English Version

THE NATIONAL REPORT UNDER

THE CONVENTION ON NUCLEAR SAFETY

OF

THE PEOPLE' REPUBLIC OF CHINA

June 1998
Beijing

STATEMENT

The Chinese Government pays great attention to nuclear safety and consistently implements "safety first" policy in the process of developing Chinese nuclear energy industry. In accordance with the requirements of the "Convention on Nuclear Safety" and "Guidelines regarding National Reports under the Convention on Nuclear Safety", the Chinese Government prepared this "National Report under the Convention on Nuclear Safety of the People's Republic of China" which comprehensively described the implementation of Chinese obligations under the "Convention on Nuclear Safety".

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

Content

1. INTRODUCTION

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

1.1 Development and Policy of Nuclear Industry in China

The Chinese nuclear industry was initiated in 1955. From the late 50’s to 70’s, 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-up policy. The nuclear industry has shifted from taking defense as the dominant factor to focuse on economical construction and improvement of people’s life. At early 80’s, the State Council decided to build Qinshan NPP and Guangdong Daya Bay NPP. The development of the Chinese nuclear power industry thus began.

1.2 Current Nuclear Power Developing Policy

The Chinese total installed electricity generating capacity is 250GW by the end of 1997. The generating capability increases by the installed capacity of 13 to 15GW per year from 1991 to 1995 to meet requirements of modernizing economical construction.

According to the situation of energy resources, funds and technology in China, the Chinese government enacts the current power developing policy as “adhering to the optimization of thermal power structure, developing hydroelectric power strongly, developing nuclear power appropriately, developing various new energy to generate power in the light of local conditions, practically strengthening electricity grid construction, developing and saving in parallel and putting economization onto the first place”.

The current nuclear power developing policies are as follows:

(1) Implementation of “Safety First” Policy.

(2) Development of nuclear power steadily, primarily developing nuclear power in the coastal area where the economic development is relatively rapid .

(3) Introduction of foreign capital and technologies appropriately on the basis of our own and cooperation between China and abroad.

(4) Realization of keeping the design initiative in our own hands and domestic manufacturing of equipment with great effort.

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

1.3 Nuclear Power Program by the Year 2000

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

Four NPPs total 8 units have been put under construction and planned to be constructed during the year 1996 to 2000. The total installed capacity is about 6600 MW(e). They will be completed by the year 2001 to 2005. At that time, nuclear power installed capacity is about 2.5% of our total electricity generation installed in China.

1.4 Nuclear Safety Policy

China has paid great attention to nuclear safety from the beginning of nuclear industry development and clearly laid down “Safety First” policy to protect personnel, publics and environment. The National Nuclear Safety Administration (NNSA) was established in 1984 by the State Council to start with the independent regulation for nuclear safety of civilian nuclear installations, to establish surveillance system of nuclear safety and at the same time make clear the responsibilities of governmental departments and operating organizations. The nuclear safety regulations have been promulgated one after the other from 1986 to regulate nuclear safety based on them.

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”, which generally and systematically described the work done in connection with the implementation of Chinese obligations under the Convention up to the end of 1997.

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

2. Existing NPPs

2.1 List of Existing NPPs

In Appendix 1, it listed all together the 6 NPPs with 11 units in operation, construction and planned to construct in China (Data of NPPs in Taiwan province of China is left open for the time being).

2.2 Safety Evaluation of Existing NPPs

The Chinese Qinshan NPP was designed and constructed by ourselves in the 80’s, which began construction in March of 1985 and firstly went into commercial operation on December , 1991. The Chinese Guangdong Daya Bay NPP was introduced from France at early 80’s and began construction in 1987. Its units 1 & 2 went into commercial operation in August 1993 and February 1994 respectively.

Both Chinese NPPs were designed and built after the accident of the Three Mile Island NPP, absorbed its experiences and drew the lessons.

The Chinese NPPs and all activities related to nuclear safety have been carried out under its regulations since the establishment of the National Nuclear Safety Administration. in 1984. Overall safety reviews of Guangdong Daya Bay NPP were performed. Although the Chinese nuclear safety regulations were not yet issued when Qinshan NPP was designed, however foreign design standards and rules were referred to at that time. After the promulgation of the Chinese nuclear safety regulations, safety review for Qinshan NPP was retrospected.

The OSART safety reviews by IAEA were performed before and after the operations of Qinshan NPP and Guangdong Daya Bay NPP.

The Chinese NPPs in operation have gone through the operational practice for many years until December of 1997 and achieved good operational results. Unit capacity factors of altogether three units for Qinshan NPP and Guangdong Daya Bay NPP in 1997 were respectively 81.34%, 82.45%, and 70.60%. Detailed performance indicators for the two NPPs are shown in Appendix 2.

Safety barriers of the Chinese NPPs in operation have shown integrity through tests and monitoring. The integrity of fuel element cladding satisfies the requirements of technical specification. The average leakage rates of the reactor and reactor cooling system in a whole year and the containment are far below the limits of technical specification.

The discharges of radioactive effluents of the NPPs have been effectively controlled and monitored. There has been no over dose release event occurred since the first fuel loading. The level of discharge volume per year and occupational exposure dose are far lower than the State regulatory limits. The level of radioactivity of the surrounding environment has been kept at the ground level.

2.3 Views on Continual Operation of Existing NPPs

The Chinese Qinshan NPP and Guangdong Daya Bay NPP are in the initial stage of design life. It shows that the safety of continual operation for these Chinese NPPs is guaranteed through their several-year operational practice, in-service inspections, tests, analyses and several safety reviews and assessment carried out by the NNSA.

3. LEGISLATION AND REGULATION

3.1 Laws, Regulations, Standards on Nuclear Safety

3.1.1 Legislation on Nuclear Safety

In 1984, the NNSA which is endowed with the responsibilities of independent surveillance and management of the safety of Chinese civilian nuclear installations was established by the Sate Council.

In 1989, “Environmental Protection Act of the People’s Republic of China” was authorized by the National People’s Congress Standing Committee (NPCSC).

“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” were promulgated by the Sate Council in 1986 and 1987 respectively, which systematically stipulated the purpose and scope of surveillance of civilian nuclear installations and nuclear materials, establishing nuclear safety licensing system, defined the duty of regulatory bodies and the legal responsibility of operation organizations. In 1993, “Emergency Management Regulations for Nuclear Accidents at Nuclear Power Plant” was promulgated by the Sate Council, which stipulated principle, countermeasure and measure adopted for nuclear accident emergency preparedness.

Codes on the safety of NPPs siting, design, operation and quality assurance were issued by the NNSA in 1986. In 1990, National Environmental Protection Administration (NEPA) issued “Management of Radioactive Environment”. Codes on Radiation Protection were enacted by the NNSA, the Ministry of Health, etc. In 1991, the NNSA promulgated “Codes on the Safety of the Management of Radioactive Waste from Nuclear Power Plants”. All these rules and regulations form the basic requirements on safety of NPPs.

Furthermore, the NNSA, the NEPA and ministry of Health formulated relevant codes of practice and safety guides, thereby formed a relatively systematic hierarchy of rules and regulations on nuclear safety.

3.1.2 Scope of Regulations on Nuclear Safety

At present, the scope of regulations on nuclear safety in China includes:

(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) Management of radiological environment and personal dose;

(5) Facilities for radioactive waste treatment and disposal;

(6) Emergency preparedness of nuclear accidents;

(7) Ownership, use, production, storage, transportation and disposal of nuclear materials;

(8) Nuclear pressure retaining components (design, manufacture, installation and usage).

3.1.3 Nuclear Safety Regulation Hierarchy

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 nuclear safety regulations hierarchy of China. It consists of state laws, administrative regulations of the Sate Council, department rules, nuclear safety guides, standards and specifications.

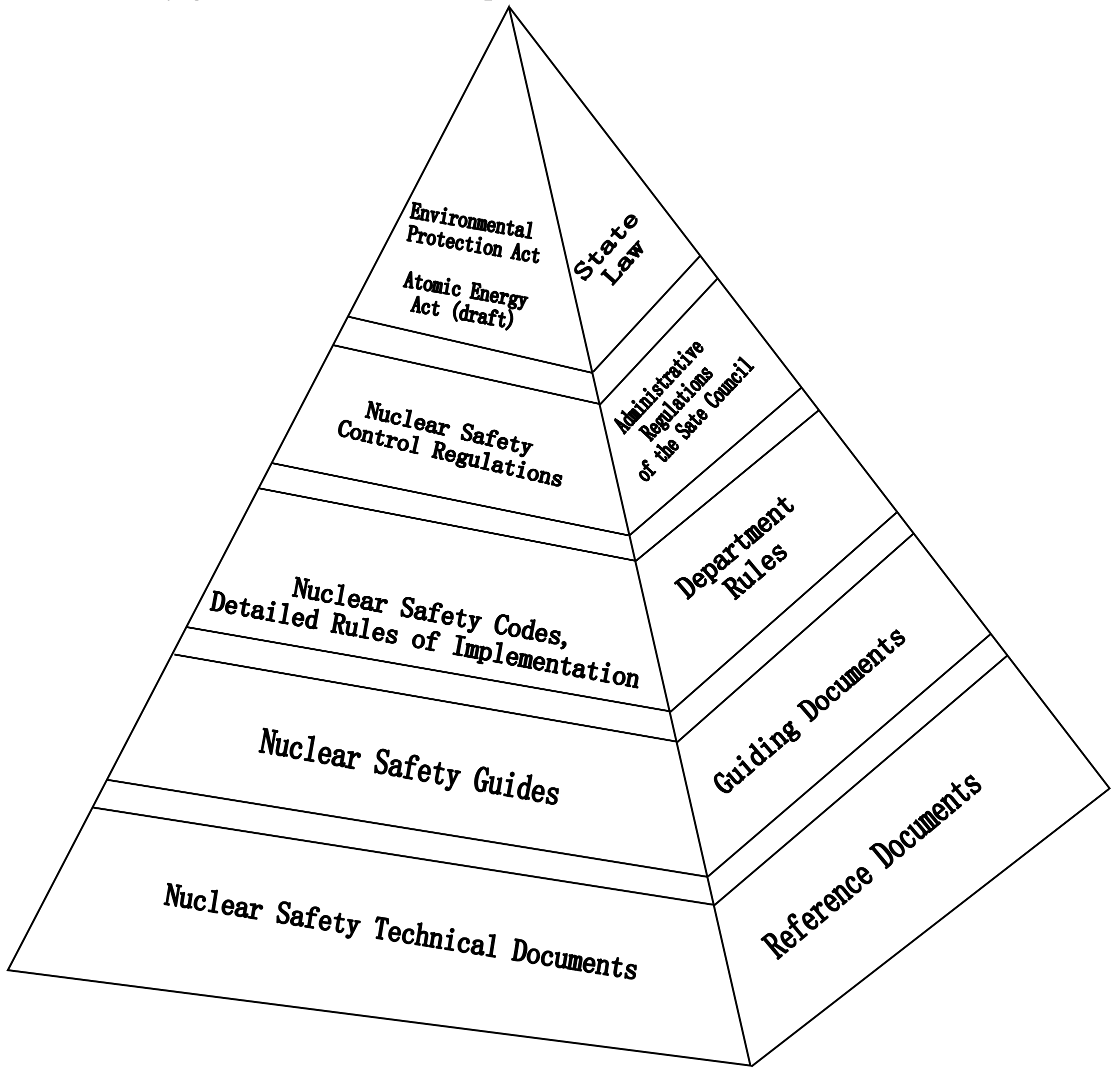

Fig 3.1 The hierarchical structure of nuclear safety regulations of China

(1) Sate laws:

— Environment Protection Act of People’s Republic of China issued by National People’s Congress Standing Committee is a state law which is to protect and improve the environment of living, prevent and cure pollution and contamination, ensure public health, promote development of society.

