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Nuclear power development and radiation safety control in China

Hu Erbang

China Institute for Radiation Protection, Taiyuan 030006, China

Abstract—This paper introduced the nuclear power development and radiation safety control in China. A brief introduction of Qinshan and Guangdong nuclear power plant and a program for future development were described. Follow up, some basic states and information about radiation safety control in China were introduced, such as: establishment of radiation safety criterion, organization of radiation safety control, system of review of safety analysis report and environment impact report, emergency plan and preparedness, emergency assessment system for nuclear accident and so on.

Keywords: nuclear power; radiation safety control; China.

1 Introduction

Qinshan Nuclear Power Plant is the first nuclear power plant which was designed and structured ourself and was into operation in December 1991 in China. It is PWR type and the total nuclear net capacity installed is 300 MW(e). It is located at the foot of Qinshan Mountain, Haiyan County, Zhejiang Province. The site is 87 km south-west of Shanghai and 67 km north-east of Hangzhou. It is a hilly land near the seacoast.

The climate of the site belongs to that of subtropics moist area.

Based on the census data in 1982, the total number of the population with the range of 80 km around the plant is about 10 million, the average density of population is 539 people/km^2.

There are two PWR of 900 MW(e) in Guangdong Nuclear Power Plant. It is located in Guangdong Province about 150 km from Guangzhou and 50 km from Hong Kong.

GNPP is situated on the west coast of Daya Bay bordering the South China Sea. Paiya Mountain (710 m) rises steeply far about 3 km at northwest, but the terrain in the area between the site and Pengchan Village (4 km far from the site) is relatively flat.

The annual average temperature is 22℃ to 23℃. The annual prevailing wind directions are NNE and ESE with frequency of more than 50%. There are two large cities Shenzhen and Hong Kong within 50 km. Their population are 0.19 and 5.37 million.

One unit of GNPP will be into operation in the end of 1993.

2 Program for future development

The structure of the second stage of Qinshan Nuclear Power Plant was begun in the end of 1992.

The Qinshan II Nuclear Power Plant includes two units (each is a 600 MW class). The site is located at the Yangliu Mountain which is about 1.5 km south - west from Qinshan I site.

The Qinshan III Nuclear Power Plant (2×600 MW) will be also built in the future in the same site.

Guangdong Province Electric Power Bureau is deliberating the second project of nuclear power plant in Guangdong Province. The site is to be selected.

In addition, a 5 MW nuclear district heating reactor was into operation in 1990 in Tsinghua University. The possibility of building a 200 MW nuclear heating model reactor in Jilin Province, is under review.

The structure of nuclear power plant is also being taken into account by the local government of several east provinces in China now (Such as Jiangsu, Liaoning, Zhejiang and so on).

3 The radiation safety control

3.1 The main goals of nuclear safety technique are:

To avoid occurrence of accident;

To assure the consequences of all accidents, which have been into account during design of nuclear power plants, to be little;

To assure the probability of serious accident, which could result in large amount of radioactive material to be released into environment and serious radiological consequences, to be very low.

3.2 The main measures on safety of nuclear power plants

The main measures on safety of nuclear power plants in China, which is basically as same as other countries, are as follows: the deep protection in design (e.g. fuel material, fuel cladding, primary pressure boundary and containment), the quality assurance during design, manufacture of items, construction and operation of nuclear power plant, the establish of code, regulations and guides on safety, emergency plan and PSA code, the recruitment, training and authorization of operating personnel and so on.

3.3 Establish of several relative radiation safety criterion

3.3.1 Safety regulations and guides for sitting, design, operation and quality assurance of nuclear power plants

The code on safety of nuclear power plants in People's Republic of China includes the following four parts: "Safety regulation for sitting of nuclear power plants (HAF 0100)"; " Safety regulation for design of nuclear power plants (HAF 0200)"; " Safety regulation for operation of nuclear power plants (HAF 0300)"; and " Safety regulation for quality assurance of nuclear power plants (HAF 0400)". They were published by National Nuclear Safety Administration (NNSA) in 1986.

Total 48 "Safety Guides" in relation to above four basic code on safety of nuclear power plants have been also published by NNSA. There are 13 safety guides in relation to " Safety regulation for sitting of nuclear power plants", such as "Earthquakes and associated topics in relation to nuclear power plant sitting (HAF 0101)". "Atmospheric dispersion in nuclear power plant sit-

ting (HAF 0103)", "Site selection and evaluation for nuclear power plants with respect to population distribution (HAF 0104)", " Hydrological dispersion of radioactive material in relation to nuclear power plant sitting (HAF 0106)", " Design basis flood for nuclear power plants on coastal sites (HAF 0111)" and so on.

