criteria of the NPP.

— Realizing the computerized management of the national intermediate and low-level radioactive waste disposal facilities, and examining the first-stage project of Guangdong Beilong waste disposal facility and the preparation for renovating the flood-control project at the Northwest waste disposal facility.

— Performing the in-situ surveillance and inspection of the waste disposal system of the nuclear installations such as Qinshan NPP, and putting forward requirements on strengthening the waste management.

(4) The Ministry of Health

— Establishing regulations and criteria on managing the radioactive sanitation of nuclear facilities and the medical emergency under nuclear accident.

— Organizing review of the evaluation report of radiation protection at feasible stage of Jiangsu Tianwan NPP.

— Conducting monitoring of water and food around the NPPs.

4.7 Emergency Preparedness

4.7.1 Regulations and Requirements for Emergency Preparedness

The "Emergency Management Regulations for Nuclear Accidents at Nuclear Power Plant" is the legal basis of emergency preparedness for nuclear accidents in

China. It 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. Regulatory system for nuclear emergency and three level emergency preparedness system for nuclear accident have been established by Chinese government. The government can take necessary and effective emergency response actions once NPP severe accident occurs.

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.

4.7.2 Emergency Preparedness Measures

4.7.2.1 Category of Emergency Conditions

The emergency of nuclear accidents is classified into the following four conditions:

(1) Emergency Awaiting Orders: In case of some specific situations or external events which may lead to endangering the safety of NPP, relevant plant personnel are getting into on the alert status.

(2) Plant Emergency: The consequences of the accident situation are confined within a limited section of the plant, on-site personnel are activated according to the requirements of on-site emergency response plan and off-site emergency response organizations are notified.

(3) Site Emergency: The consequences of the accident spread to the whole site, the personnel on-site take emergency response actions to nuclear accident, organizations assigned by the provincial people's government are notified, some off-site emergency response organizations for nuclear accidents may take emergency response actions against nuclear accidents.

(4) Off-site Emergency: The consequences of the accident situation go beyond the site boundary, the on-site and off-site emergency response plans are put into effect.

4.7.2.2 Emergency Preparedness System

According to "Emergency Management Regulations for Nuclear Accidents at Nuclear Power Plant", 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 4.1.

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

(1) The NCCNE

The NCCNE is responsible for the organization and coordination of the national emergency management of nuclear accidents;

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

— Overall coordinating emergency response activities of departments concerned in the State Council, the nuclear industry administration, local government, NPP and other nuclear installations as well as the Army;

— Reviewing national work programme 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 emergency response;

— Making decision, organizing and commanding response actions for emergency support, reporting to the State Council in timely manner;

— 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 side or multilateral cooperation agreements; reviewing and approving communique and international notice for nuclear accident; working out the scheme for requesting international aids;

— Conducting other affairs that the State Council asked;

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

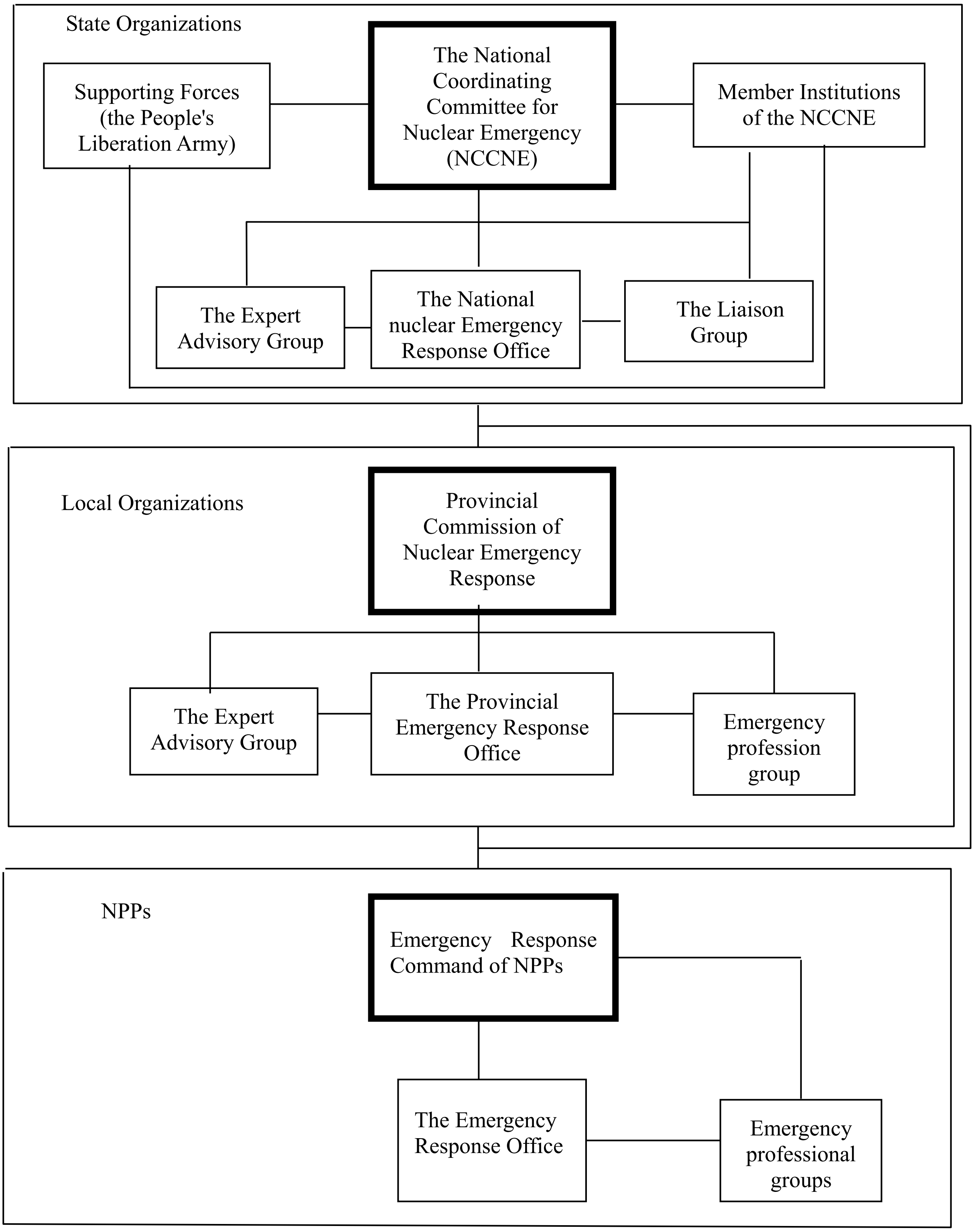

Figure 4.1 Organizational Structure of National Nuclear Emergency Response System

(2) The National Nuclear Emergency Response Office (NNERO)

The NNERO is a 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;

— Being in charge of routine activities of the NCCNE;

— Implementing national nuclear emergency plan; inquiring, coordinating and supervising emergency preparedness activities of member institutions of the NCCNE; notifying, guiding, and coordinating related emergency preparedness of local government and NPP;

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

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

— Organizing to review off-site emergency plan, off-site integrated exercise plan, and joint exercise plan of on-site and off-site; putting forward review comments.

— Organizing activities of liaison persons and experts advisory group.

— Organizing relevant training and exercise on nuclear emergency.

— When responding to emergency, collecting information, putting forward report and proposal, timely communicating and conducting decisions and orders from the State Council and the NCCNE; checking and reporting the evolution of implementation.

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

(3) The relevant departments of the NNSA, the SEPA, the Ministry of Health, and the Army conduct relevant emergency activities for nuclear accident according to their respective responsibilities.

(4) The Provincial Commission Of Nuclear Emergency Response at which the NPP located being responsible for emergency management for nuclear accident in its

district:

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

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

— Directing off-site emergency response actions;

— Organizing and providing support 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.

(5) The emergency Organization for nuclear accident of NPP operating organization is responsible for:

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

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

— categorizing 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 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 deal with the emergency response management of nuclear accidents.

4.7.2.3 On-site and Off-site Emergency Plans of Nuclear Power Plant

(1) Based on nuclear accidents that probably occur, on-site emergency response plan is prepared by operating organization, off-site emergency response plan is prepared by local government and the national emergency response plan of nuclear accident is prepared by the NCCNE. The contents of these three-level emergency response plans are co-related and coordinated. Each plan has its implementing procedures as a supplement and details. Besides, emergency schemes are prepared

respectively by the main member institutions of the NCCNE, emergency support organizations and the Army. The emergency response plans and the schemes are prepared, reviewed and approved and put to be revised periodically according to regulations.

The contents of emergency response plans include the emergency response organizations and their responsibilities, emergency preparedness with detailed schemes, facilities and equipment, coordination among emergency organizations and their support to be provided and other technical aspects.

The emergency plan of the NPP operating organization is reviewed and approved by the 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 plans is reviewed and approved by the State Council.

(2) The reporting system of emergency for nuclear accident:

When NPP is under an awaiting-order condition of emergency, the emergency organization of nuclear accident in the NPP timely reports to its superior authority and the NNSA. Depending on the situations, it can decide whether or not to report to the organization assigned by provincial government. When it is possible to have radioactive release or having already released, the organization timely declares to be in plant emergency or in site emergency condition depending on the situation, and promptly reports to its superior administration of NPP, the NNSA, and organization assigned by the provincial government. When the radioactive substance has probably or already diffused to off-site of NPP, the organization should make a proposal on being in off-site emergency condition and taking urgent protection measures to the organization assigned by provincial government. When receiving the report on the situation of NPP nuclear accident, the organization assigned by the provincial government should promptly take relevant emergency countermeasure for nuclear accident and urgent protection measure and timely report to the department assigned by the State Council. Decision on declaring to be in off-site emergency condition shall be approved by the department assigned by the State Council. Under special situation, the organization assigned by the provincial government have the priority to decide to be in off-site emergency condition and immediately report to the department assigned by the State Council.

(3) According to the principle for positive compatibility on emergency of

nuclear accident: to fully utilize the existing conditions, to establish a national technical supporting system for nuclear emergency and guarantee national capability in nuclear emergency response. It is necessary to establish and maintain a technical supporting center or technical aid organizations to cope with emergency decision support, radiation surveying, medical curing, meteorological service, and NPP operation assessment, etc.