— Atomic Energy Act (awaiting for approval) is the legal document to adjust and accelerate the development of atomic energy enterprises and has the highest legal effect in atomic energy areas. It is not only enacting principle of development of atomic energy enterprise, but also enacting requirements of nuclear safety surveillance and management.

— Act of Prevention and Remedy of Radioactivity contamination (awaiting for approval)is a legal, document. It gives directives to prevent environment contamination of due to the exhausting of waste gas, discharging of liquid waste, disposing of solid waste and penetrated radioactivity, during the process of nuclear energy development. Nuclear techniques application and the exploitation of associated mineral resources resulted in the protection of the environment and taking care of the public health.

(2) Administrative regulations of the Sate Council:

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

(3) Department rules:

— Detailed rules and regulations of implementation are department rules, which stipulated exact measures to be put into effect. They have been promulgated by departments concerned of the Chinese government according to Nuclear Safety Control Regulations and have legal binding effect.

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

Standards and specifications related to nuclear safety enacted by the NEPA and the Ministry of Health, etc:

(4) Guiding documents:

Nuclear Safety Guides are guiding documents that supplement or illustrate nuclear safety codes and recommend relevant methods or procedures.

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

3.2 Nuclear Safety Surveillance and Management System

“Safety First” is the principle of both developing nuclear energy and nuclear safety surveillance and management of China.

Nuclear safety laws and regulations system is the base of surveillance and management.

The NNSA is charged with 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 license, the NNSA supervises NPPs, nuclear materials and nuclear activities.

The NEPA is charged with the surveillance and management of environmental protection of NPPs throughout the country.

According to nuclear safety regulations, the licensee of nuclear safety (or applicant) beas the whole responsibility for the safety of NPPs, nuclear materials and nuclear activities.

By means of license examination and approval, supervision, enforcement of laws, rewards and punishment, 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 adopted licensing system for nuclear safety.

Nuclear safety license is a legal document that is approved by regulatory body and authorizes applicant to deal with nuclear safety related specific activities (such as siting, constructing, commissioning, operation, decommissioning of NPPs; ownership, use, production, storage, transportation and disposal of nuclear materials, etc).

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

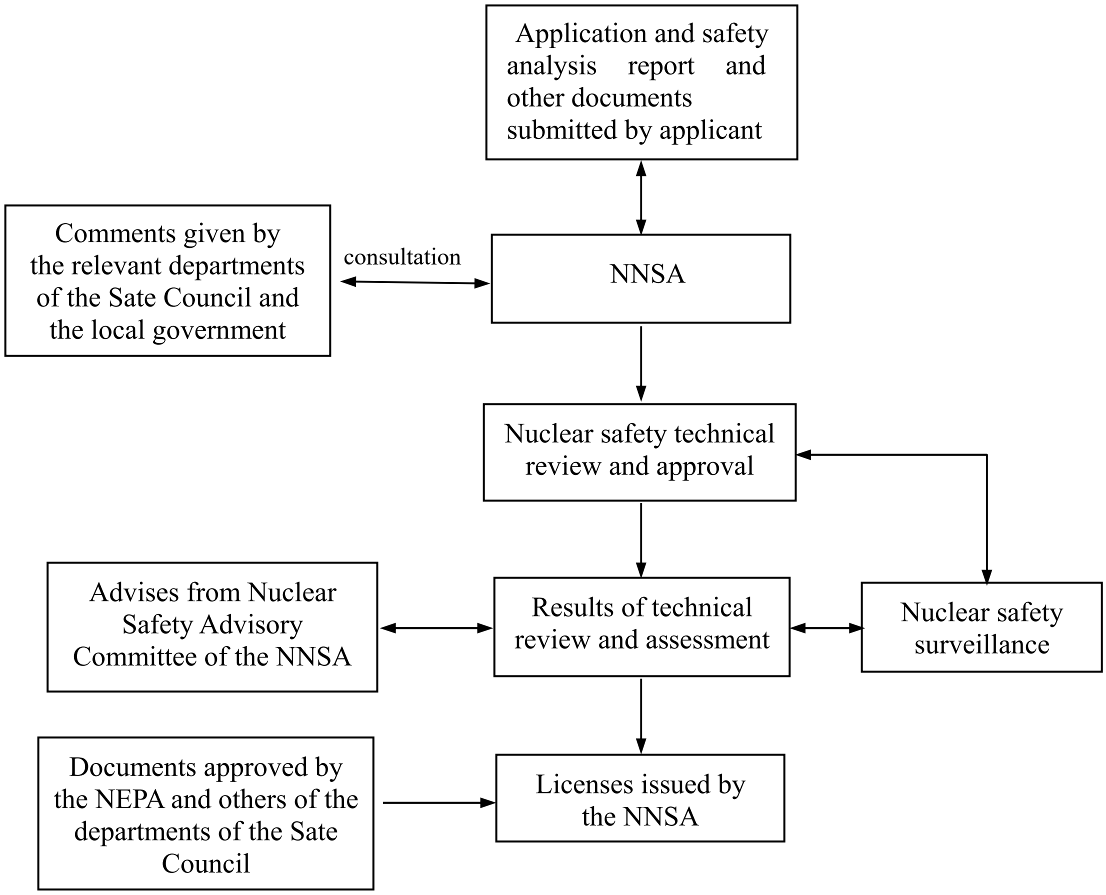

Figure 3.2 The procedures of application and issuing of licenses

3.3.1 Type of Licenses for NPP

Safety licenses which 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 to operator of NPP;

(4) License of nuclear materials;

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

The NEPA 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 to the NNSA for appraisal and approval and only after that, applicant can carry out relevant nuclear activities.

During the process of appraisal, the NNSA should ask for opinions of the departments concerned of the Sate 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 departments concerned 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.

3.4 Regulatory Body of Nuclear Safety

The NNSA, the NEPA and the Ministry of Health are responsible for surveillance on safety of NPPs, environmental protection and occupational and public personal dose, public health management and hygiene evaluation respectively.

3.4.1 Duties and Responsibilities of Regulatory Bodies

3.4.1.1 Duties and Responsibilities of the NNSA

(1) to organize the drafting and formulating of regulations relating to 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 exercising nuclear safety surveillance;

(4) to be responsible for investigating and dealing with accidents of nuclear safety;

(5) to provide guide and surveillance in drawing up and implementing emergency preparedness plan in cooperation with departments concerned;

(6) to organize departments concerned to develop scientific research relating to safety and management of NPPs, disseminate information to the public as well as relevant international professional links;

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

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

(9) to conduct mediation and adjudication of disputes relating to nuclear safety in cooperation with departments concerned.

3.4.1.2 Duties and Responsibilities of the NEPA

(1) to be responsible for formulating, supervision and enforcement of the regulations and standards relating 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 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 nuclear facilities,

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

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

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

3.4.2 Organizational Structure of Regulatory Bodies

3.4.2.1 The NNSA

The headquarter of the NNSA is in Beijing, and four regional offices respectively are established in Shanghai, Shenzhen, Chengdu and Beijing which are in charge of day-to-day supervision of nuclear safety in these areas.

The Nuclear Safety Advisory Committee (NSAC) is an organization which gives advice and acts as a consultant to help the NNSA to enact nuclear safety regulations, nuclear safety technology and to take part in reviewing and supervision of nuclear safety.

Figure 3.3 is the organization of structure the NNSA

3.4.2.2 The NEPA

The NEPA is in charge of unified surveillance of environmental protection all over the country.

Departments in charge of environmental protection are established in different provinces and municipalities.

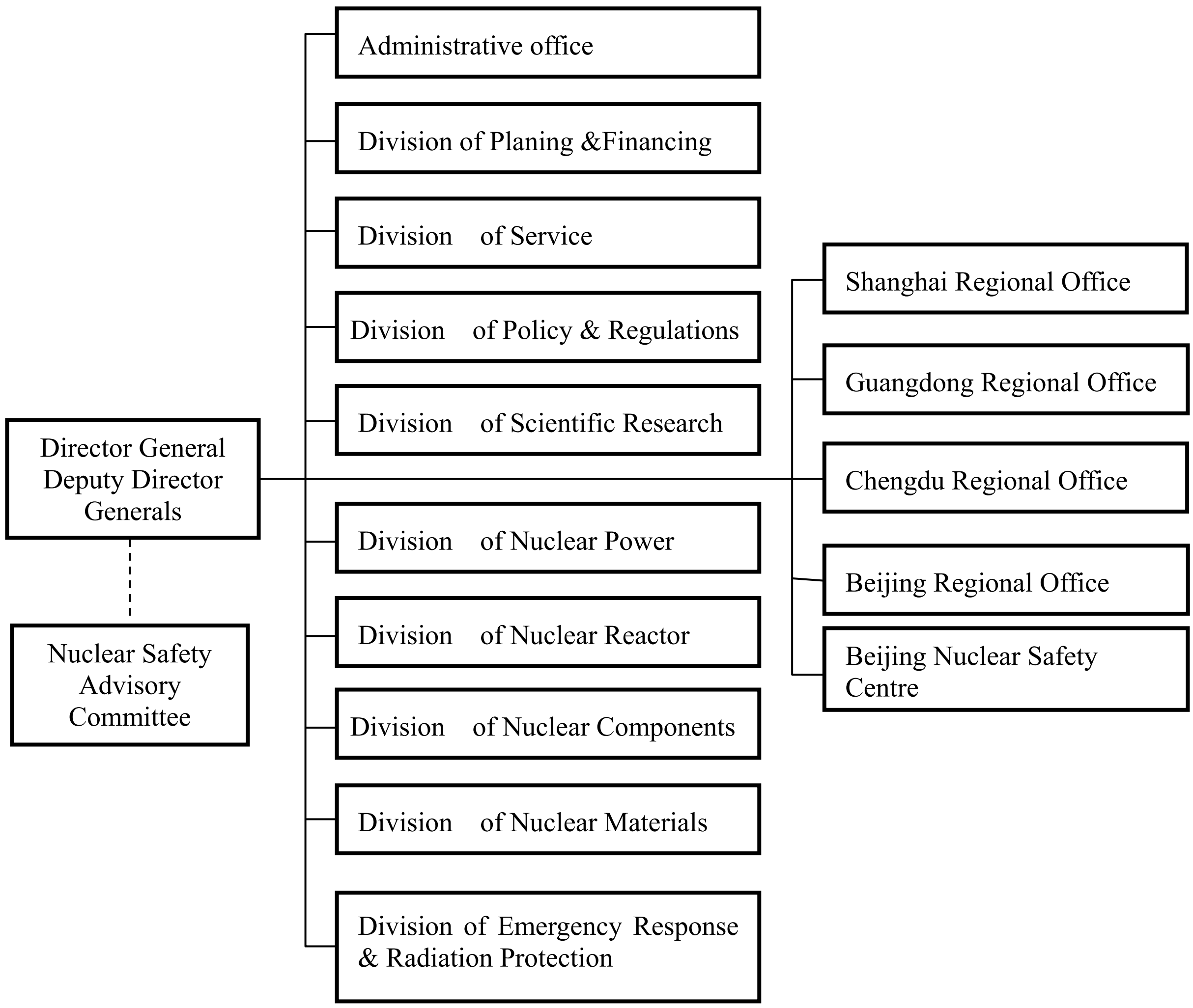

Fig 3.3 The organization structure of the NNSA

3.4.2.3 The Ministry of Health

The Ministry of Health is in charge of unified surveillance of personal dose health effects management and hygienic evaluation all over the country.