There are 14 safety guides in relation to "Safety regulation for design of nuclear power plants", such as "Fire protection in nuclear power plants (HAF 0202)".

There are 11 safety guides in relation to "Safety regulation for operation of nuclear power plants", such as "In - service inspection for nuclear power plants (HAF 0302)".

There are 10 safety guides in relation to "Safety regulation for quality occurrence of nuclear power plants ", such as "Establishing of the quality assurance program for nuclear power plants (HAF 0401)".

3.3.2 **Regulations for radiation protection (GB 8703-88)**

This is a most basic national standard for radiation protection. It was published by National Environmental Protection Agency (NEPA) in 1988 . Table 1 shows the recommended dose limits for individual.

Table 1 Recommended dose limits

Application	Dose limit	
	Occupational	Public
Effective dose Annual equivalent dose	50 mSv per year	1 mSv per year
in the lens of the eye	150 mSv	50 mSv
Other single organ	500 mSv	
The skin		50 mSv

3.3.3 **Regulations for environmental radiation protection of nuclear power plant (GB 6249-86)**

This is a most important national standard of radiation protection for nuclear power plant. It was published by NEPA in 1986. According to this regulation the effective dose equivalent of any individual (adult) of population exposed from environment radioactive nuclides released from each nuclear power plant must be less than 0.25 mSv/a for normal operation. Table 2 and Table 3 show the control limit of annual release amount of gaseous and liquid radioactive effluents.

Table 2 Control limit of annual release amount of gaseous effluents

Gaseous effluents	Control limit
Inert gases	2.5×10^{15}Bq
Iodine	7.5×10^{10}Bq
Particulate ($T_{1/2}>$ 8d)	2.0×10^{11} Bq

Table 3 Control limit of annual release amount of liquid effluents

Liquid effluents	Control limit
Tritium	1.5×10^{11} Bq
Others	7.5×10^{11} Bq

3. 3. 4 Intervention principles and levels for the protection of the public in the radiological emergency of a nuclear accident (HAF 0703, NEPA 9002)

This a basic national regulation for the radiological emergency of a nuclear accident. It was published by NNSA and NEPA in 1990. Table 4 shows the intervention levels for early stage of a nuclear accident.

Table 4 Intervention levels for early stage

Protection measures	Dose (mSv or mGv)	
	Whole body	Lung, thyroid or other single organ
Sheltering	5-50	50-500
Distribution of stable iodine tablet		50-500
Evacuation	50-500	500-5000

3. 4 On the organization of radiation safety control

3. 4. 1 On the organization of radiation safety control

Fig. 1 shows the organization system of radiation safety control.