4.7.2.4 The Public's Acquaintance with Emergency Preparedness

Local governments are responsible for the universal education on the basic knowledge of nuclear safety and radiation protection to the public living near NPPs, and propagating knowledge of emergency protection widely , 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 makes the public to dispel nuclear panic and to be activated effectively in case of an emergency through strengthening communication with local government and the public and explanation on the dialectical relationship between nuclear safety and nuclear emergency response.

4.7.3 Training and Exercises for Emergency Preparedness

4.7.3.1 Emergency Response Training

The objectives of emergency response training are to make the emergency response personnel be acquainted with the national regulations, standards and guides related to nuclear emergency response, master the basic contents of emergency response plans and implementing procedures so that the emergency response personnel possess the emergency awareness, basic knowledge and skills to fulfill specific emergency response tasks.

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

4.7.3.2 Emergency Exercises

Different categories of emergency exercises are implemented periodically in order to verify, improve, and strengthen the capability for emergency preparedness and emergency response.

The member institutions of the NCCNE organize exercise for single-item emergency, i.e. individual exercise, normally once a year, respectively, depending on the necessity. However, exercise for communication is required to conduct more frequently. The individual exercise only involving one organization is organized by the organization itself. For exercise involving more organization, it may be coordinated under the national emergency office for nuclear accident, if necessary.

The joint exercise that includes joint exercise among the three-level emergency organizations or between national emergency organization and provincial emergency organization or between national emergency organization and NPP emergency organization, and integrated exercise performed by multiple departments and multiple disciplines are performed once every three or five year and organized by national emergency office for nuclear accident.

In June 2000, the Chinese National Meteorological Center took part in the emergency exercise on atmosphere diffuse under nuclear accident jointly conducted by the IAEA and the international meteorological organization.

4.7.4 International Arrangement

As a member of the signatory states to the "Convention on Early Notification of A Nuclear Accident" and the "Convention on Assistance in the Case of A Nuclear Accident or Radiological Emergency", Chinese government accomplishes its duties according to the requirements of these two conventions.

5 SAFETY OF NPPs

5.1 Siting

5.1.1 Regulations and Requests on Siting

The NNSA established Chinese nuclear safety regulations and guides on siting after referring related nuclear safety standards of IAEA. The main regulations and guides are as follows:

— HAF001/01 “Application and Issuance of Safety License for Nuclear Power Plant”;

— HAF101 “Code on the Safety of Nuclear Power Plant Siting”;

— HAD101/01 “Earthquakes and associated topics in relation to nuclear power plant siting” ;

— HAD101/02 “Atmospheric dispersion in relation to nuclear power plant siting”;

— HAD101/03 “Site selection and evaluation for nuclear power plant with respect to population distribution”;

— HAD101/04 “External man-induced events in relation to nuclear power plant siting”;

— HAD101/05 “Hydrological dispersion of radioactive material in relation to nuclear power plant sitting”;

— HAD101/06 “Nuclear power plant sitting – hydrogeological aspects”;

— HAD101/07 “Site survey for nuclear power plants”;

— HAD101/08 “Determination of design basis floods for nuclear power plants on river sites”;

— HAD101/09 “Determination of design basis floods for nuclear power plants on coastal sites”;

— HAD101/10 “Evaluation of extreme meteorological events for nuclear power plant sitting”;

— HAD101/11 “Design basis of tropical cyclone for nuclear power plants”;

— HAD101/12 “Safety aspects of the foundation of nuclear power plants”.

5.1.2 Licensing Process

In accordance with Chinese nuclear safety code the “Application and Issuance of Safety License for Nuclear Power Plant” and other regulations, the applicants should follow national basic construction procedure, submit the “Nuclear Power Plant Feasibility Study Report”(Siting) to the NNSA and the “Environmental Impact Assessment Report of Nuclear Power Plant” to the SEPA prior to NPP site is selected. These reports should adequately explain that the site complies with the requirements of building NPP and national environment protection standards. These reports are examined and evaluated by the NNSA and the SEPA respectively to determine whether the NPP to be built will be safely operated on the selected site, “Reviewing Comments on Nuclear Power Plant Siting” and the “Instrument of Ratification of the Environmental Impact Assessment Report for Nuclear Power Plant” are then granted.

5.1.3 Criteria for Siting

Siting for Chinese NPP should comply with the “Code on Safety of Nuclear Power Plant Siting”(HAF101). 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 of nature 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) Population density, its distribution and other characteristics of the external zone in relation to the possibility of implementing emergency response measures and the need to evaluate the risks to individuals and the population.

5.1.3.1 Criteria of Design Basis for External Natural Events

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

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

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

(4) Appropriate methodologies are adopted for establishing the design basis natural events of important natural phenomena, the methodologies should be justified as being compatible with the characteristics of the region and the current

state-of-the-art.

(5) The size of the region to which a certain methodology for derivation of design basis natural events is to be studied is large enough to include all the features and areas which could contribute to the determination of the design basis natural events under consideration and to the characteristics of the events.

(6) Important natural phenomena are expressed in terms which can be used as in-put for deriving the design bases for natural events of the NPP.

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

5.1.3.2 Criteria for Design Basis for External Man-induced Events

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

(2) The region in which the NPP site is located is examined for facilities and human activities that might under some conditions endanger the proposed NPP. 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, are considered.

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

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

(5) Each important man-induced event is expressed in terms that can be used as input for deriving the design bases for these events of the NPP.

5.1.3.3 Criteria for Defining Potential Effects of the NPP on the Region

(1) In evaluating the radiation impact on the site region in NPP's operating condition and accident condition that could need emergency measures, appropriate

estimates have to be made for expected or potential releases of radioactive substances after taking into account the design of the plant and its safety features. In the review of siting, these radioactive releases are often treated as radiation source terms.

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

(3) The relationship between the site and the design of the NPP are 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 NPP should compensate for any unacceptable effects on the region at which the NPP located, otherwise the site should be deemed unsuitable.

5.1.3.4 Criteria Derived from Population Factor and Emergency Response Planning Considerations

(1) The region in which the proposed site is to be 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 individuals and the population as a whole.

(2) In relation to the characteristics and distribution of the population, the site and plant combination should satisfy that:

— During operational conditions the radiological exposure of the population remains as low as is reasonably achievable and in any case is in accord with national regulations;

— The radiological risk to the population from accident conditions, including those which may lead to the implementation of emergency response measures is acceptably low and in accord with national regulations.

If, after thorough evaluation it is shown that appropriate measures cannot be envisaged to meet the above requirements, the site is then deemed unsuitable for the construction of the proposed NPP.

(3) The external zone for a proposed site should be established with a view of the potential for radiological consequences to people and to the capability of

implementing emergency response plans, having due regard to any external event which may hinder implementation. Before construction of the NPP is started, it shall be determined that no basic problems exist for establishing an emergency response plan for the external zone before the plant goes into operation. For this requirement to be appropriately implemented,

— An evaluation is performed of the radioactive releases associated with accidents including severe accidents to a reasonable extent, using site specific parameters as appropriate.

— The feasibility of the emergency response plans is evaluated.

5.1.4 Implementation of Codes on the Safety of NPP Siting

In accordance with the "Code on the Safety of Nuclear Power Plant Siting" for the NPP to be built, the applicant evaluates all site-related factors affecting safety and impact of the NPP on safety of individuals society and surrounding environment during its projected life.

5.1.4.1 Natural Events Affecting Safety

In China, during the NPP siting, the applicant investigates and evaluates the natural factors in detail, and formulates the engineering design basis per investigations and related safety requirements. The natural factors may affect the safety of nuclear power plant 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;

— other important natural phenomena and extreme conditions.

5.1.4.2 Man-induced Events Affecting Safety

In China, the applicant investigates the man-induced events such as aircraft crashes, chemical explosion and other man-induced events that could affect the NPP.

After analysis, it indicates that the probability of occurring of these events is small. They don't endanger the safety of the NPP. The impact on the NPP safety is within acceptable level by proper design.

During the NPP siting, the relevant governmental department takes into adequate considerations of getting control over the activities of potential external man-induced events and their evolution in the region in accordance with the protection level demanded by the NPP.

5.1.4.3 Impact of NPP on Surrounding Environment and Inhabitants

In China, during siting, the applicant adequately investigates the risk of potential releases of radioactive substances to the surrounding environment and inhabitants, studies and controls the pathways which may lead to risks.

The applicant mainly investigates extensively the atmospheric dispersion of radioactive substances, dispersion of radioactive substances through surface and ground water, population distribution, use of land and water, etc., and observes them periodically, studies and analyzes by using models and controls effectively the risk of potential releases of radioactive substances to the surrounding environment and inhabitants.

5.2 Design and Construction

5.2.1 Codes and Requirements Related to Design of NPP

By reference to the corresponding Nuclear Safety Standard (NUSS) of the International Atomic Energy Agency (IAEA), China formulated the following codes and guidelines related to design and construction of NPP:

— HAF102 Code on the Safety of Nuclear Power Plant Design;

— HAD102/01 General Design Safety Principles for Nuclear Power Plants;

— HAD102/02 Anti-Seismic Design and Appraisal for Nuclear Power Plants;

— HAD102/03 Safety Functions and Component Classification for BWR, PWR, and PTR;

— HAD102/04 Protection against internally Generated Missiles and Their Secondary Effects in Nuclear Power Plants;

— HAD102/05 External Man-Induced Events in Relation to Nuclear Power Plant Design;

— HAD102/06 Design of the Reactor Containment Systems in Nuclear Power

Plants;

— HAD102/07 Design for Reactor Core Safety in Nuclear Power Plants;

— HAD102/08 Reactor Cooling Systems and Their Related Systems in Nuclear Power Plants;

— HAD102/09 Ultimate Heat Sink and directly Associated Heat Transport Systems for Nuclear Power Plants;

— HAD102/10 Protection System and Related Features in Nuclear Power Plants;

— HAD102/11 Fire Protection in Nuclear Power Plants;

— HAD102/12 Design Aspects of Radiation Protection for Nuclear Power Plants;

— HAD102/13 Emergency Power Systems at Nuclear Power Plants;

— HAD102/14 Safety-Related Instrumentation and Control Systems for Nuclear Power Plants;

— HAD102/15 Fuel Handling and Storage Systems in Nuclear Power Plants.