There are also departments in charge of hygiene monitoring affairs in provinces and municipalities.

3.4.3 Position of the Regulatory Body in the Governmental Structure

Under the administration of the State Science & Technology Committee, the NNSA represents the country to enforce surveillance function on nuclear safety independently.

The NEPA and the Ministry of Health are subordinate to the Sate Council.

3.4.4 Relationship of the Regulatory Body with Agency Responsible for Promotion and Utilization of Nuclear Energy

China Atomic Energy Authority (CAEA) is a governmental organization responsible for the promotion and utilization of nuclear energy. Its governmental functions include:

research and putting forward guiding principle policy and strategy of development of China's nuclear industry, working out development program nuclear discipline putting into effect the management in this domain, pursuing research, development and utilization of atomic energy and together managing and promoting international co-operation in peaceful use of atomic energy.

CAEA, NNSA, NEPA and the Ministry of Health are mutually independent governmental organizations.

3.5 Responsibilities of the Licensee

The operating organizations of NPPs are directly responsible for the safety of NPPs they operate.

The 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 be subjected to the surveillance on safety by the NNSA, the NEPA and the Ministry of Health, etc.; to report in time the safety situation strictly according to the facts 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.

3.6 Nuclear Safety Surveillance

The NNSA and its accredited regional offices may sent regional inspection group (inspector) to the work-site of siting, manufacture, construction and operation of NPPs to exercise the following duties:

(1) to examine whether the information submitted relating to safety is in conformity with the actual situation;

(2) to supervise whether the construction is carried out in accordance with the approved design;

(3) to supervise whether the management proceeded is in accordance with the approved quality assurance program;

(4) to supervise whether the construction and operation of NPPs have fulfilled the nuclear safety regulations and conditions specified in the licenses;

(5) to investigate whether the operators are adequately competent for safety operation and carrying out emergency response plan;

(6) other functions necessary to be supervised.

The nuclear safety supervisors when they are performing a mission have the right to gain access to the sites of components manufacturing, construction or operation of NPPs to investigate and collect information relating to nuclear safety.

When situation becomes essential, the NNSA has the right to take compulsory actions up to stop the operation of NPPs.

In order to encourage all organizations and individuals who have made contributions to nuclear safety, to ensure the execution of the laws and regulations, reward and penalty system has been established.

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 nuclear power plants, the principle of “Safety first” has the utmost priority. Organizations and individuals engaged in nuclear power activities 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 nuclear safety objectives are defined as follows:

Nuclear power plant operating organization should possess sufficient measures to guarantee quality and safety operation, to prevent nuclear accidents and to minimize their potential harmful effects. The site personnel and public should safeguarded against undue exposure and contamination which the limits have been stipulated by the state, while radiation and contamination should be reduced to the levels as low as reasonably achievable.

4.1.2 Safety Culture and its Cultivation

Chinese government considers that safety culture refers to the establishment of a set of scientific and rigorous administrative regulations and department rules plus consciousness of observing discipline and acting on regulations with good working habit of all staff members involved in safety related activities by every body. In nuclear power plants which finally forms a atmosphere of conscientious concern about nuclear safety.

The high level of safety achieved by NPP to a great extent depends on the level of safety culture in that NPP. The effectiveness of safety culture depends on the leader group and managers level, their awareness of the importance of safety, their intensity of efforts put in the process of legislation and regulation of safety. In the same way, the effectiveness of safety culture also directly depends on individuals engaged in nuclear power activities, their correct understanding of the safety requirement, their seriousness in implementing safety regulations, their good working habit of being scrupulous about every detail and their seeking every opportunity anywhere and anytime to raise safety level. In China the leader group, managers and ordinary workers of NPPs not only bear the safety responsibility of the part they are responsible for but also they form an alliance achieving contributions to safety. This is the level of safety culture we require.

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

All of these standards are widely popularized among staff of NPPs. At the same time 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 popularizing and cultivating safety culture in the nuclear plant we have got progress since the initiating the education program a few years ago. Good safety achievements of NPPs are growing up every year. Further efforts should be made in popularizing safety culture in order to persevere this good situation, but the safety awareness on the leading group level and higher administrative level should be stressed in future, because it is very necessary for implementing “Safety first” principle.

In the two NPPs in China, following steps are taken to familiarizing safety culture:

(1) Established nuclear power plant's safety goals. Management of safety operation is carried out in a quantizing way. Safety goals are reviewed and a revised every year.

(2) Established management structure with defined responsibilities and independent quality assurance supervisory department.

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

(4) Established “Event report system” and “Event analysis and experience feed-back system”. Learning from experience is encouraged.

(5) Worked out and executed safety culture education program. 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.

4.1.3 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 should give its commitment to nuclear power plant safety. All other organizations such as design and engineering, construction, constructors should give their commitments 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.

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 nuclear power plants. Before approving the issuing of safety licenses, NNAS 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 suppliers, if necessary.

Exercising nuclear safety supervision by the NNSA is independent and compulsory. The NNSA has the right, when necessary, to take compulsory actions to order the operating organizations of nuclear power plants to adopt safety measures or to stop any activities that endangering safety.

The National Environmental Protection Agency establishes its own independent surveillance system around the NPP to take supervisory measurements of the NPP's effluents and the level of radioactivity of the environment

4.2 Financial and Manpower Resources

4.2.1 Financial Resources

In China all the expenses on safe operating and improving in safety of NPPs are borne by the nuclear power plants.. After nuclear power plant have been put into operation, a defined percentage of the benefit from generating energy is preserved and to be used to improve safety of unclear power plant, to radioactive waste management and to final decommissioning of the plants. Items for improving safety and their expenses are included in the annual plan and financial budget. The government also allocates certain amount of funds to be used for the technical development of nuclear power and R&D in nuclear safety technology.

4.2.2 Manpower Resources

The qualified personnel required by the nuclear power plant of China come from following resources:

(1) The nuclear industry of China fostered a batch of qualified nuclear engineering specialists and management personnel. They have rich experiences in design, construction and operation management and serve as backbone of the scientific and technological team in organizations engaged in nuclear power plants.

(2) Qualified personnel for NPP under construction are also being trained in NPPs already been put into operation.

(3).There are many people specialized in conventional island and electrical engineering from the Chinese power supply industry, which may be recruited by the nuclear power plants.

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

(5) Recruitment of foreign nuclear power specialists by contracts.

The recruitment, training and retraining, authorization of operating personnel are carried out according to the Chinese Safety Guide “Staffing of Nuclear Power Plants and the Recruitment, Training and Authorization of Operating Personnel”.

The personnel have to pass special training courses before going to the job. Inside the operating nuclear power plant area training centers are established and full-scope training simulators are installed. They are used training and examining operating personnel and for training management personnel.

4.3 Human Factors

4.3.1 Actions Taken to Prevent and Correct Human Errors

From practice it shows that human errors is one of the dominating factors that initiates safety importance events. Therefore, researches on human factors in China have been emphasized to find out effective measures which can reduce human errors so that the safety level of nuclear power plant can be maintained and improved.

(1) Human factors have been taken into account in the design of nuclear power plant: work areas for staff on site are designed according to man-machine effectiveness principle, paying attention to human factors. In the design of control room, the working load, the probability of the occurrence of human errors and the reacting time of operational personnel have been taken into account to reduce the physical and mental labor of operational personnel to the minimum limit 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 work licensing system: a work licensing system is established for operation, maintenance and periodic testing so that any safety related work is required to be done with license or permit.

(3) Establishing operation experience feedback system to prevent and human errors: A tree level of nuclear power operation experience feedback system is established in operating organization, competent department of nuclear power plant and the National Nuclear Safety Administration (NNSA) respectively Experiences and lessons related to human factors from International Atomic Energy Agency (IAEA) and World Association of Nuclear Operators (WANO).can be analyzed and used in China to reduce human errors, and to improve operation management level and supervisory management level of nuclear safety

4.3.2 Measures in the Operation Management Systems

(1) Establishing post personal responsibility system to reduce human errors occurring in management and coordination..

(2) Establishing response system for operation events. Prompt investigation and analysis are carried out when important events occur, while timely relevant training for operation personnel are carried out in accordance with the kind of human errors occurred.

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

(4) 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.

(5) Establishing a system of advertising for staffs, training and assessing technical proficiency before go on duty. Self-appraisal activity is carried out in the course of safety culture education to improve self -consciousness on implementing safety requirements.

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 check a examining the qualification of safety related personnel of nuclear power plant and 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. Important and risky work is carried out by technical responsible persons on site. Import operation and testing are assigned to qualified and experienced personnel. Safety related quality supervision on site is strengthened so as to put forward preventive measures and corrective principles for human errors.

4.4 Quality Assurance

4.4.1 Quality Assurance Policies

(1) The operating organization of a NPP has overall responsibility for ensuring the safety of the NPP. The operating organization establishes and implements effectively the overall quality assurance programme and its sub-programme of each of the constituent works (e.g. siting, design procurement manufacturing, construction, commissioning, operation and decommissioning of the plant.)

(2) The operating organization may delegate to other organizations the work of drafting and implementing all, or a part, of the programme but retains itself the responsibility for the effectiveness of the overall programme.

(3) The quality assurance program encompasses the activities necessary for achieving the appropriate quality of respective item or service and activities that are necessary for verifying that the required quality is achieved and that objective evidence is produced to that effect.

(4) The contractor and the supplier relating to the safety of unclear power plant establish respective quality assurance programme according to the requirements of the contract in order to control its activity.

(5) The basic responsibility for achieving quality rests with those assigned the task and not with those verifying the quality.

(6) The personnel having responsibility for verifying and inspecting the task should not be related to the personnel or group who directly perform the task, and the personnel carried out the independent review and surveillance should also not be related to the organization that have responsibility for performing the task.

(7) Operating organization carries out periodical management review of the quality assurance programme in order to assess the applicability and effectiveness of the programme.

Quality assurance programme is to be submitted to the national regulatory body for approval.. .

4.4.2 Quality Assurance Programs at Each Stage of NPPs

The nuclear power plants in China have established quality assurance programmes according to the requirements of the nuclear safety regulations in each stage of the plant including siting, design, manufacturing, construction, installation, commissioning, and operation within the whole life time of the plant.