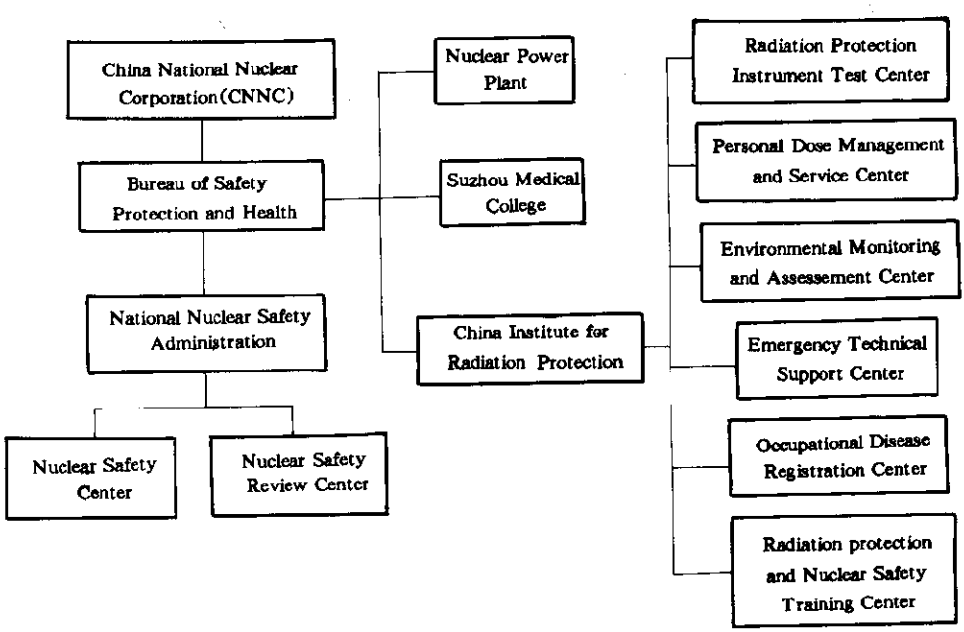

Fig. 1 Organization system of radiation safety control

3.4.2 On the organization of radiation emergency

Fig. 2 shows the organization system of radiation emergency at national level. Fig. 3 shows the radiation emergency technical support center in the China National Nuclear Cooporation (CNNC). Up to now the Nuclear Accident Emergency Committee for Guangdong Province and Zhejiang Province have been established.

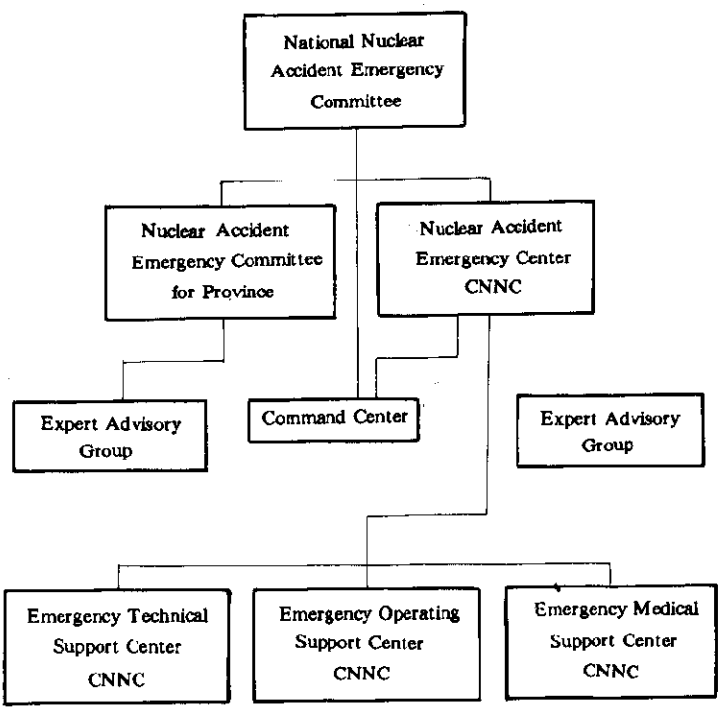

Fig. 2 Organization system of radiation emergency at national level

3.5 On the review of safety analysis report (SAR) and environment impact report (EIR)

3.5.1 On the review of SAR

The operator of nuclear power plant or nuclear installation must provide a preliminary SAR before construction and a final SAR before operation of nuclear power plant. These SAR would be first reviewed by an expert group of CNNC then reviewed by an expert group of NNSA and final formally approved by NNSA.

3.5.2 On the review of EIR

The operator of nuclear power plant must provide EIR respectively for sitting stage, design stage and before fuel loading of nuclear power plant. These EIR would be first reviewed by an expert group of CNNC then reviewed by an expert group of NEPA and final formally approved by NEPA.

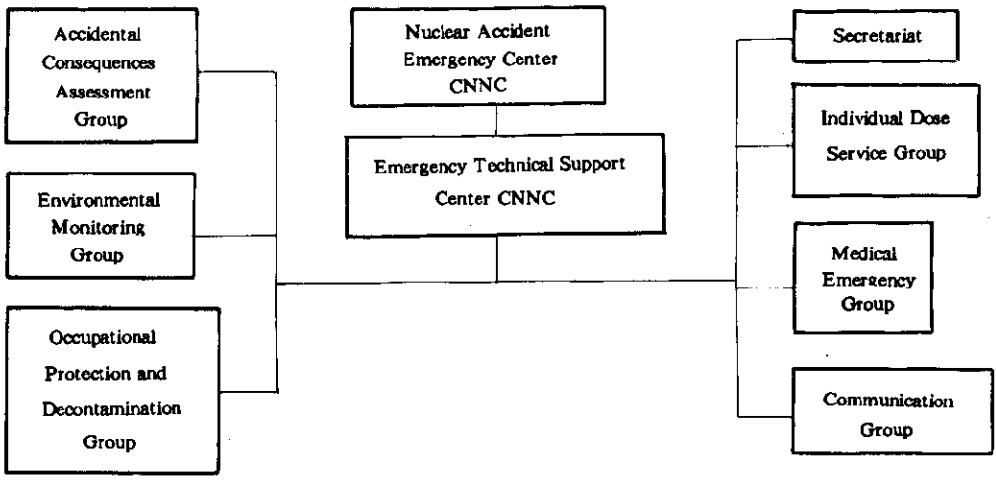

Fig. 3 Radiation emergency technical support center in CNNC

3.6 Emergency plan, emergency plan zone and emergency exercise

3.6.1 Emergency plan

The emergency plan for Qinshan Nuclear Power Plant (first stage) and Guangdong Nuclear Power Plant were finished in 1990 and 1991, respectively.