During reviewing the design of the imported NPPs, the NNSA requires the applicant of the “Nuclear Power Plant Construction Permit” to illustrate that the standards and specifications to use are in compliance with the requirements in related regulations and guides on nuclear safety of China. If there are no these standards and specifications in China, their adoption should be approved by the 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 conducive to preventing the general public and the environment from radioactive hazard.

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

The design criteria provided by the “Code on the Safety of Nuclear Power Plant Design” (HAF102) are as follows:

(1) Radiation protection

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

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

(2) Safety function

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

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

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

(3) Plant safety characteristics

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

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

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

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

(4) Design basis

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

(5) Severe accidents

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

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

(6) Quality of nuclear power plant

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

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

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

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

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

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

(8) Design for system and component reliability

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

— Redundancy;

— Single failure criteria;

— Diversity;

— Independence;

— Fail-safe design;

— Auxiliary services;

— Common cause failure;

— Equipment outages;

(9) Design for optimized operator performance

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

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

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

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

(10) Heat transfer to an ultimate heat sink.

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

In addition, the “Code on the Safety of Nuclear Power Plant Design.” (HAF102) also provides the requirements about the protection against fire and explosion, the effects associated with equipment failures, the sharing of structures, systems and components in multi-reactor NPP, the systems containing fissionable or radioactive materials, evacuation routes and means of communication, as well as the control of access to NPP and the decommissioning of NPP.

5.2.2 Approval Process of the Design Qualification and Construction Permit

(1) The applicant engaged in the nuclear island design should apply for the

qualification license from the Ministry of Construction, which grants to the applicant the qualification license of the nuclear island design after it is reviewed and qualified.

(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 NNSA. The NNSA grants the corresponding qualification license after it is reviewed by the competent department and finally checked and approved by the NNSA jointly with the departments concerned.

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

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

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

— Instrument of ratification of the "Environmental Impact Assessment 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 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 NNSA issues to the applicant the "Nuclear Power Plant Construction Permit".

5.2.3 Defense-in-Depth Conception and Its Applications

5.3.2.1 Defense-in-Depth Conception

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

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

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

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

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

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

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

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

5.2.3.2 First Application of the Defense-in-Depth concept

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

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

— Adequate attention is paid to all aspects of quality, such as the selection of materials, specifications, the use of construction and operation experiences and regulations of inspection, maintenance and 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 supply water

control system and the reactivity control system, etc.) are provided, and the operating procedures are established to prevent or minimize damage from such as 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, failure-safety 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 on in-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-base 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 every anticipated situations.

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

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

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

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

(3) The containment

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

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

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

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

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

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

5.2.4 Prevention and Mitigation of Accidents

5.2.4.1 Measures of the Accident Prevention

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

— The adequate use of inherent safety features;

— The adequate margins for material properties and technical parameters during the design and operation of the NPP;

— The adoption of effective technologies proven by the engineering practices;

— Systems and components which monitor and control the NPP operation being designed as far as possible to be of failure 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 NPP for seeking weak points in design;

— The operational experience feedback for improving the design and operational procedures of NPP.

In the design stage of Chinese NPP, human errors which may occur during operation are considered. In order to minimize human errors, first of all, the transient actions of the NPP 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 will be mentioned in 5.2.6.

5.2.4.2 Measures of the Accident Mitigation

Measures of accident mitigation of Chinese NPPs 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 NPPs.

In Chinese NPPs, 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 NPPs.

The accident emergency response measures of Chinese NPPs are described in 4.7.

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 NNSA. The documents (e.g., the FSAR) submitted to the NNSA by the operating organizations shall describe the adopted process and technology, which must be validated and verified by the operating organizations.

(2) The codes and standards adopted in the design process of Chinese NPPs have been identified and evaluated before their application, in order to confirm their applicability, and adequacy and to ensure 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) Qinshan NPP is the first NPP which is self-designed and constructed in China. On the basis of fully drawing on the mature experience of foreign commissioned PWR NPPs, China has carried out a large number of research, development and testing projects which mainly focus on the fields such as reactor physics, thermo-hydraulics, stress analysis, new materials, main equipment, instrumentation and controls, civil works, site environment, corrosion, welding and non-destructive inspections, etc.. The domestic expert group had reviewed Qinshan NPP after its design was finished. The design and calculation of certain important equipment were consulted with and verified by the foreign qualified manufacturers.

The design of Qinshan Phase II NPP also adopts mature and proven process and technology.

Guangdong Daya Bay NPP , Tianwan NPP and Qinshan Phase Ⅲ NPP are introduced from France, Russia and Canada, respectively. Their adopted process and technology is mature.

Guangdong Lingao NPP is designed and constructed by reference to Guangdong Daya Bay NPP.

5.2.6 Optimized Design for Operator Performance

The working areas and working environment of the site personnel of Chinese NPP 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 NPP.

(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 helps 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 function symbols to easily remind the operators of the devices under monitoring and control.

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

5.3 Operation

5.3.1 Regulations and Requests for Operation

5.3.1.1 Regulations and Guides for Operation

In order to ensure safe operation of NPPs, China established the following regulations and guides for operation:

— HAF103 “Code on the Safety of Nuclear Power Plant Operation”

— HAF103/01 “Management of Refueling, Modifications and Accidental Shutdown of Nuclear Power Plant”;

— HAD103/01 “Operation limits and conditions for nuclear power plants”;

— HAD103/02 “Commissioning procedures for nuclear power plants”;

— HAD103/03 “In-core and fuel management for nuclear power plants”;

— HAD103/04 “Radiation protection during operation of nuclear power plants”;

— HAD103/05 “Staffing, recruitment, training and authorization of nuclear power plants”;

— HAD103/06 “Management of nuclear power plants for safe operation”;

— HAD103/07 “In-service inspection for nuclear power plants”;

— HAD103/08 “Maintenance of nuclear power plants”;

— HAD103/09 “Surveillance of items important to safety in nuclear power plants”;

— HAD401/01 “Management of radioactive effluents and wastes in nuclear power plants”.

When examining the operation of imported NPPs, the NNSA demands the applicant of the "Operation License of Nuclear Power Plant" to clarify that adopted specifications and standard in supplier’s country are in accordance with the requirements in Chinese regulations and guides on nuclear safety.

5.3.1.2 Basic Requirements of the Regulations on Nuclear Power Plant Operation

HAF103 “Code on the Safety of Nuclear Power Plant Operation” provides the following essential requirements that must be met:

(1) Operating organization, competent department of nuclear power plant, and national regulatory body

— Operating organization of nuclear power plant shall have the overall responsibility with respect to the safety operation of the nuclear power plant.

— Competent Department of nuclear power plant shall have the leading responsibility with respect to the safety operation of the nuclear power plant.

— The operational safety of a nuclear power plant shall be accepted surveillance from the national regulatory body.

(2) Operational limits and conditions

— The operating organization shall establish operational limits and conditions covering technical and administrative aspects to ensure that the nuclear power plant is operated in accordance with design requirement. Operational limits and conditions shall reflect the final design and shall be reviewed and approved by the national regulatory body before commencement of operation. Operational limits and conditions shall contain requirements for different operational states, including shutdown.

— Requirements on internal surveillance that is conducted by the operating organization for ensuring compliance with the operational limits and conditions, including periodic checks, tests, calibrations and inspections of safety systems. The operating organization of NPP must establish surveillance programme and implement it correctly.

(3) Commissioning

— A detailed programme of tests shall be prepared, and the responsibility for implementing and reporting on the various parts of the programme shall be clearly defined. Close liaison shall be maintained between the national regulatory body and the operating organization during execution of the whole commissioning programme.

(4) Structure of the operating organization

— A documented organizational structure shall be established and the organization staffed with competent managers and sufficient qualified personnel. The staffed personnel shall be familiar with the technical and administrative requirements on safety and have high safety awareness. In order to guarantee safe operation in all operational states, mitigate accident results, and make correct response to emergent situation, the identifications of responsibilities, authority grades, relationship between supervisor and underling staff, and internal and external communication channel shall clearly defined.

(5) Plant management and operating personnel

— The operation managers bear the direct responsibility for the safe operation of the NPP. The operating organization shall empower a sufficient authority to the operation managers to ensure their effectively discharging the responsibility. The plant operation managers shall ensure that the NPP is operated in a safe manner, especially in compliance with the operational limits and conditions.

— The management structure of plant operation shall be suitable for implementing all functions that have direct effects on safe operation of the plant. The responsibilities for implementing these functions shall be clearly proclaimed in writing.

At any time a sufficient number of qualified persons shall be available for performing these functions.

(6) Operation procedures

— Before the commencement of operation, the operating organization must formulate the written detailed operation procedures.

— The operating personnel must be familiar with the contents of operation procedures and their revisions.

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

— When needing a procedure that is not existed in reality, the operation manager shall prepare the related special procedure and make it go into effect only by authorized persons .

— Once the reactor is shutdown caused by accident, the plant can be restarted only after finding out the root cause of shutdown and taking correcting measures.

— Except being clearly defined in the procedures, the operation personnel are not allowed to change, event temporarily, the physical configuration of the plant before receiving the written orders from authorized persons. In any case, such changes shall not violate the operational limits and conditions. The authorization and implementation of the changes shall be clearly recorded in operation records and be marked at the physical points and control points of the changes. The changes shall be removed as soon as possible.

— For the purpose of controlling important manipulations, the use of written orders shall be clearly stipulated.

(7) Maintenance, testing, examination and inspection

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

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

(8) Core and fuel management

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

— The operating organization must prepare and issue specifications and procedures for the procurement, loading, utilization, unloading, and testing of fuel and core components. A programme for loading and reloading of fuel must be established in accordance with the design requirements and submitted it to the national nuclear safety body. The surveillance of core condition must be conducted and the programme for loading and reloading of fuel shall be reviewed and modified as necessary. Criteria and procedures for treatment of defective fuel must be established to minimize fission product activity in the primary coolant or in gaseous effluents.

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

— Provisions shall be made to ensure that in each reactor only fuel whose design and enrichment have been approved by the regulatory body for use with that reactor is loading. The storage plans for fresh and irradiated fuel shall also be submitted to the national regulatory body for approval.

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

— A complete record system on core management, fuel performance, fuel and core component handling activities, and fuel storage shall be established and maintained.