4.4.3 Implementation and Assessment of Quality Assurance Programes

The nuclear power plants in China use quality assurance as an essential tool of effective management. Quality assurance progamme are effectively implemented through thorough analysis of the tasks to be performed, identification of the skills required, the selection and training of a satisfactory environment in which activities can be performed, 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. The nuclear power plants also have established quality assurance department, which is directly leaded by the plant manager and independent from other plant departments. The responsibility and activities of the quality assurance department is as following:

(1) Establish and periodically revise the quality assurance programme of the nuclear power plant;

(2) Perform the quality assurance supervision and assessment in planned schedule to each department of the plant and each contractor for determining the effectiveness of quality assurance programmes implemented;

(3) Perform the real time quality assurance supervision to each department of the plant and contractor on site in order to discover problem in time and report severe quality deficiencies if any to high level management;

(4) Pre-evaluate and examine the qualification of the supplier and periodically issue the list of qualified suppliers;

(5) Examine the quality of documents, including all management procedures of the nuclear power plant, documents package of amendment of design, quality control plan, report on items of non-conformance, procurement documents and quality assurance programmes of contractors, etc;

(6) Periodically submit to the management the reports on quality work, statistics reports

of quality deficiencies and analysis reports of quality trends;

(7) Perform training and re-training of personnel of the plants on subject of quality assurance;

Quality assurance department performs annually the assessment of quality assurance programme's implementation and its effectiveness. The basis of assessment is the results of the quality assurance investigation and supervision performed in the year and information provided by other related departments of the plant. While assessing the quality assurance programme's implementing effectiveness, each key element of the programme is assessed and following aspects are emphasized during assessment:

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

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

(3) Severe quality deficiencies unresolved;

(4) Overall assessment of the programme's implementing effectiveness based on programm's applicability;

(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.

4.4.4 Regulatory Control Activities

(1) Draw up and promulgate the code on nuclear power plant quality assurance and related safety guides, technical documents;

(2) Examine & verify the quality assurance programmes of nuclear power plant.

(3) Supervise the implementation of the quality assurance programme of nuclear power plants 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 nuclear power plant is maintained primarily through the corresponding licenses approved by the National Nuclear Safety Administration(NNSA) which authorizes the correlative activities actions and places conditions to comply with by the licensee.

Siting－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 National Environmental Protection Bureau (NEPB). After the review and assessment is approved, the “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 NEPB respectively.

Construction-The applicant submits the “Application for the Construction of Nuclear Power Plant” to the NNSA, together with “Preliminary Safety Analysis Report” (PSAR), "Quality Assurance Programme of NPP" 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 nuclear power plant are reviewed and assessed by the NNSA, a conclusion is reached on whether the nuclear power plant is safe after it’s constructed. After the review and assessment is approved, the “Construction License for Nuclear Power Plant” is issued.

First Fuel loading-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) and the “Commissioning Programme of Nuclear Power Plant”. The NNSA reviews these documents and determines whether the nuclear power plant 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 “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 NEPB. Instrument of ratification of environmental impact assessment reports are issued by NEPB 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 nuclear power plant in China.

4.5.2 Main Results of Continuous Surveillance and Safety Assessment.

Up to December of 1997, the Qinshan NPP and the two units of Daya Bay NPP have experienced the trials of four reactor fuel recycling period. The results of periodic testing, in-service inspection and safety assessment of nuclear power plants in China indicate that the safety performances of nuclear power plants meet the requirement of the technical specifications and the integrity of three safety barriers is kept well. The results of monitoring carried out by the National Environmental Protection Bureau indicate that the annual radiological liquid effluent releases and the annual radiological airborne effluent releases are far below than the release limits of national standard. The occupational exposures on both the personnel of nuclear power plant and the public are far below than the limits of the national standard.

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 nuclear power plants 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 nuclear power plants for further improvement of preventive maintenance. 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. Periodic testing and inspection for safety related systems and facilities are carried out according to the requirements of the superrision programmes prepared by nuclear power plants in operation in China.

4.6 Radiation Protection

4.6.1 Regulations and Standards on Radiation Protection of NPPs

Radiation protection regulations and standards of the NPP are listed in Appendix 3.

The radiation protection aim of the NPP of China is to ensure that the individual dose equivalent to the site personnel and members of the general public does not exceed the dose equivalent limits set by the competent authority concerned and that the doses are kept at a level as low as reasonably achievable (ALARA). This target is embodied in the activities of design, construction, operation, maintenance and the others.

The State’s standards stipulate that the yearly effective dose limit of the occupational exposure is 50mSv, the yearly effective dose limit of the general public is 1mSv. The yearly effective dose to any members (adults) of the general public by the discharge of the radioactive substance of each NPPs shall not exceed 0.25mSv, and the yearly discharge of each NPPs in normal operation shall not exceed the discharge limits listing in below:.

The Yearly 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 The Dose Limits

(1) The occupational exposure

The yearly average dose equivalent to the site personnel of NPPs of China is far below the dose equivalent limit established by the State’s standards, (see Table 1 of Annex 2).

(2) Exposures on the public

The environment monitoring centers of the province where Chinese NPPs are located have performed the monitoring of the environment around NPPs, the results indicate that the radioactivity of the surrounding environment keeps at the level during 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 State’s standards.

4.6.2.2 Releases of Radioactive Effluents

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

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

(1) The application of ALARA principal in design.

The radiation protection design of Chinese NPPs not only fulfills the requirements of limiting the radiation exposure both within and outside the plant to prescribed limits in the operational states and acceptable limits in accident conditions, but also fulfills the optimum principle of radiation protection.

Suitable measures have been provided in the design and lay out of NPPs to minimize exposure and contamination from all sources of radioactivity. Such measures include proper design of systems and components with respect to reducing radiation exposure during maintenance and inspection, shielding from direct radiation, reduction of corrosion product activation by proper specification of material, means of monitoring, control of access to the nuclear power plant, zoning in accordance with the level of radiation and contamination and suitable decontamination facilities.

(2) The application of ALARA principal in operation

The operating organizations of Chinese NPPs have the responsibility for taking all possible and reasonable protective measures. The radiation protection branch is organizationally independent of the operation branch and the maintenance branch, etc., and provided with professional radiation protection staffs who are well trained, qualified, and are capable of preparing and implementing a radiation protection programme according to the State’s radiation protection Codes and the operating experience of foreign NPPs. The programme includes technical and administrative precautionary measures to ensure that all activities involving radiation exposure are carried out as planned, and are monitored..

All site working personnel have an individual responsibility for putting into practice the exposure control measures which is specified in the radiation protection programme. The operating organization of NPPs takes such measures as radiation protection education, administrative control, training and retraining, etc., to make the site personnel strictly execute working plans.

The operating organizations of NPPs focus their study on all operations related to radiation exposures in controlled areas and work out detailed protective procedures. Aiming at working tasks, the radiation protection branch studies the information on radiation of the plant, investigate the existing working conditions on the spot, evaluates the harmfulness of radiation and contamination and determines the protective measures and alternative approaches. Especially for operation 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. During manipulation, the operating organizations of NPPs carry out routine monitoring and evaluate the individual exposure of operators by using thermoluminescent detectors (TLDs) and electronic dosimeters. In the period of special operation, radio protection workers monitor the working area. After operation, the radiation protection branch evaluates the data of doses to operators for the purpose of reducing them in similar events in the future.

4.6.2.4 The Environment Radioactivity Monitoring

(1) The environment investigation of pre-operation

— The operating organizations of NPPs fulfill two-year investigation of the ambient radioactivity and the ocean ecosystem.

— The operating organizations obtain informations of critical nuclides, critical path of exposure (transportation) and critical public groups.

— The media of the environment for investigation include the air, the surface water, the ground water, land-living organisms, water-living organisms, food, soil, etc..

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

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

(2) The routine environment radiation monitoring

— The operating organizations of NPPs have established a environment 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..

— To satisfying the environmental evaluation needs, the operating organizations of NPPs adequately use the investigation data obtained before operation to achieve the optimum of environmental monitoring. The focal points of environmental monitoring are those items which would give most hazard to the critical public groups.

(3) The effluent monitoring

The operating organizations and the local environmental protection departments monitor all types of airborne and liquid radioactive effluents after NPPs are being put into operation. The measuring content includes the total discharge quantity, the discharge concentration and the analysis of main nuclides.

(4) The accident environment emergency monitoring

— The operating organizations have established an environment emergency monitoring plan which is submitted to the provincial environment protection departments before the trial operation of NPPs. The environment emergency monitoring plan 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 organizations have equipped such instrumentation as the radiation monitors, the radiation detectors, the contamination monitors, the air samplers and the environment 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.

4.7 Emergency Preparedness

4.7.1 Regulations and Requirements for Emergency Preparedness

The regulations of emergency preparedness for nuclear accidents at nuclear power plant in China are listed in Appendix 3.

The "Emergency Management Regulations for Nuclear Accidents at Nuclear Power Plant" issued by Chinese government, which is the basis of emergency preparedness for nuclear accidents, specifies as follows: the principle of emergency management of nuclear accidents should be ever on the alert, positively compatibly, unified command, energetic coordination, protection of the public and protection. of the environment.

The emergency preparedness includes: emergency response plan, emergency response implementing procedures, emergency response facilities and periodic emergency response training and exercises. Specific requirements for 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 nuclear power plant, 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 situation 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

A three-level emergency preparedness system in China consists of National Coordinating Committee for Nuclear Emergency (NCCNE) (main member institutions include China National Nuclear Corporation, National Nuclear Safety Administration, National Environmental Protection Bureau and the Ministry of Health), local governments and operating organizations, see Figure 4.1. National Nuclear Safety Administration, National Environmental Protection Bureau and the Ministry of Health accomplish the corresponding emergency tasks during nuclear accidents within the scope of their own responsibilities.