They belong the operating organization emergency plan. The basic content are following: emergency organization and its duty; emergency facilities; the types of emergency situations and emergency plan zone; report, notification and communication; accident consequences assessment; emergency measures; emergency medical treatment; recovery; public education and information; emergency preparedness; records and reports.

3.6.2 Emergency plan zone

3.6.2.1 The plume emergency plan zone

The area within 10 km of radius from reactor is defined as plume emergency plan zone. The population in this zone is about 100 thousand and about 28 thousand respectively in Qinshan and Guangdong nuclear power plant. The plume plan zone is divided further into two parts: internal zone (within 0-5 km of radius) and external zone. The main countermeasures are sheltering, distribution of stable iodine tablet, control of food and drinking water and evacuation. The evacuation will be only into account for internal zone.

3.6.2.2 The ingestion emergency plan zone

The area within 50 km of radius from reactor is defined as ingestion emergency plan zone. The main countermeasures are control of food and drinking water.

3.6.3 Emergency exercise

A site emergency exercise was done in end of June 1991 in Qinshan Nuclear Power Plant and was done in February 1993 in Guangdong Nuclear Power Plant . A comparative exercise of

accident consequences assessment will be held in March this year between CNNC and NNSA. A plan of off-site emergency exercise for Guangdong Nuclear Power Plant was finished and will be conducted in the July 1993.

3.7 Emergency assessment system for nuclear accident

3.7.1 The emergency assessment system of an accident release for Qinshan Nuclear Power Plant

It consists of following three parts: "A computer code system for the real-time dose assessment of an accident release"; "A rapid dose assessment code of an accident release"; "A hand book for rapid dose evaluation of an accident release".

3.7.2 A similar rapid dose assessment code has been also finished for Guangdong Nuclear Power Plant

3.8 On the PSA and other research program

A computer code CRACBJ is developed in order to suit the Guangdong Nuclear Power Plant probabilistic safety assessment requirements. The CRACBJ is a revised version of the U.S. consequence modelling code CRAC2. In CRACBJ the atmospheric diffusion parameters for large roughness recommended by IAEA are adopted to suit the topography of site in Guangdong Nuclear Power Plant.

A cooperative research on assessment method of radiological safety for shallow land disposal of low level radioactive waste between CIRP. China and JAETI, Japan was carried out during 1988.1-1993.1.

3.9 Prediction of environment impact from nuclear power in 2000

According to a report of People's Daily the total nuclear net capacity is about 6.5 GW(e) in 2000 in China. The activity of nuclide in the radioactive effluent from nuclear power plants in the end of this century in China is evaluated, based on the effluent date of Qinshan and Guangdong nuclear power plant. Table 5 and Table 6 show the annual releases of gaseous and liquid nuclide from nuclear power plant in the end of this century respectively. The annual collective dose equivalent from nuclear power plant is about 11 man. Sv, which is about 19% of those from total nuclear industry in China in 2000.

Table 5 Annual releases of gaseous nuclide in 2000 (TBq)

Nuclides	Inert gases (exception to 85Kr	^{85}Kr	^{131}I	$^{133+136}I$	^{3}H	^{14}C	Aerosol
Relenses	5.8×10^{3}	5.3×10^{2}	6.3×10^{-2}	5.5×10^{-2}	2.9×10^{1}	1.5	3.5×10^{-2}

Table 6 Annual releases of liquid nuclides in 2000 (TBq)

Nuclides	^{3}H	Gross, β (exception to ^{3}H)	^{131}I	^{51}Cr	^{58}Co
Releases	5.7×10^{2}	5.5	1.2	1.9×10^{-2}	2.3×10^{-1}
Nuclide	^{60}Co	^{134}Cs	^{137}Cs	^{106}Ru	
Releases	2.5×10^{-2}	1.1×10^{-1}	1.9×10^{-1}	2.1×10^{-3}	

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