(9) Modifications

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

(10) Radiation protection

— Radiation protection programme shall be established by the operating organization.

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

(11) Effluent and waste management

— The operating organization shall prepare discharge limits for effluents and establish methods and procedures for monitoring and controlling such discharges in order to comply with relevant regulations.

— The operating organization shall establish a waste management programme.

— The packaging, transport and dispatching of radioactive wastes shall be carried out in accordance with the relevant regulations.

(12) Review of operation and feedback of experience

— The operating organization shall perform regular reviews of the operation of the NPP.

— Operating experience shall be carefully examined to detect any possible symptoms of being adverse to safety, so that corrective actions can be taken before severe conditions occur to avoid recurrence of the incidents.

— The operating organization shall manage to obtain and evaluate the operational experience and lessons from other plants in order to use for reference in its operation. To this end, the exchange of experience and the application national and international databases are of great importance.

— The evaluation of operating experience of the current NPP and other NPPs shall be performed systematically by designating competent persons. Abnormal events important to safety shall be investigated to establish their root cause. Recommendations shall be given to the plant operation manager according to the result of the investigation. Information on experience feedback shall be fed back to the operating personnel in time and be as part of training programme.

— Plant operation manager should maintain suitable liaison with the design organizations in order to feed back operating experience to them and obtain some valuable suggestions on treating equipment failure or abnormal events.

— Data from operating experience are also essential to collecting information to improve the accuracy and the reliability of residual life evaluations and probabilistic risk assessment. Data from operating experience shall be kept and be available to the national regulatory body.

HAF103 “Code on the Safety of Nuclear Power Plant Operation” also provides the regulations for emergency preparedness, quality assurance programme, site safeguard, record and report, and decommissioning.

The performance of operation safety of Chinese NPPs indicates that the above basic requirements for operation safety are very important to ensuring the safety of operating NPPs. The operation regulations will be perfected in company with the development of nuclear safety and techniques and the accumulation of experience feedback.

5.3.2 Operation Licensing Process

The licensing process for Chinese NPP is divided into two phases: Phase 1, before operation, the operating organization applies 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 the “Operation License of Nuclear Power Plant” twelve months after the trial operation on full power.

5.3.2.1 The Licensing Process of “Instrument of Ratification for the First Fuel Loading of Nuclear Power Plant”

The operating organization must submit the “Application for the First Fuel Loading of the Nuclear Power Plant” to the NNSA prior to the first fuel loading of the NPP, together with the following documents:

— “Final Safety Analysis Report”;

— Instrument of ratification of the “Environmental Impact Assessment Report of Nuclear Power Plant” (one month before the first fuel loading);

— “Commissioning Program of Nuclear Power Plant”;

— Qualification certificates of operators for the NPP (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”;

— 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 NPP (one month before the first fuel loading);

— The list of operation rules of NPP(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 NNSA organizes related experts to review and assess the above mentioned documents. After confirming that these documents are in compliance with the requirements of the national nuclear safety standards, the “Instrument of Ratification for the First Fuel Loading of Nuclear Power Plant” is issued to the applicant.

5.3.2.2 The Licensing Process of “Operation License of Nuclear Power Plant”

The operating organization shall timely submit the following documents to the NNSA twelve months after 12 month’s trial operation on full power of the NPP:

— “Revised Final Safety Analysis Report of Nuclear Power Plant”;

— Instrument of ratification of the “Environmental Impact Assessment 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 NNSA organizes related experts to review and assess the above mentioned documents. After confirming that these documents are in compliance with the requirements of the national nuclear safety standards, the “Operation License of Nuclear Power Plant” is issued to the applicant.

5.3.3 Actions Taken to Assure the Operation Safety

5.3.3.1 Safety Analysis and Commissioning

The initial authorization for operating a NPP in China is based upon the proven fact that the constructed NPP 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 NPP;

— The postulated initiating events related to the NPP 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.

(2) Commissioning program and quality assurance program are drawn up in China by the operating organization to plan and ensure the effective implementation of commissioning activities. The commissioning program includes the verification of safety equipment and their functional characteristics as well as radiation protection. Until the evaluation of results and audits in current commissioning stage are available and to ascertain meeting all objectives and nuclear safety regulatory requirements, the next stage will not be started. Chinese NPPs had performed commissioning tests at the stages of fuel loading, criticality and power escalation. The NNSA had set the control points at each important commissioning stage.

The NNSA reviews and assesses such documents as “Final Safety Analysis Report of Nuclear Power Plant”, “Reports of Commissioning and Trial Operation of Nuclear Power Plant after Fuel Loading”, “Quality Assurance Program of Nuclear Power Plant during Operation Period”, etc. revised by the operating organization of the NPP. Through the surveillance and inspection on nuclear safety during trial operation to make sure that the results of commissioning is consistent with the design and examine and approve the revised operation limits and conditions. After one year’s full power operation of NPP, the NNSA will issues the “Operation License of Nuclear Power Plant” to the operating organization when receiving the instrument of ratification of the “Environmental Impact Assessment Report of Nuclear Power Plant” from the NPP.

5.3.3.2 Establishment and Periodic Revision of Operation Limits and

Conditions

In China, the operation limits and conditions that are prepared by the operating organization and approved by the NNSA shall form an important part of the basis on which the operating organization is authorized to operate the NPP. The operating personnel who are directly responsible for operation shall be familiar with and strictly comply the operational limits and conditions.

The operational limits and conditions are classified according to their attributes as:

(1) Safety limits;

(2) Limits on safety system settings;

(3) Limits and conditions for normal operations;

(4) Surveillance requests.

The operational 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 shall be made according to the results of tests in the phase of commissioning.

The operation limits and conditions are reviewed periodically throughout the operating life of the NPP in the light of accumulated experience and technological developments. The operating organization is responsible for preparation of the working procedures for revising operation limits and conditions and makes revision of operation limits and conditions according to the procedures. Assessments and reports of anticipated operational incidents shall be important bases for determining whether or not the operation limits and conditions need to revise. Any revision on operation limits and conditions made by Chinese NPPs should be reviewed and approved by the NNSA.

5.3.3.3 Program of Operation, Maintenance, Inspection and Testing

Before commencement of operation, the operating organization has prepared the written operation procedures and the programmes for periodic maintenance, testing, examination, and inspection of those structures, systems, and components that are essential to safe operation. The operation procedures and the programmes for maintenance, inspection, and testing shall be in accordance with the operation limits and conditions approved by the NNSA and other regulatory requirements on nuclear safety. Operation, maintenance, inspections, and tests of the NPP shall be implemented exactly according to the approved procedures.

The operation procedures and the programme of maintenance, inspections, and tests are periodically reviewed, reevaluated and updated in the light of operating experience.

5.3.3.4 Accident Response Procedures

In China, the response procedures for both anticipated operational occurrences and accidents have been prepared and verified on full-scale simulator and/or on-site as far as possible. The operators shall be taken training on the procedures.

The accident response procedures of Qinshan NPP are designed by referring to the relevant criteria of the similar foreign nuclear power plants. The procedures are composed of the event-oriented Best Recover Procedure, the Condition Trees for judging the critical function conditions, and symptom-oriented Function Recover Procedure. The Best Recover Procedures cover the design basis accidents and the multi-failure with high probability. The Function Recover Procedures cover the conditions uncovered in the Best Recover Procedures. The Best Recover Procedures instruct the operators recover the plant from design-base accidents and multi-failure. The operators are provided a set of systematic means to cope with the impact to critical safety functions by using the Critical Safety Function Recover Procedures combined with the Condition Trees. By combined use of the two procedures, the operators may continuously monitor the critical safety functions of the plant, conduct the operations for best recovery, and make a systematic response to the conditions uncovered in the Best Recover Procedures.

According to the principles for treating design-base accident and the functions of engineered safety features, being based on design methods, the accident response procedures of Daya Bay NPP are classified into two kinds:

(1) Single event deterministic procedures are based on preliminary studied event evolution in order to let the reactor maintain in or transit to a safe condition. These procedures include Abnormal Condition Treatment Procedure(I), Design-Base Accident Treatment Procedure(A), and Beyond-Design Basis Accident Treatment Procedure(H).

(2) Condition approaching procedures were written with reactor physical condition approaching methodology to deal with the problems caused by possibly accumulated equipment failure and/or human errors. These procedures include Severe

Accident Treatment Procedure(U), Continuous Monitoring Procedure(SPI) under Abnormal Condition, and Continuous Monitoring Procedure under Severe Accident (SPU).

5.3.3.5 Engineering and technical support

All operating organizations of Chinese NPPs have established specific technique 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. Some special 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.

5.3.3.6 Incident Reporting System

According to the requirements of “The Reporting System of Operating Organization”, NPPs in China has to report to regulator body, nuclear industry administration and other appropriate organizations in case of the following events during the period of testing and operation:

(1) Any event that violates the technical specifications of the NPP;

(2) Any event that brings the characteristics of safety barriers or important equipment of the NPP 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 NPP;

— A working condition not taken into account by the operation regulations or emergency response regulations of the NPP;

(3) Any natural event or other external event that would pose actual threat to the safety of the NPP or clearly hinder site personnel on duty in their performance

necessary for the safe operation of the NPP;

(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, arrays or channels with the three basic safety functions and the function of mitigating the event consequences to lose effectiveness simultaneously;

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

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

(9) Any event that is not covered by the above eight items and is defined by the 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.

About statistics on the operation events of Qinshan NPP and Guangdong Daya Bay NPP from 1998 to 2000, see Annex 3.

For incident reporting system under emergency conditions, see 4.7.2.3.

5.3.3.7 Operating Experience Feedback

In China, program to collect and analyze the operating experience of NPPs has been formulated, furthermore, the experience feedback system for the program has also been established.

China puts the focal point of experience feedback on the utilization of the experience from the operating organization that has prepared the operating experience feedback program and implementing procedures. The main objectives of the operating experience feedback of the operating organization are:

— Analyzing in depth the event, trends and consequences thoroughly, summarizing the internal operating experience;

— Consummating the rules of operation, maintenance, inspection and testing together with the technical specifications, improving the personnel assignment and training.

The operating experience feedback of NPPs in China includes both internal and external experience feedback.