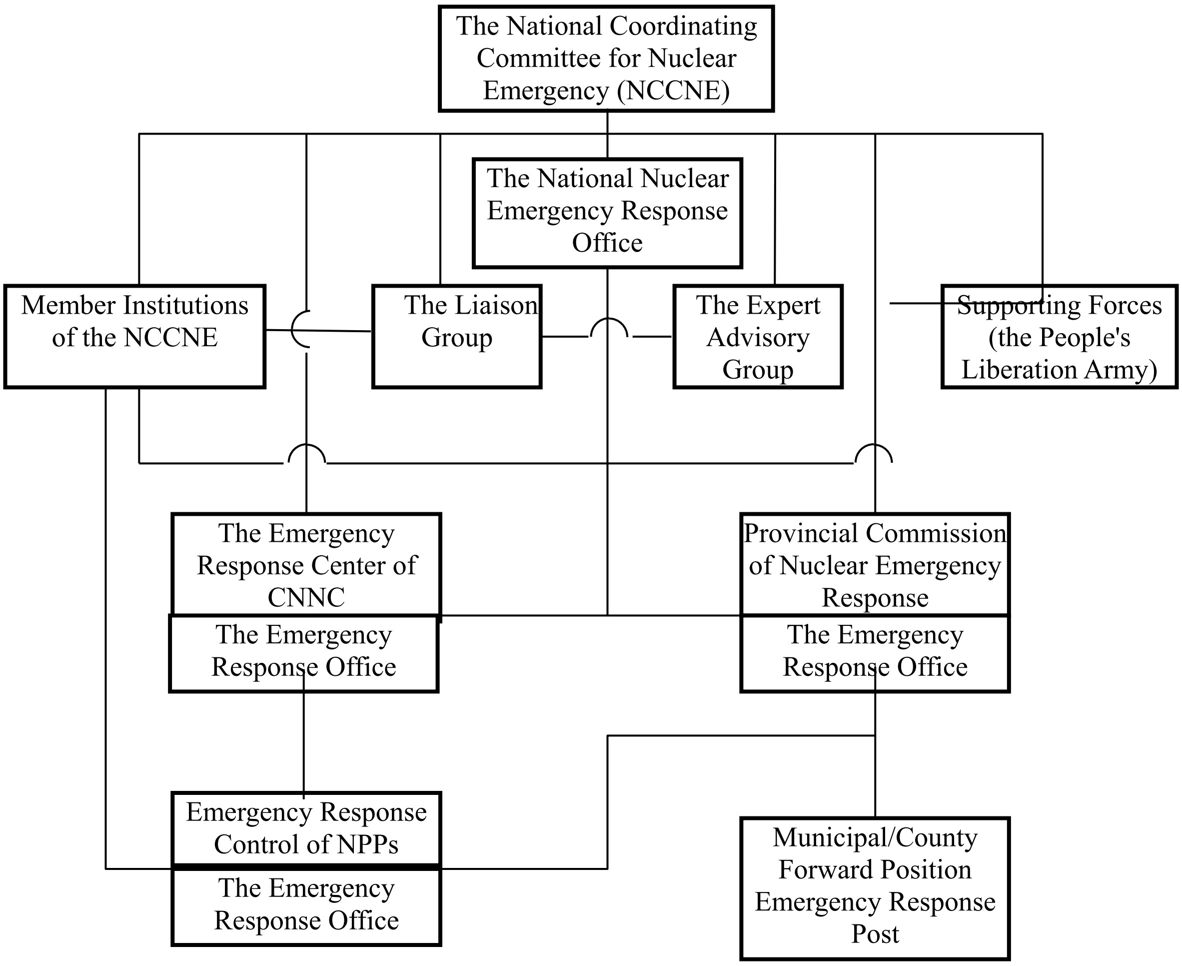

Figure 4.1 Organizational Structure of National Nuclear Emergency Response System

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

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

— Outlining national policies for emergency management of nuclear accidents;

— Overall coordinating emergency response activities of departments concerned in the State Council, the Army and local people's governments;

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

— Approving the declaration and termination of the off-site emergency situation at appropriate time;

— Putting forward suggestions on implementing emergency response actions of nuclear accidents;

— Reviewing and approving communique on nuclear accidents and international notifications, working out the scheme for requesting international aids;

— Asking the State Council to exercise leadership, organize and coordinate the national emergency management of nuclear accidents if necessary.

(2) The CNNC is responsible for:

— inspecting and directing the emergency response plans and their preparedness of nuclear power plants which belong to CNNC or industrially attached to CNNC;

— organizing, directing and supporting on-site emergency response, collecting and assessing accident situations timely and reporting to the NCCNE and NNSA;

— providing support of off-site emergency response according to the direction of NCCNE or the requests from local governments.

(3) The National Nuclear Safety Administration is responsible for :

— examining and assessing on-site emergency plans of organizations concerned, inspecting and monitoring their emergency preparedness;

— assessing technically and monitoring the decision-making and actions taken of the operating organizations during emergency response and taking intervention actions if necessary; providing technical advice to national and local emergency organizations.

(4) The National Environmental Protection Bureau is responsible for :

— directing local environmental protection organizations to cope with emergency plan and its preparedness;

— organizing members available of the emergency preparedness system taking the lead to provide off-site emergency radiation monitoring under the condition of off-site emergency according to the arrangement of NCCNE; and

— monitoring the environmental restoration at the late phase of an accident.

(5) The emergency response organizations under local provincial governments are responsible for emergency management of nuclear accidents within the local areas.

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

— Preparing 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 neighbouring provinces, autonomous regions and municipalities directly under the central government;

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

(6) The 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 people's 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) 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 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 together with the schemes are prepared, examined 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 operating organization is examined and approved by the NNSA, the emergency response plan of the local provincial government where the NPPs are located is examined and approved by the NCCNE and the national emergency plan shall be reviewed and approved by appropriate leaders of the State Council.

(2) The emergency support of nuclear power plants in China mainly relates to emergency operation, engineering rescue, assessment of accident and its consequences, radiation emergency and personnel evacuation. The emergency support of the local government mainly involves emergency environmental radiological monitoring and the assessment, contamination surveillance, decontamination and access control of the personnel and vehicles evacuating from nuclear power plant. Emergency preparedness is fulfilled through the implementation of emergency response plans and procedures together with the related plans contracts.

(3) Emergency communication system (including satellite communication system and corresponding information transfer equipment) and technical support are incorporated in each level of the emergency organization structure in China. An emergency response center of nuclear accidents has been set up in Hong Kong , China and the cooperation between the center and Guangdong province keeps on well. Several individual and integrated exercises have been performed before and after the operation of Qinshan Nuclear Power Plant and Daya Bay Nuclear Power Plant. Officers from IAEA observed the integrated off-site emergency exercise carried out in Guangdong province; Combined exercise between Daya Bay Nuclear Power Plant and the CNNC was also carried out. The response capabilities of dealing with emergency of nuclear accidents have been strengthened through these exercises.

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 close near nuclear power plants, and make knowledge of emergency protection widely available, such as alarm, shielding, evacuation and administration of preventive anti-radiation medicine in case of an emergency, and give directions on how to take these actions. The operating organization makes the public to dispels nuclear panic and to be activated effectively in case of an emergency through the strengthening of 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 in China 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 and basic knowledge and skills to fulfill specific emergency response tasks.

Emergency response personnel of nuclear power plant are trained and examined systematically by the operating organization before the first fuel loading of nuclear power plant in China. They are re-trained every year in the NPPs.

4.7.3.2 Emergency Exercises

Emergency exercises are categorized into combined exercise, integrated exercise and individual exercise. The combined exercise has to be carried out once every five years, the integrated exercise once every two years and the individual exercise is carried out once or several times every year.

On-site and off-site combined exercise are specified to be carried out the first fuel loading of nuclear power plant in China. The assessment on the results of the exercise, experiences obtained and the problems left over is made and the emergency plans are improved and perfected after the exercise.

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", China accomplishes its duties according to the requirements of these two conventions.

5 SAFETY OF NPPs

5.1 Siting

5.1.1 Licensing Process

In accordance with Chinese nuclear safety code “Application and Issuance of Safety License for NPP”, the applicants should follow national basic construction procedure, submitting the “NPP Feasibility Study Report” to the NNSA and the “Environment Impact statement Assessment Report of NPP” to the NEPB 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 NEPB respectively to determine whether the NPP to be built will be safely operated on the selected site, “Reviewing Comments on NPP Siting” and “Instrument of Ratification of the Environmental Impact Assessment Report for NPP” are then granted.

5.1.2 Criteria for Siting

Siting for Chinese NPP should comply with “Code on Safety of NPP Siting” and also take reference to IAEA code (IAEA Safety Series No.-50 C-S, Safety in NPP Siting). The following aspects have been taken into considerations:

(1) Effects of external events occurring in the region of the particular site (these events could be 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.

5.1.2.1 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 which 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 which are sufficiently relevant to the region of interest may be used in the formulation of the design basis event.

5.1.2.2 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 site of NPP 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.

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

(1) In the evaluation of a site for its radiological impact on the region in operatingl condition and accident condition which could lead to emergency measures, appropriate estimates have to be made of expected or potential releases of radioactive substances taking into account the design of the plant and its safety features. It is a common practice for the purpose of site evaluation to refer to these releases as source terms.

(2) The direct and indirect pathways by which radioactive substances released from the NPP could reach and affect the people are evaluated; in this evaluation unusual regional and site characteristics are taken into account with special attention given to the role of the biosphere in the accumulation and transport of radionuclides.

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

(4) The design of the plant should compensate for any otherwise unacceptable effects of the NPP to the region, otherwise the site should be deemed unsuitable.

5.1.2.4 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.

5.1.3 Implementation of Codes on the Safety of NPP Siting

In accordance with “Code on the Safety of NPP Siting”, for the NPP to be built, the applicant evaluates all site-related factors affecting safety and impact of NPP on safety of individuals society and surrounding environment during its projected life, submits “NPP Feasibility Study Report” and the “Preliminary Safety Analysis Report for NPP” during siting stage. After “NPP Feasibility Study Report” is approved by the NNSA, the applicant receives the “Reviewing Comments on NPP Siting” from the NNSA. When the NNSA approves the “Preliminary Safety Analysis Report for NPP”, “Construction Permit of NPP” is issued to the applicant by the NNSA.

5.1.3.1 Natural Events Affecting Safety

In China, during NPP siting, the applicant investigates and evaluates the natural factors such as floods, earthquakes, seismic sea waves, tornadoes, tropical cyclones, geological structure, behavior of foundation soil in detail, and formulates the engineering design basis per investigations and related safety requirements.

5.1.3.2 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.

5.1.3.3 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 Safety Codes and Guides Related to Design

"Code on the Safety of NPP Design" and a series of guidelines have been enacted focusing on the design of NPPs (see Appendix 3). These codes and guidelines are formulated by reference to the corresponding related Nuclear Safety Standard (NUSS) of the International Atomic Energy Agency (IAEA).

During the reviewing of the design of imported NPP, the NNSA requires the applicant of "NPP Construction Permit" to illustrate that the regulations, the codes and the standards which are used in the export country are in compliance with the requirements of the Chinese NPP design regulations and guidelines.

5.2.2 Approval Process of the Design and Construction Permit

(1) After the site is selected, the applicant for the "NPPs 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 NPP";

— Instrument of Ratification of the "Feasibility Study Report for NPP";

— Instrument of ratification of "Environmental Impact Assessment Report of NPP" (one month before issuing the construction permit);

— "Preliminary Safety Analysis Report for NPP";

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

The NNSA organizes the specialists concerned for reviewing and making assessment. After confirming that the contents of documents listed above are in compliance with the requirements of nuclear safety regulations, the NNSA issues to the applicant "NPP Construction Permit".

(2) The applicant engaged in the nuclear island design should apply for the qualification license from the Ministry of Construction which authorizes CNNC to review and make assessment. The Ministry of Construction grants to the applicant the qualification license of the nuclear island design after it is reviewed and considered to be qualified.

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

5.2.3 Implementation of the Defense in Depth Concept in Accordance with the Principle of Multiple Safety Levels

The NPP design process in China 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 implementable, i.e. reactivity control, 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 limit the consequences of accidents.

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.

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

(1) The aim of the first echelon of defense is to prevent deviation from normal operation. In order to achieve this aim, the following measures have been adopted in the NPP design process in China:

— All safety functions of the structures, systems and components are defined.

Structures, systems and components are classified on the basis of their importance to safety.

— Adequate attention is paid to all aspects of quality, such as the selection of materials, specifications, use of construction, operation experiences and regulations of inspection, maintenance and testing, etc.. This relates 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 NPP 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 operatingl occurrences from escalating into accident conditions. To meet this objective, in NPP design process in China, special systems e.g. (the emergency power supply 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 be evolved into becoming the design basis accidents.