(1) The process of internal experience feedback in Chinese nuclear power plants includes four steps: detecting and reporting, analysis, implementation, and summing-up. All departments and staff in the plant have the responsibility of detecting and reporting events, and the special department is set up for analyzing operational experience and reviewing effectiveness of operational experience feedback.

(2) The external experience feedback includes the following two aspects:

— China has joined the Incident Reporting System of International Atomic Energy Agency (IAEA-IRS); All NPPs in operation in China have joined World Association of Nuclear Operators (WANO).

— Operating experiences have been exchanged regularly or irregularly among domestic NPPs in operation and also among domestic NPPs, foreign NPPs and nuclear power research institutes.

The results obtained from the analysis of the events by the operating organization are distributed to the management personnel and the personnel concerned in the form of experience feedback sheet. During the correction action and project improvement period, strict quality surveillance and tracking activities are carried out to meet the requirements specified.

5.3.3.8 Control and Storage of the Radioactive Waste

According to the discharge limits for radioactive effluents, the operating organizations of Chinese NPPs have set relevant control target values, and prepared methods and procedures for monitoring and controlling discharge of effluents. The radioactive effluent discharges during operation of Chinese NPPs are far below the limits specified by the national standards (see Table 2 in Annex 2). Besides, the off-site monitoring program is also prepared by the operating organization. Radioactivity surveillance of the environment is described in section 4.6.4.

The waste management program is prepared and implemented by the operating organization in China. The operation and maintenance of the waste management system are implemented according to pre-established written regulations which take into account not only the impact resulted from the operating status such as start up, heavy loading and shutdown, but also the design intention and operational limits and conditions including the principle of keeping the approved discharge limits and exposures ALARA.

There are enough facilities for the storage of the waste produced during the normal operation and from the anticipated operational occurrences of NPPs in China. Excess accumulation of untreated waste is avoided during the treatment process of the waste. Records and documents of the amount of the waste stored is well kept in accordance with requirements of relevant regulations and quality assurance.

In order to ensure the integrity of the spent fuel and keep them under sub-criticality condition, the operating organization handles and stores spent fuel following written procedures by approved facilities inside the approved installation. The under-water storage conditions and water quality are kept in accordance with the chemical and physical characteristics specified.

5.3.3.9 Operating personnel qualification

In China, the examinations for operating personnel license include qualified test and qualification reviewing for applicants’ licenses, and qualification reviewing for renewing licenses. The operators must pass the qualification examination before submitting application to the NNSA for license and renewing license.

The CAEA has issued “Management Method on License Examination for Operators of Nuclear Power Plants” and “Rules on License Examination for Operators of Nuclear Power Plants”, and founded a organization named “Review Committee on Qualification for Operators of Nuclear Power Plants”(RCQO). The RCQO is overall in charge of the examinations for operators of nuclear power plants and is composed of the representatives and the experts hired from the CAEA, the operating organizations of NPPS and the technical support organization.

The licenses for operators of the NPPs are classified into “Operator License” and “Senior Operator License”. The period of validity for both licenses is two years. The examination for the applicants of license includes paper test, simulator test and oral test. The examination for renewing license includes simulator test and oral test. Any failing to pass one of all tests will lead to the examinee losing his current license examination.

The RCQO makes a review of the qualifications of the license applicants. The CAEA proposes license applications to the NNSA according to the review results for operators’ qualifications by the RCQO. The NNSA will issue the relevant licenses after approval.

The strict license examinations ensure the capability of operators to perform their tasks and making the nuclear power plants operate in a safe condition.

6. PLANNED ACTIVITIES AND THEIR PROGRESS ON IMPROVING SAFETY

6.1 Further perfecting nuclear safety regulations

6.1.1 New issuance and revision of regulatory documents

In 1998, the NNSA had re-compiled and printed “The Collection of Regulations on the Nuclear Safety of People’s Republic of China” and “Collection of Safety Guides on the Nuclear Safety of People’s Republic of China”.

(1) In the new version of collection of nuclear safety guides, following nuclear safety guides had been added:

— “Operation of Storage Facility of Spent Nuclear Fuel”

— “ Safety Evaluation of Storage Facility of Spent Nuclear Fuel”

— “ Classification of Radioactive Waste”

— “ Siting of Near –surface Disposal of Radioactive Waste”

— “Siting of Geologic Disposal Site of Radioactive Waste”

— “Physical Protection of Nuclear Power Plant”

(2) In May 1998, the NNSA had approved and issued the nuclear safety regulation “Rules for the Implementation of Emergency Management Regulations for Nuclear Accidents at Nuclear Power Plant”, Part one: “Emergency Preparedness and Response for Operating Organization of Nuclear Power Plant”

(3) The following standards, guides, and technical documents had been developed or revised through organizing forces by the NNSA:

— “Technical Specification for Radiation Environmental Surveillance”

— “Criteria on Determining Three Keys of Nuclear Facility’s Influence on Environment”

— “Method for Establishing Emergency Action Level of Nuclear Accidents at Nuclear Power Plant”

— “Emergency Plan and Preparedness of Nuclear Power Plant (Revised)”

— “Review Program for Environmental Evaluation Standard of Nuclear Power Plant”

— “Atmosphere Diffusion Mode in Environment Evaluation of Nuclear Installation”

— “Alarm System against Intrusion into Periphery of Nuclear Power Plant

(Protected Zone)”

— “Video Monitoring System for Alarm Check”

(4) The documents are being planned or drafted:

— Drafting of “Nuclear Safety Act” is being promoted.

— “Act of Prevention and Remedy of Radioactivity Contamination”(draft) has been submitted to State Council for examination.

— “Periodic Safety Review for Nuclear power Plant”.

— Regulations on the series of “Management on Transport of Radioactive Waste” are being established.

— The NNSA had organized preparing the drafts on 11 items of regulations and standards related to the management of radioactive waste.

— The revisions of “Regulations on Nuclear Material Control” and their detailed rules have been put into the legislation plan of the State Council.

6.1.2 The departmental rules Issued by the CAEA

The CAEA is issuing and establishing a series of departmental regulations. The issued safety-related departmental regulations are as follows:

— “Management Method on the License Examination of Operators of Nuclear Power Plant” (tryout)

— “Management Method of INES and IRS” (tryout)

— “Rules on the training for Emergency of Nuclear Accidents of Nuclear Power Plants”

— “Nuclear Emergency Guide: Protection Measures and Decisions in the Latter Phase of Severe Accident”

— “Technical Document of Nuclear Emergency Management: Emergency Preparedness and Response to the Accident of Radioactive Material Transport”

— “Rules on the License Examination of Operators of Nuclear Power Plant” (tryout)

6.2 Enhancing Nuclear Safety Culture

In order to ensure the safe operation of the NPPs, Chinese NPPs strengthen the education on nuclear safety culture for management personnel at all levels and operation personnel. The consciousness on safety culture of the NPP staff has been enhanced roundly.

On promoting safety culture, Chinese NPPs adopted the following measures:

— Perfecting the organization system of promoting safety culture.

— Carrying out the policy of “Safety is First”, enhancing the risk consciousness of personnel.

— The plan on promoting safety culture is included in the annual management target of the plant.

— The training of safety culture is included in the plan of training and re-training for plant personnel. The training is started from the plant leadership, and then gradually extended to supervisory and generic staff.

— Combining the education activities on safety culture and enterprise culture with the education of occupational morality. Conducting a variety of activities on the training, exchanging, and propagandizing of safety culture.

— Conducting the self-evaluation of safety culture within the plant.

— Reinforcing the training activities on the safety culture and their summarizing and feedback.

— Perfecting the method of safety culture evaluation.

Chinese NPPs in construction have also prepared some concrete measures.

6.3 Periodic Safety Review and Operation Assessment

6.3.1 Periodic Safety Review

According to the NNSA requirements on the Periodic Safety Review (PSR), Qinshan NPP had finished preparing “The First Periodic Safety Review Program of Qinshan Nuclear Power Plant”. The PSR will be finished in 2003 on schedule and the related review reports will be submitted to the NNSA for examination. Guangdong Daya Bay NPP has established its PSR plan. Up to now, the checkup of the PSR program has been completed and submitted to the NNSA for approval. Other related PSR documents are in preparation.

6.3.2 The System on Operation Assessment of Nuclear Industry Administration

Chinese nuclear industry administration is establishing a system for the operation assessment of the NPPs to perform operation assessment of the NPPs regularly or irregularly, for the sake of assuring safe operation. The departmental regulations for the operation assessment are in the process of preparation.

6.4 Strengthening the training of nuclear safety surveillance personnel and operating personnel of the NPPs

(1) To enhance the performance and level of its inspectors, the NNSA will perform training and retraining for the staff in headquarters and the inspectors in its Regional Offices.

(2) To perfect the training of plant licensee, Chinese nuclear industry administration issued "Management Method on the Examination of Operating Personnel of Nuclear Power Plant" (tryout) and other rules.

(3) Under the supports from Chinese Government, Qinshan NPP had conducted technical cooperation with IAEA and UNDP to learn the foreign advanced operational experience and enhance the management level of its senior managers.

(4) On the staff training in Guangdong Daya Bay NPP, the following activities had been conducted:

— The original full-scale simulator had been modified.

— Through cooperation with IAEA and WANO, the training on the safety culture evaluations for both managing and technical personnel and the root cause analyses of events or accidents had been conducted.

— A training base for maintenance personnel had been founded.

— The training or international exchanges for management personnel had been conducted in batches.

6.5 Intensifying operation experience feedback of the NPP

In order to strengthen operation experience feedback of the NPP and prevent and correct the human errors, China has established different levels of operation experience feedback systems in which the multi-sides participated. China actively performs both internal and external experience feedback, learns lessons from these activities, and makes great efforts to avoid the recurrence of the similar human errors and operation events in China or foreign countries.

In 2000, the CAEA, the NNSA, the operating organizations of the NPPs, and the technical supporting organizations conducted jointly an activity on operation experience feedback of the NPPs.

Between the operating NPPs in China, an activity of exchanging operation experience and sharing good practices is conducted each year.

Since 1993, the technical supporting organization for nuclear power operation has kept on selecting some IAEA and WANO typical operation events or accidents for further research. The results of analyses and researches are then compiled into operation experience feedback reports that are transferred to the NPPs, the NNSA, and the CAEA for reference in management decision in order to avoid recurrence of similar events or accidents.

Among Chinese NPPs and foreign NPPs or nuclear power research institutes, the experience exchange activities are conducted regularly or irregularly.

6.6 Improvement of equipment safety

Chinese NPPs had prepared their plans on improving equipment safety according to their practices. All changes of the safety important structures, systems, and components that have influence on the operation permit bases should be reported to the NNSA for approval before implementation.

Qinshan NPP had installed a liquid level indicator of the reactor pressure vessel, developed a monitoring system for loose components. It will bring forward a further plan of improving equipment’s safety after PSR.

The design and making of the fifth diesel generator of Guangdong Daya Bay NPP will be finished in 2003 on schedule. The modification of auxiliary external power source had been completed. At present, the modification of the supporter of vibration damper in the nuclear island is being conducted. The replacement of the head of reactor pressure vessel will be finished in 2003.

6.7 Spreading application of probability safety assessment method

The experience of the NPPs in the world is shown that the NPP safety can be enhanced efficiently by using a method of probability safety assessment (PSA). Therefore, in China, both nuclear industry administration and nuclear safety regulatory body attached high importance to PSA and its spreading the applications in the field on nuclear safety.

China is now establishing the database on reliability to further raise the level of PSA, on the basis of original PSA.

Since 2000 Guangdong Daya Bay NPP has endeavored to apply the probability safety assessment in the activities of operation, maintenance and engineering modification.

Qinshan NPP made a PSA plan. At present, the plan is carrying into execution.

Qinshan Phase III, Guangdong Lingao NPP, and Jiangsu Tianwan NPP have finished their level-1 PSA .

6.8 Intensifying the research of countermeasures against the management of severe accidents of the NPP

In 1998, Guangdong Daya Bay NPP began the feasibility research on managing severe accidents. It systematically performed the investigations on the following items:

— Phenomena of severe accidents of PWR NPPs

— Worldwide regulations for managing severe accidents

— Policies and strategies

— Technical measures and their implementation styles

— Current status of Guangdong Daya Bay NPP and the gap between its level and international level.

Furthermore, it studied thoroughly the documents on managing severe accidents of foreign countries and conducted the discussions on the severe accidents with foreign experts. On the basis of the feasibility research, it conducted the research on the spectrum of severe accidents and completed the related research reports for Guangdong Daya Bay NPP. From 1999, Guangdong Daya Bay NPP had put the project on managing severe accidents into its 5-year development plan in 1999.

Qinshan NPP will start the research on severe accidents after finishing its level-1 PSA.

The NNSA is preparing the issuance of codes related to severe accidents.

6.9 Accepting recommendations and suggestions from International Regulatory Review Team

In October 2000, the NNSA accepted a review on the status of Chinese nuclear safety regulation from International Regulatory Review Team (IRRT). The IRRT experts had affirmed the performance and the good practices in nuclear safety regulatory activities of China. Meanwhile, they had pointed out that the NNSA should make some improvement and perfection in its regulatory activities.

In view of the recommendations and the suggestions from IRRT, the preferential considerations have been taken by the NNSA as follows:

— The researching and drafting of “Nuclear Safety Act” is being started.

— The staffing of the NNSA has been enlarged by Chinese Government approval.

— A rule of charging for nuclear safety review will be implemented. It will be a supplement of the NNSA financial resource.

— The NNSA is making one or two regional offices be an inspection template in order to define the basic requirements for inspection and guarantee the effectiveness in safety inspections of constructing, commissioning and operating NPPs. The NNSA plans to conduct a training and examination for the staff in its headquarters and regional offices.

— For each key link in the emergency preparedness of nuclear installation, its effectiveness will be verified through strengthening on-site inspection and observing and evaluating the emergency exercise in operating organization. Therefore, the NNSA organized a special training for managing and technical personnel for emergency surveillance.

Appendix 1

The List of Nuclear Power Plants in China (by December 31, 2000)

	NPP Name	Unit No.	Location	Reactor Type	Nominal Power (MWe)	Date of the Construction	Date of the First Connection to the Grid
In Operation	Qinshan NPP	CN01	Haiyan, Zhejiang Province	PWR	300	1985-03-21	1991-12-15
	Guangdong Daya Bay NPP	CN02 CN03	Shenzheng City, Guangdong Province	PWR PWR	984 984	1987-08-07 1988-04-07	1993-08-31 1994-02-07
Under Construction	Qinshan Phase II NPP	CN04 CN05	Haiyan, Zhejiang Province	PWR PWR	600 600	1996-06-02 1997-04-01	2002-02-01 2002-12-01
	Guangdong Lingao NPP	CN06 CN07	Shenzhen City, Guangdong Province	PWR PWR	984 984	1997-05-15 1997-11-28	2002-04-05 2002-12-15
	Qinshan Phase III NPP	CN08 CN09	Haiyan, Zhejiang Province	CANDU CANDU	700 700	1998-06-08 1998-09-25	2002-11-10 2003-06-15
	Jiangsu Tianwan NPP	CN10 CN11	Lianyungang City, Jiangshu Province	PWR PWR	1000 1000	1999-10-20 2000-10-20	2004-05-15 2005-05-15

* Data of nuclear power plants in Taiwan province of China is left open for the time being.

Appendix 2

Performance Indicators of Qinshan NPP and Guangdong Daya Bay NPP(from 1998 to 2000)

No.	Year / Unit / Item (Unit)	1998			1999			2000		
		Qinshan CN1	Guangdong Daya Bay		Qinshan CN1	Guangdong Daya Bay		Qinshan CN1	Guangdong Daya Bay	
			CN2	CN3		CN2	CN3		CN2	CN3
1	Unit Capability Factor (%)	49.00	81.03	84.21	27.75	86.60	86.10	76.80	86.07	88.00
2	Unplanned Capability Loss Factor (%)	31.2	4.61	1.32	71.3	0.40	0.40	4.4	2.18	0.18
3	Automatic Scrams per 7000 Hours Critical (Times)	1.6	0	0	5.3	0	0	1	1	0
4	Collective Radiation Exposure (Man.Sv)	0.794	0.669	0.669	0.324	0.666	0.666	0.646	0.565	0.565
5	Volume of Solid Radioactive Waste (M^3)	42.4	89	89	29.2	92	92	40.4	93	93
6	Safety System Performance: High-Pressure Safety Injection System	0.0015	0.003	0.024	0.0008	0	0	0.001	0.003	0.003
	Auxiliary Feed-Water System	0.0027	0.013	0	0.0059	0.002	0.001	0.001	0.015	0.003
	Emergency AC Supply System	0.026	0.003	0.003	0.0002	0.011	0.011	0.001	0.008	0.008
7	Thermal Performance (%)	97.3	99.7	99.9	97.2	99.7	99.8	96.5	100	100
8	Fuel Reliability (Bq/g)	398.4	0.04	0.04	1.41	0.04	0.04	17.4	0.04	0.04
9	Chemistry Performance	1.15	0.18	0.19	1.02	1	1.01	1.09	1.07	1.02
10	Industrial Safety Accident Rate	0	0.132	0.132	0.3	0.0657	0.0657	0.2	0.137	0.137

Appendix 3

Laws, Regulations and Guidelines of China on Nuclear Safety

(By the end of December 31, 2000)

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)
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)

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 January 3, 1992; Revised on June 14, 1995)
5. Rules for the Implementation of Regulations on Emergency Management of Nuclear Accident for Nuclear Power Plant
-- Part One: Emergency Preparedness and Response for Operating Organization of Nuclear Power Plant (HAF002/01)
(Issued by NNSA on May 12, 1998)
6. Code on the Safety of Nuclear Power Plant Quality Assurance (HAF003)
(Promulgated by NNSA on July 7, 1986; Revised on July 27, 1991)
7. Code on the Safety of Nuclear Power Plant Siting (HAF101)
(Promulgated by the National Nuclear Safety Administration on July 7, 1986; Revised on July 27, 1991)
8. Code on the Safety of Nuclear Power Plant Design (HAF102)
(Promulgated by NNSA on July 7, 1986; Revised on July 27, 1991)
9. Code on the Safety of Nuclear Power Plant Operation (HAF103)
(Promulgated by NNSA on July 7, 1986; Revised on July 27, 1991)
10. Code on the Safety of Nuclear Power Plant Operation (HAF103)
Appendix One: Management of Refueling, Modifications and Accidental Shutdown of Nuclear Power Plant (HAF103/01)
(Issued by NNSA on March 2, 1994)
11. Code on the Safety of Civilian Nuclear Fuel Cycle Installations (HAF301)
(Promulgated by NNSA on June 17, 1993)
12. Code on the Safety Regulation for Radioactive Waste (HAF401)
(Promulgated by NNSA on November 5, 1997)
13. Rules for the Implementation on Regulations on Nuclear Materials Control of the

People's Republic of China(HAF501/01)
(Promulgated by NNSA, the Ministry of Energy and the National 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. Management Methods for License Examination of Operators of NPP (tryout)
(Issued by National Atomic Energy Authority on September 6,1999)
(Issued by National Atomic Energy Organization on January 19,2001)
19. Management Rules for Review and Approval for Transfer and Transit Transportation of Nuclear Products
(Issued by National Atomic Energy Authority on January 27,2000)
20. Codes on the Radiation Protection of NPP Environment (GB6249-86)
(Issued by the National Environmental Protection Administration on April 23, 1986)
21. Management Methods for Radioactive Environment
(Issued by the NEPA on June 22, 1990)
22. Rules on the radiation protection (GB 8703-88)
(Issued by the NEPA on March 11, 1988)
23. The Basic Standard on the Radioactive Health Protection (GB 4792－84)

(Issued by the Ministry of Health on December 1, 1984)

24. Management Rules of The Radiological Health Protection of Nuclear Facilities
(Decree by Minister, Issued by the Ministry of Health, 1992)
25. Management Rules of the Medical Emergency Response Under Nuclear Accident
(Decree by Minister, Issued by the Ministry of Health, 1994)
26. Management Rules of the Health of Radiological Working Personnel
(Decree by Minister, Issued by the Ministry of Health in 1988. Revised in 1997)
27. 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)
28. Format and Content of Report of Environment Impacts of Nuclear Power Plant (NEPA RG-1)
(Issued by the NEPA in 1997)
29. Standard of Surveillance of Environmental Radiological Health and Public Health Survey
(Issued by Ministry of Health, 1985)
30. Surveillance and Evaluation Standard of the Public Dose during Normal Operation and Accident Condition of Nuclear Installation
(Issued by Ministry of Health, 1992)
31. Intervention to the Public Protection and the Derived Intervention Level during Nuclear Accident or Radiation Emergency
(Issued by Ministry of Health, 1995)
32. Criteria of the Safety Class Electric Power System of NPP (GB 12788-91)