(3) Additional equipment (equipment with special engineering safety features and the protection system etc.) and procedures are provided as the third echelon to prevent the design basis accidents be evolved into severe accidents. A further major objective of this echelon is to achieve stable and acceptable conditions following accident conditions.

(4) Beyond the third echelon there are further measures to the protection of the public and site personnel by special designate supplementary facility which would be available to mitigate consequences of events beyond the design basis and by emergency response plans and preparedness. The measures of the accident prevention and to mitigation of Chinese NPPs are described in 5.2.4.

During the NPP design process in China, the second application of the defense in depth concept is the provision of multiple physical barriers, in the NPP to prevent the escape of radio-active substance to outside These physical barriers include the fuel matrix, the fuel cladding, the reactor coolant system 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 are designed to be able to keep their integrity under design basis accidents.

The fuel is monitored by performing continuous measurements of overall reactor coolant activity and by performing periodic measurements of the concentration of certain isotopes topes 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. All safety valves and their set points meet the criteria of American Society of Mechanical Engineers (ASME) standard of overpressure protection.

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.

Through control of the reactor coolant 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

The attention of Chinese NPPs for the accident management mainly focuses on the major measures of obtaining safety, i.e. the accident prevention especially those accidents which could severely damage the reactor core.

5.2.4.1 Measures of the Accident Prevention

The accident prevention of Chinese NPPs relies on high-standard designed 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 NPP design and operation;

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

— The 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 the NPP for seeking weak points in design.

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 off-site emergency response measures.

The accident management procedures 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 operators to find out quickly the cause of going 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 the Chinese NPPs.

The off-site emergency response measures of Chinese NPPs are described in 4.7.

5.2.5 Assurance for Adopting Proven and Up to Standard Process and Technology

(1) The codes and standards adopted in the design process of Chinese NPPs have been identified and evaluated before their application, to confirm their applicability and adequacy and to ensure quality to satisfy the required safety function.

(2) 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 which illustrate their qualification.

(3) The design of Chinese NPPs adopts technologies proven by experience and testing:

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 test works which mainly focus on fields as reactor physics, thermo-hydraulics, stress analysis, new material development, main equipment, instrumentation and controls, civil works, site environment, corrosion, welding and non-destructive inspections, etc..

Zero-power experimental facilities, facilities for fuel assembly hydraulic test, rigs for reactor thermo-hydraulic test, hot-condition tests of both the separator of steam generator and the control rod driven mechanism, etc., are specially built in China, their main research and experimental projects include:

— The reactor zero-power test: to verify the correctness of the reactor physics design;

— Thermal hydraulic test of the reactor core: to verify the feasibility of the core hydraulic design, fuel assembly and its grid design.

— Stress analysis and strength tests of the main equipment: to illustrate that the strength of the reactor vessel, steam generator, main pump and main pipeline satisfy the design requirements with proper margins;

— Alignment test of the driven line and drop test of the control rod: to verify the reasonableness of the design of driven line components;

— A series of fuel assembly in-core and out-core tests: to verify the safety and reliability of the structure design of the fuel assembly;

— The steam generator separator test in hot and cold conditions: to verify the separator performance.

In addition, prototype pump of nuclear class 2 for safety injection, residual heat transfer and spray, etc. are developed, and various performance tests are performed, including heat impact performance test. More than ten types of nuclear grade valves are developed and their performance tests are carried out. Anti-seismic analysis and its test of all nuclear grade equipment are performed. A ring model test in full-scale of the pre-stressed containment is performed to provide reliable data for the design and construction of the containment.

The domestic expert group had reviewed Qinshan NPP after the design was finished. The design and calculation of certain important equipment were consulted with and verified the calculation by foreign qualified manufacturers.

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 controling 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 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 operator in short term, and alleviate their mental burden.

(7) The control and display function symbols are conveniently linked together with the devices under monitoring and control.

(8) Control devices and their function displays are designed to be put in a place where operators are easy to watch and manipulate.

5.3 Operation

5.3.1 Regulations and Guides for Operation

"Regulations on the Operational Safety of NPP " and guides(see appendix 3) referring to the operation of NPP are laid down taking reference to the corresponding Nuclear Safety Standards (NUSS) of IAEA.

During the examining of imported NPPs, the NNSA demands the applicant for "Operation License of NPP" to assure that the regulations, codes and standards which have been used in the exported country are in accordance with the requirements of Chinese regulations and guides of NPP operation.

5.3.2 Operation Licensing Process

(1) The licensing process begins with the issuance of the “Instrument of Ratification for the First Fuel Loading of NPP”. The operating organization must submit the “Application for the First Fuel Loading of the NPP” to the NNSA twelve months prior to the first fuel loading of the NPP, together with the following documents:

— “Final Safety Analysis Report”;

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

— “Commissioning Program of NPP”;

— Qualification certificates of operators for NPP (one month before the first fuel loading;

— “Emergency Response Plan of the Operating Organization of NPP (six months before the first fuel loading);

— “Report of the Construction Progress of the NPP” (six months before the first fuel loading);

— “In-service Inspection Program of the NPP”;

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

— “Commissioning Report of NPP before Fuel Loading” (one month before the first fuel loading);

— The certificate of possessing nuclear material of 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 NPP” (six months before the first fuel loading);

— “Quality Assurance Program of NPP” (commissioning stage);

The NNSA organizes experts concerned 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 NPP” is issued to the applicant.

(2) The operating organization shall submit the following documents in time to the NNSA twelve months after the first full power trial operation of the NPP:

— “Revised Final Safety Analysis Report of NPP”;

— Instrument of ratification of “Environmental Impact Assessment Report of NPP”;

— “Reports of Commissioning and Trial Operation of NPP after the Fuel Loading”;

— “Quality Assurance Program of NPP” (operation stage).

The NNSA organizes experts concerned 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 NPP” 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 to operate a NPP in China is based upon the identification that the NPP constructed is consistent with the design and with the requirements in the corresponding safety analysis and commissioning program.

(1) The scope of safety analysis includes:

— Demonstration that operation limits and conditions satisfy with the requirements for normal operation of NPP;

— The postulated initiating events are appropriate to the NPP design and its location;

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

— Comparison of the results of the analysis with the radiological acceptance criteria and design limits;

— Establishment and confirmation of the design basis;

— Anticipated operational occurrences and accident conditions can be managed with the response of automatic safety system.

(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 activity. The commissioning program includes the verification of safety equipment and their functional characteristics as well as radiation protection. Commissioning tests are carried out in China at the stages of fuel loading, criticality and power raising operation. Process from one stage to the next is not to be continued until an evaluation of the results available from the commissioning tests of the previous stage and an audit has been carried out to ascertain that all objectives and nuclear safety regulatory requirements have been met. Control points have been set up at each important commissioning stage by the NNSA.

After the revised documents “Final Safety Analysis Report of NPP”, “Reports of Commissioning and Trial Operation of NPP after Fuel Loading” and “Quality Assurance Program of NPP during Operation Period etc.” which are submitted by the operating organization have been reviewed and assessed by the NNSA, the surveillance and inspection on nuclear safety during trial operation are carried out to determine whether the result of commissioning is consistent with the design, then check the revised operation limits and conditions. Twelve months after full power operation of NPP, The “Operation License of NPP” is issued to the operating organization under the condition that the instrument of ratification of the “Environmental Impact Assessment Report of NPP” is received by the NNSA.

5.3.3.2 Establishment and Periodic Revision of Operation Limits and Conditions

In China, the operation limits and conditions which 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 operation limits and conditions shall specify various requirements for ensuring all the safety systems (including the engineering safety features, ESF) to be functioning under accident conditions.

The operation limits and conditions are reviewed periodically during the operating life of the NPP in the light of experience accumulated and technological developments. The operating organization is responsible for the preparation of the working procedures of the revision of operation limits and conditions and revise the operation limits and conditions according to the working procedures. Assessment and report of anticipated operational occurrences shall form an important part of the basis on which whether the operation limits and conditions need to be revised. In China, any revision on operation limits and conditions should be reviewed and approved by the NNSA.

5.3.3.3 Program of Operation, Maintenance, Inspection and Testing

Operation, maintenance, inspection and testing are conducted according to the technical specifications approved by the NNSA. The procedures prepared by the operating organization meet the requirements of technical specifications and are implemented exactly according to the approved procedures.

5.3.3.4 Accident Response Procedures

In China, response procedures have been prepared for both anticipated operational occurrences and accidents and verified on full-scale simulator on which the operators are trained as far as possible.

The accident response procedures of Qinshan NPP are symptom-oriented response procedures. The accident response procedures of Guangdong Daya Bay NPP include both response procedures for design basis accident and procedures for part of beyond basis accidents.

5.3.3.5 Engineering and Technical Support

Technical support organizations are set up inside every operating organization in China.

CNNC is capable of providing engineering and technical supports in operational safety related areas. Nowadays, the engineering and research organizations attached to CNNC have become technical support organizations for NPPs in China, for instance, there are research institute of nuclear power operation, research and design institute of nuclear power engineering and institute of radiation protection. CNNC is responsible for coordinating the developing trends of engineering and technical support.

5.3.3.6 Incident Reporting System

According to the requirements of “The Reporting System of Operating Organization”, NPP in China has to report to appropriate organizations in case of the following events during the period of testing and operation:

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

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

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 NPP;

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

NPPs in China have reported events to the regulatory body according to the event reporting system(see Annex 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 which 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.

The internal experience feedback is obtained from the reports of personnel carrying out operation and maintenance, and assessed by the management and technical staffs of NPP to find out problems.

The external experience feedback includes the following two aspects:

(1) 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).

(2) 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 follow-up tracing activities are carried out to meet the requirements specified.

5.3.3.8 Control and Storage of the Radioactive Waste

The operating organizations in China have prepared discharge limits for effluents and established methods and procedures for monitoring and controlling such discharges in order to comply with relevant regulations. The radioactive effluent discharges during the operation of NPPs in China are far below the limits specified by the national standards(see Table 2 of Annex 2). Besides, the off-site monitoring program is also prepared by the operating organization Radioactivity surveillance the environment is described in section 4.6.2.4).

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 is enough facilities for the storage of the waste produced during the normal operation and from the anticipated operational occurrences of NPPs in China. A regional low and medium level radioactive waste disposal facility is under construction in Beilong, Guangdong province. 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 Training of operational personnel

The first group of commissioning and operational personn was sent to foreign NPPs for training by the operating organizations before commissioning of NPPs in China. For instance, the first group of commissioning and operation personnel of Qinshan NPP was sent to the NPPs in Japan, Yugoslavia, Germany and Spain before commissioning, and the first group of commissioning and operation personnel of Guangdong Daya Bay NPP was sent to the NPPs in France. Operatiol personnel working in conventional island of NPPs were sent to domestic fossil plants for practising and training. All these training activities have played very positive role in ensuring the safety of commissioning and operation of NPPs.

6. PLANNED ACTIVITIES TO IMPROVE SAFETY

(1) Further perfecting nuclear safety regulations

China has established a set of nuclear safety regulations, but along with the accumulation of experience in nuclear power construction and operation, China plans to revise and further perfect nuclear safety regulations to keep pace with the trend of world development of NPP. For instance, “Code on the Safety of NPP Quality Assurance” and the “Basic Safety Standard of Ionizing Radiation Protection and Radiant Safety” etc. will be revised.

(2) Enhancing nuclear safety culture

To intensify the nuclear safety culture education of all level of management personnel and operating personnel, and to enhance fully nuclear safety culture consciousness of all personnel for ensuring safety operation of NPP. A program for upgrading safety culture covering all organizations is being worked out.

(3) Periodic safety assessment

To establish periodical safety assessment system for NPP safety operation.

(4) Strengthening the training of nuclear safety surveillance personnel and operating personnel of NPP

In addition to continuously perfecting training of licensee, China plans to establish the training center for NPP maintenance personnel. Besides the training of nuclear safety surveillance personnel, NPP management personnel and maintenance personnel by using advanced and systematic training methods.

(5) Intensifying operating experience feedback of NPP

To intensify the domestic and international exchange of nuclear power information and perfect the operating experience feedback system of NPP for improving the level of NPP design, construction and operation.

(6) Improvement of equipment safety

Guangdong Daya Bay NPP is planning to replace the head of reactor vessel and Qinshan NPP is planning to install water-level meter to the reactor pressure vessel.

(7) Spreading application of probability safety assessment method

China will further systematically collect the data of domestic NPPs to establish a database on reliability for further raising the level of assessment on the base of NPP probability safety assessment been performed and spreading the application of the probability safety assessment to other domains.

(8) Intensifying the research of countermeasures against the management of severe accidents of NPP

In the research of NPP severe accident management, China plans to systematically study the experience of foreign countries and lays down appropriate policies applicable to Chinese reality.

Appendix 1

List of Nuclear Power Plants in China (by December 31, 1997)*

	NPP Name	Unit No.	Location	Reactor Type	Rated Power (MWe)	Date of Construction	Date of First Connection to 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		Haiyan, Zhejiang Province	PWR PWR	600 600	1996-6-2 1996-6-2	
	Guangdong Lingao NPP		Shenzhen City, Guangdong Province	PWR PWR	984 984	1997-5-12 1997-5-12	
In Planning	Qinshan Phase Ⅲ NPP		Haiyan, Zhejiang Province	CANDU CANDU	700 700		
	Lianyungang NPP		Lianyungang City, Jiangshu Province	PWR PWR	1000 1000		

* 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 1995 to 1997)

No.	Item (Unit) \ Year / Unit	1995			1996			1997		
		Qinshan CN01	Guangdong Daya Bay		Qinshan CN01	Guangdong Daya Bay		Qinshan CN01	Guangdong Daya Bay	
			CN02	CN03		CN02	CN03		CN02	CN03
1	Unit Capability Factor (%)	86.80	49.00	81.50	81.92	77.38	67.75	81.34	82.45	70.60
2	Unplanned Capability Loss Factor (%)	2.00	35.70	2.00	0.90	3.95	8.18	2.85	0.20	1.50
3	Unplanned Automatic Scrams per 7000 Hours Critical (Times)	6.10	4.81	6.72	1.85	5.01	1.19	3.82	0	3.22
4	Collective Radiation Exposure(Man.Sv)	0.15	0.99	0.99	0.79	0.83	0.83	0.3668	0.7538	0.7538
5	Volume of Low-Level Solid Radioactive Waste (M^3)	83.79	126.00	126.00	14.80	97.13	97.13	33.596	103.34	103.34
6	Safety System Performance:									
	High-Pressure Safety Injection System	0.01	0	0	0	0	0	0.0057	0.007	0.001
	Auxiliary Feed-Water System	0.01	0	0	0	0	0	0	0.001	0.001
	Emergency AC Supply System	0	0	0	0	0	0	0	0.014	0.014
7	Thermal Performance (%)	98	100	100	97	99	100	97.6	98.88	99.53
8	Fuel Reliability (Bq/g)	4.45	498.60	72.90	9.15	0	572.2	1.34	0	0
9	Chemistry Index	0.51	0.59	0.38	0.29	0.33	0.23	1.59	0.21	0.21
10	Industrial Safety Accident Rate	0	0.79	0.79	0.10	1.59	1.59	0.295	1.8379	1.8379

Appendix 3

Laws, Regulations and Guidelines of China on the Nuclear Safety

Ⅰ. **National Laws**

1. Laws on the Environmental Protection of the People’s Republic of China
   (Issued by the National People’s Congress, standing Committee on December 26, 1989)
2. Draft on the Atomic Energy Act of the People’s Republic of China (to be approved)

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, 1998)
3. Emergency Management Regulations for Nuclear Accidents of Nuclear Power Plant
   (Promulgated by the State Council on August 4, 1993)

Ⅲ. **Department Rules**

1. Code on the Safety of Nuclear Power Plant siting （HAF 0100 (91)）
   (Promulgated by the National Nuclear Safety Administration on July 7, 1986; Amended on July 27, 1991)
2. Code on the Safety of Nuclear Power Plant Design （HAF 0200 (91)）
   (Promulgated by NNSA on July 7, 1986; Amended on July 27, 1991)
3. Code on the Safety of Nuclear Power Plant Operation （HAF 0300 (91)）
   (Promulgated by NNSA on July 7, 1986; Amended on July 27, 1991)
4. Code on the Safety of Nuclear Power Plant Quality Assurance （HAF 0400 (91)）
   (Promulgated by NNSA on August 29, 1991)
5. Code on the Safety for the Management of Radioactive Wastes from Nuclear Power Plant （HAF 0800）
   (Promulgated by NNSA on August 29, 1991)

6. Code on the Safety Regulation for Civilian Nuclear Pressure Retaining Components （HAF 0900）

   (Issued by NNSA, the Ministry of Machine Building and Electronics Industry and the Ministry of Energy on March 4, 1992)

7. Code on the Safety of Research Design （HAF 1000－1）

   (Issued by NNSA on June 6, 1995)

8. Code on the Safety of Research Reactor Operation （HAF 1000－2）

   (Issued by NNSA on June 6, 1995)

9. Code on the Safety of Civilian Nuclear Fuel Cycle Installations （HAF 1100）

   (Issued by NNSA on June 17, 1993)

10. Appendix One: Management of Refueling, Modifications and Accidental Shutdown of Nuclear Power Plant

    （HAF0300 (91)—1）

    (Issued by NNSA on March 2, 1994)

11. 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（HAF0501 (1)）

    (Issued NNSA on April 1987; Amended on December 31, 1993)

12. Rules for the Implementation of Regulations on the Safety Regulation for Civilian Nuclear Installations of the People’s Republic of China

    — Part One: Safety surveillance of Nuclear Installations （HAF0502(1)）

    (Issued by NNSA on April 14, 1988; amended June 14, 1995)

    Appendix One: The Reporting System for Operating Organization of Nuclear Power Plant （HAF0502 (1)—1）

    (Issued by NNSA January 3, 1992; Amended on June 14, 1995)

    Appendix Two: The Reporting System for Operating Organization of Research Reactor （HAF0502 (1)—2）

    (Issued by NNSA on July 8, 1988; Amended on June 14, 1995)

    Appendix Three: The Reporting System for Operating Organization of Nuclear Fuel Cycle Installations （HAF0502 (1)—3）

    (Issued by NNSA on June 14, 1995)

13. Rules for the Implementation of Regulations on Nuclear Materials Control of the People’s Republic of China （HAF0601）

    (Issued by NNSA, the Ministry of Energy and the Commission of Science Technology and Industry for National Defense on September 25, 1990)
14. Rules for the Implementation on Code on the Safety Regulation for Civilian Nuclear Pressure Retaining Components （HAF0901）

    (Issued by NNSA, the Ministry of Machine Building and Electronics Industry and the Ministry of Energy on March 5, 1993)
15. The Management on the Training, Examining and Certificating of the Personnel Undertaking Non-destructive Examination for Civilian Nuclear Pressure Retaining Components （HAF0902）

    （Issued by NNSA on June 6,1995）
16. The Management on the Training, Examining and Certificating of the Welders and the welding Operators for Civilian Nuclear Pressure Retaining Components （HAF0903）

    （Issued by NNSA on June 6,1995）
17. Rules on the Environmental Radiation Protection of Nuclear Power Plant

    (Issued by the National Environmental Protection Administration on April 23, 1986)
18. Management on the Radioactive Environment

    (Issued by the National Environmental Protection Administration on June 22, 1986)
19. Rules on the radiation protection

    (Issued by the National Environmental Protection Administration on March 11, 1988)
20. The Basic standard on the radioactive health protection （GB4792－84）

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

Ⅳ. **Guiding Documents**

1. Earthquakes and associated topics in relation to nuclear power plant siting (HAF010)

   (Issued on April 17, 1987 by NNSA, the National Seismic Administration; Amended on April 6, 1994)
2. Seismic analysis and testing of nuclear power plants (HAF0102)

   (Issued on April 17, 1987 by NNSA, the National Seismic Administration; Amended on April 6, 1994)

3. Atmospheric dispersion in relation to nuclear power plant siting (HAF01023)
(Issued by NNSA on October 20, 1987)
4. Site selection and evaluation for nuclear power plants with respect to population distribution (HAF0104)
(Issued by NNSA on November 20, 1987)
5. Extreme man-induced events in relation to nuclear power plant siting (HAF0105)
(Issued by NNSA on November 28, 1987)
6. Hydrological dispersion of radioactive material in relation to nuclear power plant siting (HAF0106)
(Issued by NNSA on April 26, 1991)
7. Nuclear power plant siting-hydrogeological aspects (HAF0107)
(Issued by NNSA on April 26, 1991)
8. Safety aspects of the foundation of nuclear power plants (HAF0108)
(Issued by NNSA on February 20, 1990)
9. Site survey for nuclear power plants (HAF0109)
(Issued by NNSA on November 28, 1989)
10. Determination of design basis floods for nuclear power plants on river sites (HAF0110)
(Issued by NNSA on July 12, 1989)
11. Determination of design basis floods for nuclear power plants on coastal sites (HAF0111)
(Issued by NNSA on May 19, 1990)
12. Evaluation of extreme meteorological events for nuclear power plant siting (HAF0112)
(Issued by NNSA on April 26, 1991)
13. Design basis tropical cyclone for nuclear power plants (HAF0113)
(Issued by NNSA on April 26, 1991)
14. Safety functions and component classification for BWR, PWR, and PTR(HAF0201)
(Issued by NNSA on October 30, 1986)

15. Fire protection in nuclear power plants (HAF0202)
(Issued by NNSA on October 30, 1986)
16. Protection system and related features in nuclear power plants (HAF0203)
(Issued by NNSA on October 6, 1988)
17. Protection against internally generated missiles and their secondary effects in nuclear power plants (HAF0204)
(Issued by NNSA on October 30, 1986)
18. External man-induced events in relation to nuclear power plant design (HAF0205)
(Issued by NNSA on November 28, 1989)
19. Ultimate heat sink and directly associated heat transport systems for nuclear power plants (HAF0206)
(Issued by NNSA on October 30, 1986; Amended on April 17, 1987)
20. Emergency power systems at nuclear power plants (HAF0207)
(Issued by NNSA on October 6, 1988; Amended on February 13, 1996)
21. Safety-related instrumentation and control systems for nuclear power plants (HAF0208)
(Issued by NNSA on October 6, 1988)
22. Design aspects of radiation protection for nuclear power plants (HAF0209)
(Issued by NNSA on May 19, 1990)
23. Fuel handling and storage systems in nuclear power plants (HAF0210)
(Issued by NNSA on February 20, 1990)
24. General design safety principles for nuclear power plants (HAF0211)
(Issued by NNSA on July 12, 1989)
25. Design of the reactor containment systems in nuclear power plants (HAF0212)
(Issued by NNSA on May 19, 1990)
26. Reactor cooling systems and their related systems in nuclear power plants (HAF0213)
(Issued by NNSA on April 13, 1989)
27. Design for reactor core safety in nuclear power plants (HAF0214)
(Issued by NNSA on July 12, 1989)
28. Staffing of nuclear power plants and the recruitment, training and authorization of operation personnel (HAF0301)
(Issued by NNSA on April 17, 1987)
29. In-service inspection for nuclear power plants (HAF0302)