Ⅳ. Guiding Documents(safety guide)

Series for General

1. Emergency preparedness for the operating organization of nuclear power plant (HAD002/01)
(Issued by NNSA on August 12, 1989)
2. Emergency Preparedness of Local Government for Nuclear Power Plant (HAD002/02)
(Issued by NNSA, the National Environmental Protection Administration and the Ministry of Health on May 24, 1990)

3. Interfering Principles and Levels for public protection during the Emergency of Nuclear Accidental Radiation (HAD002/03)
   (Issued by NNSA, the National Environmental Protection Administration on April 19, 1991)
4. Levels of Derived Intervention of Public Protection during the Emergency of Nuclear Accident Radiation (HAD002/04)
   (Issued by NNSA, the National Environmental Protection Administration on April 19, 1991)
5. Emergency Preparedness and Response of Medicine during Nuclear Accident (HAD002/05)
   (Issued the Ministry of Health and NNSA on June 24, 1992)
6. Preparation of the Quality Assurance Program for Nuclear Power Plants (HAD003/01)
   (Issued by NNSA on October 6, 1988)
7. Quality Assurance Organization for Nuclear Power Plants (HAD003/02)
   (Issued by NNSA on April 13, 1989)
8. Quality Assurance in the Procurement of Items and Service for Nuclear Power Plants (HAD003/03)
   (Issued by NNSA on October 30, 1986)
9. Quality Assurance Record System for Nuclear Power Plants (HAD003/04)
   (Issued by NNSA on October 30, 1986)
10. Quality Assurance Audit for Nuclear Power Plants (HAD003/05)
    (Issued by NNSA on January 28, 1988)
11. Quality Assurance in the Design of Nuclear Power Plants (HAD003/06)
    (Issued by NNSA on October 30, 1986)
12. Quality Assurance during the Construction of Nuclear Power Plants (HAD003/07)
    (Issued by NNSA on April 17, 1987)
13. Quality Assurance in the Manufacturing of Items for Nuclear Power Plant (HAD003/08)
    (Issued by NNSA on October 30, 1986)
14. Quality Assurance during Commissioning and Operation of Nuclear Power Plants (HAD003/09)
    (Issued by NNSA on January 28, 1988)

15. Quality Assurance in the Procurement, Design and Manufacture of Nuclear Fuel Assemblies (HAD003/10)
(Issued by NNSA on April 13, 1989)
16. Guide for Nuclear Emergency—Protective Actions and Recovery Decision for Post-Emergency of Serious Accident
(Issued by National Atomic Energy Authority on September 28,2000)
17. Technical Document of Nuclear Emergency Management —Emergency Preparedness and Response for Transportation Accident of Radioactive Materials
(Issued by National Atomic Energy Authority on September 28,2000)

Series for NPP

18. Earthquakes and Associated Topics in Relation to Nuclear Power Plant Siting (HAD101/01)
(Issued on April 17, 1987 by NNSA and the National Seismic Administration, Revised on April 6, 1994)
19. Atmospheric Dispersion in Relation to Nuclear Power Plant Siting (HAD101/02)
(Issued by NNSA on November 20, 1987)
20. Site Selection and Evaluation for Nuclear Power Plant with Respect to Population Distribution (HAD101/03)
(Issued by NNSA on November 20, 1987)
21. External Man-induced Events in Relation to Nuclear Power Plant Siting (HAD101/04)
(Issued by NNSA on November 28, 1989)
22. Hydrological Dispersion of Radioactive Material in Relation to Nuclear Power Plant Sitting (HAD101/05)
(Issued by NNSA on April 26, 1991)
23. Nuclear Power Plant Sitting - Hydrogeological Aspects (HAD101/06)
(Issued by NNSA on April 26, 1991)
24. Site Survey for Nuclear Power Plants (HAD101/07)
(Issued by NNSA on November 28, 1989)
25. Determination of Design Basis Floods for Nuclear Power Plants on River Sites (HAD101/08)
(Issued by NNSA on July 12, 1989)
26. Determination of Design Basis Floods for Nuclear Power Plants on Coastal Sites

(HAD101/09)
(Issued by NNSA on May 19, 1990)

27. Evaluation of Extreme Meteorological Events for Nuclear Power Plant Sitting (HAD101/10)
(Issued by NNSA on April 26, 1991)
28. Design Basis of Tropical Cyclone for Nuclear Power Plants (HAD101/11)
(Issued by NNSA on April 26, 1991)
29. Safety Aspects of the Foundation of Nuclear Power Plants (HAD101/12)
(Issued by NNSA on February 20, 1990)
30. General Design Safety Principles for Nuclear Power Plants (HAD102/01)
(Issued by NNSA on July 12, 1989)
31. Seismic Analysis and Testing of Nuclear Power Plant (HAD102/02)
(Issued by NNSA on May 13, 1996)
32. Safety Functions and Component Classification for BWR, PWR, and Pressure Tube Reactor (HAD102/03)
(Issued by NNSA on October 30, 1986)
33. Protection against Internally Generated Missiles and Their Secondary Effects in Nuclear Power Plants (HAD102/04)
(Issued by NNSA on October 30, 1986)
34. External Man-induced Events in Relation to Nuclear Power Plant Design (HAD102/05)
(Issued by NNSA on November 28, 1989)
35. Design of the Reactor Containment Systems in Nuclear Power Plants (HAD102/06)
(Issued by NNSA on May 19, 1990)
36. Design for Reactor Core Safety in Nuclear Power Plants (HAD102/07)
(Issued by NNSA on July 12, 1989)
37. Reactor Cooling Systems and Their Related Systems in Nuclear Power Plants (HAD102/08)
(Issued by NNSA on April 13, 1989)
38. Ultimate Heat Sink and Directly Associated Heat Transport Systems for Nuclear Power Plants (HAD102/09)
(Issued by NNSA on October 30, 1986; Revised on April 17, 1987)

39. Protection System and Related Facilities in Nuclear Power Plants (HAD102/10)
(Issued by NNSA on October 6, 1988)
40. Fire Protection in Nuclear Power Plants (HAD102/11)
(Issued by NNSA on October 30, 1986, revised on May 13,1996)
41. Design Aspects of Radiation Protection for Nuclear Power Plants (HAD102/12)
(Issued by NNSA on May 19, 1990)
42. Emergency Power Systems at Nuclear Power Plants (HAD102/13)
(Issued by NNSA on October 6, 1988; Revised on February 13, 1996)
43. Safety-related Instrumentation and Control Systems for Nuclear Power Plants (HAD102/14)
(Issued by NNSA on October 6, 1988)
44. Fuel Handling and Storage Systems in Nuclear Power Plants (HAD102/15)
(Issued by NNSA on February 20, 1990)
45. Operation Limits and Conditions for Nuclear Power Plants (HAD103/01)
(Issued by NNSA on April 17, 1987)
46. Commissioning Procedures for Nuclear Power Plants (HAD103/02)
(Issued by NNSA on April 17, 1987)
47. Core and Fuel Management for Nuclear Power Plants (HAD103/03)
(Issued by NNSA on November 28, 1989)
48. Radiation Protection during Operation of Nuclear Power Plants (HAD103/04)
(Issued by NNSA on May 19, 1990)
49. Staffing, Recruitment, Training and Authorization for personnel of Nuclear Power Plants (HAD103/05)
(Issued by NNSA on April 17, 1987, revised on February 13,1996)
50. Management of Nuclear Power Plants for Safe Operation (HAD103/06)
(Issued by NNSA on February 20, 1990)
51. In-service Inspection for Nuclear Power Plants (HAD103/07)
(Issued by NNSA on October 6, 1988)
52. Maintenance of Nuclear Power Plants (HAD103/08)
(Issued by NNSA on April 13, 1989; Revised on June 1, 1993)
53. Surveillance of Items Important to Safety in Nuclear Power Plants (HAD103/09)
(Issued by NNSA on October 6, 1988; Revised on June 1, 1993)
54. Design of Storage Facilities for Spent Fuel (HAD301/02)

(Issued by NNSA on July 10, 1998)

55. Operation of Storage Facilities for Spent Fuel (HAD301/03)
(Issued by NNSA on July 10, 1998)

56. Safety Evaluation of Storage Facilities for Spent Fuel (HAD301/04)
(Issued by NNSA on July 10, 1998)

Series for radioactive waste management

57. Management of Radioactive Effluents and Wastes in Nuclear Power Plants (HAD401/01)
(Issued by NNSA on May 19, 1990)

58. Design of Radioactive Waste Management System for NPP (HAD401/02)
(Issued by NNSA on January 16, 1997)

59. Design and Operation of Incinerators of Radioactive Waste (HAD401/03)
(Issued by NNSA on February 15, 1997)

60. Classification of Radioactive Waste (HAD401/04)
(Issued by NNSA on July 6, 1998)

61. Siting for Near Global Surface Disposal Site of Radioactive Waste (HAD401/05)
(Issued by NNSA on July 6, 1998)

62. Siting for Geology Disposal Warehouse of Radioactive Waste (HAD401/06)
(Issued by NNSA on July 6, 1998)

Series for Regulation of Nuclear Material

63. Guide on Physical Protection of Nuclear Power Plant (HAD501/02)
(Issued by NNSA on April 8, 1998)

Annex 1

Main data of Nuclear Steam Supply System (NSSS)