(Issued by NNSA on October 6, 1988)

30. Operation limits and conditions for nuclear power plants (HAF0303)
(Issued by NNSA on April 17, 1987)

31. Commissioning procedures for nuclear power plants (HAF0304)
(Issued by NNSA on April 17, 1987)

32. Radiation protection during operation of nuclear power plants (HAF0305)
(Issued by NNSA on May 19, 1990)

33. Maintenance of nuclear power plants (HAF0307（1）)
(Issued by NNSA on April 13, 1989; Amended on June 1, 1993)

34. Surveillance of items important to safety in nuclear power plants (HAF0308（1）)
(Issued by NNSA on October 6, 1988; Amended on June 1, 1993)

35. Management of nuclear power plants for safe operation (HAF0309)
(Issued by NNSA on February 20, 1990)

36. Core management and fuel handling for nuclear power plants (HAF0310)
(Issued by NNSA on November 28, 1989)

37. Operational management of radioactive effluents and wastes arising in nuclear power plants (HAF0311)
(Issued by NNSA on May 19, 1990)

38. Preparation of the quality assurance program for nuclear power plants (HAF0401)
(Issued by NNSA on October 6, 1988)

39. Quality assurance records system for nuclear power plants (HAF0402)
(Issued by NNSA on October 30, 1986)

40. Quality assurance in the procurement of items and service for nuclear power plants (HAF0403)
(Issued by NNSA on October 30, 1986)

41. Quality assurance during site construction of nuclear power plant (HAF0404)
(Issued by NNSA on April 17, 1987)

42. Quality assurance during commissioning and operation of nuclear power plants (HAF0405)
(Issued by NNSA on January 28, 1988)

43. Quality assurance in the design of nuclear power plants (HAF0406)
(Issued by NNSA on October 30, 1986)

44. Quality assurance organization for nuclear power plants (HAF0407)
(Issued by NNSA on April 13, 1989)
45. Quality assurance in the manufacture of items for nuclear power plant (HAF0408)
(Issued by NNSA on October 30, 1986)
46. Quality assurance auditing for nuclear power plants (HAF0409)
(Issued by NNSA on January 28, 1988)
47. Quality assurance in the procurement, design and manufacture of nuclear fuel assemblies (HAF0410)
(Issued by NNSA on April 13, 1989)
48. Emergency Preparedness for the Operating Organization of Nuclear Power Plant （HAF0701）
(Issued by NNSA on August 12, 1989)
49. Emergency Preparedness of Local Government for Nuclear Power Plant （HAF0702）
(Issued by NNSA, the National Environmental Protection Administration and the Public Health Ministry on May 24, 1990)
50. Interfering Principles and Levels for public protection during the Emergency of Nuclear Accidental Radiation （HAF0703）
(Issued by NNSA, the National Environmental Protection Administration on April 19, 1991)
51. Levels of Leading-out interference for Public Protection during the Emergency of Nuclear Accidental Radiation （HAF0704）
(Issued by NNSA, the National Environmental Protection Administration on April 19, 1991)
52. Emergency Preparedness and Response on the Nuclear Accidental Medicine （HAF0705）
(Issued by NNSA and the Public Health Ministry on June 24, 1992)
53. Management of Research Reactor Operation （HAF1002）
(Issued by NNSA on April 3, 1989)
54. Management on the Operational Test for Critical Installations （HAF1003）
(Issued by NNSA on April 3, 1989)
55. Decommissioning of Research Reactors and Critical Installations （HAF1004）
(Issued by NNSA on April 18, 1992)

56. Application and Modification of Research Reactors （HAF1005）
(Issued by NNSA on December 16, 1996)
57. Emergency Plan and Preparedness of Research Reactors （HAF1006）
(Issued by NNSA on August 27, 1991)
58. Standard Format and Content on the Safety Analysis Report for Uranium Fuel Processing Installations （HAF1101）
(Issued by NNSA on July 24, 1991)
59. Emergency Program on the Operating Organization of Civilian Nuclear Fuel Cycle Installations （HAF1102）
(Issued by NNSA on July 7, 1993)
60. Calculation of Low-Concentrating Uranium Transformation and Nuclear Material of Element Manufacturing Plant （HAF1103）
(Issued by NNSA on September 25, 1997)
61. Design and Operation for the Radioactive Waste burning Installations （HAF1201）
(Issued by NNSA on February 15, 1997)

Annex 1

Main Data of Nuclear Steam Supply System (NSSS) of Qinshan NPP and Guangdong Daya Bay NPP

No.	Parameters, Unit	CN01 Qinshan NPP	CN02 & CN03 Guangdong Daya Bay NPP
1	General Parameters		
	Core Type	PWR	PWR
	Electric Power, MW	300	984
	Thermal Power, MW	966	2905
	Design Life, Year	30	40
2	Core Mechanical Design		
2.1	Fuel Assembly		
	Fuel Assembly Number	121	157
	UO_2 Rod Number in each Assembly	204	264
	Assembly Dimension(Long×Wide×High)	199.3×199.3×3500	214×214×4058
2.2	Fuel Rod		
	Total Number	24684	41448
	External Diameter, mm	10	9.5
	Cladding Thickness, mm	0.7	0.57
	Cladding Material	Zr-4	Zr-4
2.3	Fuel Pellet		
	Material	UO_2	UO_2
	Pellet Diameter×Height, mm	8.43×10	8.19×13.5
2.4	Control Rod Assembly		
	Neutron Absorption Material	Ag－In－Cd	Ag－In－Cd
	Assembly Number, Black×Gray	37	41 / 12
	Absorbing Rod Number in Each Assembly	20	Black 24, Gray 8
2.5	Core Structure Characteristics		
	Equivalent Diameter, m	2.486	3.04
	Core Height, m	2.9	3.66
2.6	Fuel Concentration, Zone 1×Zone 2×Zone 3	2.4×2.672×3.0	1.8×1.4×3.1
3	Thermal Hydraulic Design		
3.1	System Pressure, MPa	15.2	15.2
3.2	Coolant Flow Rate	24000	68520
3.3	Coolant Temperature, ^{0}C		
	Nominal Temperature in Entrance, ^{0}C	288.8	292.4
	Core Average Temperature, ^{0}C	302	311.1

No.	Parameters, Unit	CN01 Qinshan NPP	CN02 & CN03 Guangdong Daya Bay NPP
3.4	Heat Transfer		
	Efficient Heat Transfer Area in the Core, m^2	2249	4519
	Average Linear Power of the Fuel Rod, W/cm	135	186
	Maximum Linear Power of the Fuel Rod, W/cm	407	≤590
	Maximum Center Temperature of The Pellet, ^0C	1881	2590 (Peak Value)
4	Reactor Coolant System		
	Pressure in Static Testing, MPa	21.48	22.45
	Design Pressure, MPa	17.16	16.866
	Operation Pressure, MPa	15.2	15.2
	Loop Number	2	3
5	Reactor Vessel Design		
	Design and Operation Pressure, MPa	17.16×15.2	16.866×15.2
	Design Temperature, ^0C	350	343
	Vessel Height×Internal Diameter×Thickness, mm	10705×3374×175	12988×3989×200
6	Main Pump Design		
	Internal Diameter, Entrance×Exit	700×700	787×698
	Nominal Speed, rpm	1500	1485
	Unit Overall Height, m	9.33	8
	Unit Quality(kg)	88	104
7	Steam Generator Design		
	Design Pressure, Primary /Secondary Side, MPa	17.16 / 7.55	16.797 / 8.33
	Design Temperature, Primary /Secondary Side, ^0C	350 / 320	343 / 316
	Overall Heat Transfer Area, m^2	3072.9	5430
	Feed-Water Temperature, ^0C	216	226
	Steam Pressure, MPa	5.2	6.58
	Steam Production, t/h	935.5	1935.6
	Maximum Steam Moisture, %	0.25	0.25
	Overall Height, m	17.248	20.848
	U-Tube Material	Incoloy－800	Inconel－690
	U-Tube Number	2977	4474
	U-Tube, External Diameter×Wall Thickness, mm	22×1.2	19.05×1.09
8	Pressurizer		
	Design Pressure, MPa	17.16	16.797
	Design Temperature, ^0C	370	360
	Total Power of the Electrical Conductor, KW	1350	1440
	Maximum Spraying Volume, t/h	40	40

Annex 2

The Occupational Exposure of Qinshan NPP and Guangdong Daya Bay NPP (from 1995 to 1997)

Table 1

Plants / Years / Items (Unit)	Qinshan NPP			Guangdong Daya Bay NPP		
	1995	1996	1997	1995	1996	1997
The Yearly Collective Effective Dose (man • Sv)	0.15	0.79	0.37	1.98	1.66	1.51
The Yearly Man Average Effective Dose (mSv)	0.25	1.20	0.45	0.85	0.81	0.65
The Normalized Collective Effective Dose (man • mSv/GWh)	0.07	0.35	0.18	0.19	0.14	0.13

The Annual Releases of Radioactive Effluents of Qinshan NPP and Guangdong Daya Bay NPP (Unit: Bg) (from 1995 to 1997)

Table 2

Types \ Items \ Years \ Plants		Qinshan NPP			Guangdong Daya Bay NPP		
		1995	1996	1997	1995	1996	1997
Gaseous Effluents	Noble gas	5.52×10^{10}	3.66×10^{10}	1.51×10^{10}	8.02×10^{13}	4.36×10^{13}	3.11×10^{13}
	Iodine & Particles	Un-measured	Un-measured	Un-measured	7.20×10^{8}	2.29×10^{8}	1.16×10^{8}
Liquid Effluents	Tritium	4.82×10^{12}	3.58×10^{12}	2.95×10^{12}	1.04×10^{13}	2.21×10^{13}	2.85×10^{13}
	Other Nuclides	4.08×10^{8}	5.57×10^{8}	3.36×10^{8}	2.69×10^{10}	1.02×10^{10}	1.13×10^{10}

Annex 3

Statistics of Operation Events of Qinshan NPP and Guangdong Daya Bay NPP (from 1995 to 1997)

Name / Year / Classification (INES Rating)	Qinshan NPP CN01			Guangdong Daya Bay NPP CN02			Guangdong Daya Bay NPP CN03		
	1995	1996	1997	1995	1996	1997	1995	1996	1997
Level 0	6	3	8	13	12	4	15	11	5
Level 1	4	2	0	4	0	3	3	3	2
Above Level 2	0	0	0	0	0	0	0	0	0
Total	10	5	8	17	12	7	18	14	7