No.	Parameters, Unit	CN01 Qinshan NPP	CN02 & CN03 Guangdong Daya Bay NPP	CN04 & CN05 Qinshan Phase II NPP	CN06 & CN07 Guangdong Lingao NPP	CN08 & CN09 Qinshan Phase III NPP	CN10 & CN11 Jiangsu Tianwan NPP
1	General Parameters Reactor Type	PWR	PWR	PWR	PWR	PHWR	PWR
	Nominal Electric Power，MW	300	984	600	984	700	1000
	Nominal Thermal Power，MW	966	2905	1936	2905	2063	3120
	Design Life，Year	30	40	40	40	40	40
2 2.1	Mechanical design of the Core Fuel Assemblies Number of Fuel Assemblies	121	157	121	157	4560	163
	Number of UO_2 Rods in Each Assemblies	204	264	264	264	37	311
	Assembly Dimension, Length×Width ×Height，mm	199.3 × 199.3 × 3500	214×214×4058	214×214×4058	214 × 214 × 4058	Outer Diameter × length 102.94×495.3	Width×Height 234×4570

No.	Parameters, Unit	CN01 Qinshan NPP	CN02 & CN03 Guangdong Daya Bay NPP	CN04 & CN05 Qinshan Phase II NPP	CN06 & CN07 Guangdong Lingao NPP	CN08 & CN09 Qinshan Phase III NPP	CN10 & CN11 Jiangsu Tianwan NPP
2.2	Fuel Rods Total Number	24684	41448	31944	41448	168720	50693
	Outside Diameter，mm	10	9.5	9.5	9.5	13.08	9.1
	Cladding Thickness，mm	0.7	0.57	0.57	0.57	0.42	0.685
	Cladding Material	Zr-4 Alloy	Zr-4 Alloy	Zr-4 Alloy	Zr-4 Alloy	Zr-4 Alloy	Zr-Nb Alloy
2.3	Fuel Pellets Material	UO_2	UO_2	UO_2	UO_2	UO_2 (Natural)	UO_2
	Pellet Dimension, Diameter×Height, mm	8.43×10	8.19×13.5	8.19×13.5	8.19×13.5	12.15×16.1	7.57×11
2.4	Control Rod Assemblies Neuron Absorbing Material	Ag-In-Cd	Ag-In-Cd	Ag-In-Cd	Ag-In-Cd	Cd(28 Shutdown Rods +4 Absorbers) S.S (21 Adjusters)	Upper: B_4C
	Number of Control Rods, Black × Gray	37	41 / 12	25 Regulating Rods，8 Scram Rods	41 / 12	(28 Rods +4 Adjusting Rods) × 21 Adjusting Rods	22 Scram Rods, 63 Adjusting Rods

No.	Parameters, Unit	CN01 Qinshan NPP	CN02 & CN03 Guangdong Daya Bay NPP	CN04 & CN05 Qinshan Phase II NPP	CN06 & CN07 Guangdong Lingao NPP	CN08 & CN09 Qinshan Phase III NPP	CN10 & CN11 Jiangsu Tianwan NPP
	Number of Absorbing Rods in Each Assembly	20	24(black)，8(grey)	24	24(black)，8(grey)		18
2.5	Structure Characteristics of the Core Equivalent Diameter, m	2.486	3.04	2.669	3.04	7.595	3.160
	Core Height, m	2.9	3.66	3.658	3.66	5.94	3.55
2.6	Fuel Enrichment, Zone 1×Zone 2×Zone 3, %	2.4×2.672×3.0	1.8×2.4×3.1	1.9×2.6×3.1	1.8×2.4×3.1	One Zone	1.6×2.4×3.67
3 3.1	Thermal Hydraulic Design System Pressure，MPa	15.2	15.5	15.5	15.5	9.89	15.7
3.2	Coolant Flow Rate，m^3/h	24000	68520	46640	68520	27720	86000
3.3	Coolant Temperature，℃ Inlet Temperature of the Core，℃	288.8	292.4	292.8	292.4	266	289.7
3.4	Average Temperature of the Core，℃	302	311.1	311.2	311.1	288	304.85

No.	Parameters, Unit	CN01 Qinshan NPP	CN02 & CN03 Guangdong Daya Bay NPP	CN04 & CN05 Qinshan Phase II NPP	CN06 & CN07 Guangdong Lingao NPP	CN08 & CN09 Qinshan Phase III NPP	CN10 & CN11 Jiangsu Tianwan NPP
	Heat transfer Effective Heat Transfer Area of the Core，m^2	2249	4519	3487.5	4519	3340	5144
	Average Linear Power Density of Fuel Rods，W/cm	135	186	160.9	186	252	166.7
	Maximum Linear Power Density of Fuel Rods，W/cm	407	≤590	<590	<590	510 (Max)	448 (Max)
4	Reactor Coolant System Pressure of Hydro-Static Testing，MPa	21.48	22.9	22.9	22.9	12.8	24.5
	Design Pressure，MPa	17.16	17.23	17.2	17.23	10.24	17.6
	Operation Pressure，MPa	15.2	15.5	15.5	15.5	9.89	15.7
	Loop Number	2	3	2	3	2	4

No.	Parameters, Unit	CN01 Qinshan NPP	CN02 & CN03 Guangdong Daya Bay NPP	CN04 & CN05 Qinshan Phase II NPP	CN06 & CN07 Guangdong Lingao NPP	CN08 & CN09 Qinshan Phase III NPP	CN10 & CN11 Jiangsu Tianwan NPP
5	Reactor Pressure Vessel Design Design×Operation Pressure，MPa	17.16×5.2	17.23×15.5	17.23×15.5	17.23×15.5	0.96×0.58	17.6×15.7
	Design Temperature，℃	350	343	343	343	108	350
	Vessel Dimension: Height × Internal Diameter×Thickness, mm	10705×3374×175	12988×3989×200	12988×3989×195	12988×3989×200	7650×6760×28.6	11185×4150×192.5
6	Primary Coolant Pump Design Internal Diameter of the Junction: Inlet×Outlet, mm	700×700	787×689	792.5×703.6	787×698	508×406	850×850
	Nominal Speed，rpm	1488	1485	1500	1485	1500	1000/750
	Unit Overall Height, m	9.33	8	8.183	8	6.1	10.791
	Unit Mass (Dry), t	88	104	104	104	66.5	

No.	Parameters, Unit	CN01 Qinshan NPP	CN02 & CN03 Guangdong Daya Bay NPP	CN04 & CN05 Qinshan Phase II NPP	CN06 & CN07 Guangdong Lingao NPP	CN08 & CN09 Qinshan Phase III NPP	CN10 & CN11 Jiangsu Tianwan NPP
7	Steam Generator Design Design Pressure，Primary/ Secondary Side，MPa	17.16/7.55	17.13/8.5	17.2/8.6	17.13/8.5	11.03/5.07	17.6/7.84
	Design Temperature，Primary/ Secondary Side，℃	350/320	343/316	343/316	343/316	318/265	350/300
	Overall Heat Transfer Area(each Set)，m^2	3072.9	5430	5430	5430	3179	6115
	Feed-Water Temperature，℃	216	226	230		187	218
	Steam Pressure in Exit Nozzle，MPa	5.2	6.58			4.2	6.27
	Steam Production(Each Set), t/h	935.5	1935.6			929.7	1470
	Maximum Steam Moisture, %	0.25	0.25	0.25	0.25	0.25	0.2
	Overall Height, m	17.248	20.848	20.848	20.848	19.33	5.61
	U-Tube Material	Incoloy-800	Inconel-690	Iconel-690	Inconel-690	Inconel-800	S.S
	U-Tube Number (Each Set)	2977	4474	4474	4474	3530	10978
	U-Tube, Outside Diameter × Wall Thickness，mm	22×1.2	19.05×1.09	19.05×1.09	19.05×1.09	15.88×1.13	16×1.5

No.	Parameters, Unit	CN01 Qinshan NPP	CN02 & CN03 Guangdong Daya Bay NPP	CN04 & CN05 Qinshan Phase II NPP	CN06 & CN07 Guangdong Lingao NPP	CN08 & CN09 Qinshan Phase III NPP	CN10 & CN11 Jiangsu Tianwan NPP
8	Pressurizer Design Pressure，MPa	17.16	17.13	17.1	17.13	11.03	17.6
	Design Temperature，℃	370	360	360	360	343	350
	Total Power of the Electrical Conductor，KW	1350	1440			1000	2520
	Internal Volume in Full-load，m^3	35	40.3	36	40.3	45.3	79

Annex 2

Table 1 Occupational Exposure of Qinshan NPP and Guangdong Daya Bay NPP (from 1998 to 2000)

Items (Unit) \ Plant Name / Year	Qinshan NPP			Guangdong Daya Bay NPP		
	1998	1999	2000	1998	1999	2000
Yearly Collective Effective Dose (man • Sv)	0.79	0.32	0.65	1.34	1.33	1.13
Yearly Man Average Effective Dose (mSv)	0.99	0.40	0.81	0.65	0.59	0.53
Normalized Collective Effective Dose (man • mSv / GWh)	0.68	0.44	0.32	0.10	0.09	0.08
Annual Maxium Individual Dose (mSv)	14.44	7.28	8.29	9.8	10.35	8.15

Table 2 Discharge of Radioactive Effluents of Qinshan NPP and Guangdong Daya Bay NPP (from 1998 to 2000)

Type	Item \ Plant Name / Year	Qinshan NPP			Guangdong Daya Bay NPP		
		1998	1999	2000	1998	1999	2000
Gaseous Effluents	Noble gas	1.90×10^{13}	1.67×10^{10}	2.52×10^{10}	2.35×10^{13}	2.57×10^{13}	1.94×10^{13}
	Iodine & Particles	6.14×10^{7}	Too low to be measured	Too low to be measured	1.01×10^{8}	9.20×10^{7}	7.50×10^{7}
Liquid Effluents	Tritium	3.06×10^{12}	2.29×10^{12}	7.63×10^{11}	2.76×10^{13}	2.39×10^{13}	3.42×10^{13}
	Other Nuclides	1.97×10^{8}	3.10×10^{8}	2.51×10^{8}	2.49×10^{9}	4.69×10^{9}	2.59×10^{9}

Annex 3

Operational Events of Qinshan NPP and Guangdong Daya Bay NPP (from 1998 to 2000)

Plant / year / INES	Qinshan			Guandong Daya Bay					
				Unit 1			Unit 2		
	1998	1999	2000	1998	1999	2000	1998	1999	2000
0	1	3	4	6	5	3	4	5	7
1	4	0	1	4	3	4	1	3	2
≥ 2	0	0	0	0	0	0	0	0	0
Total	5	3	5	10	8	7	5	8	9