OUTLINE OF CHINESE NUCLEAR REACTORS DECOMMISSIONING

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ABSTRACT

The construction of chinese nuclear facilities began in the 1950's. Some reactors, for example, heavy water research reactor, graphite water-cooled production reactor, nuclear power prototype reactor, have got into their decommissioning stages. Since 1984, monographical studies on the decontamination and decommissioning of these facilities have been implemented. This paper will describe the strategies and stages, the principle for decontamination, radiation protection and safety, the treatment and disposal of radioactive waste of decommissioning for chinese nuclear reactors.

Keywords: decontamination, decommissioning, treatment and disposal of radioactive waste.

INTRODUCTION

The construction of chinese nuclear facilities began in the fifty's of this century. After some 20 year's operation, some reactors, for example, heavy water research reactor (HWRR-1), graphite water production reactor and nuclear power prototype reactor, have got into their decommissioning stages. Decommissioning works have been accepted as formal projects of the national plan. Since 1984, monographical studies on the decontamination and decommissioning have been implemented. This paper will describe the outline of chinese nuclear reactor decommissioning through discussing mainly the first graphite water reactor.

After 20 reactor-years' operation, the first chinese graphite water production reactor was closed down in 1987. The following items are involved in the decommissioning project,

- The reactor core part of the structure inside biological shielding. Here contains over 99 percent radioactivity (about $9x10^{16}$Bq). In this part, there are 1335.8 tons of graphite and more than 4000 tons of various metal materials.
- The coolant tube systems and fueling system.
- The primary cooling water loop system, ventilation system and so on.

The total area of the reactor building is about 60,000m^2 contains about 2,400 tons of stainless steel equipment and about 6,000 tons of carbon steel equipment. The reactor building is shown in Fig.1.

According to the definition of nuclear facility decommissioning and the decommissioning stages stipulated by the IAEA and the chinese regulations on nuclear safety and the specific situations of the plant, we have worked out the philosophy for nuclear reactors decommissioning in People's Republic of China.

DECOMMISSIONING MODE

We have done three schemes for feasibility of decommissioning:

- Permanent safe storage with surveillance;
- Delayed dismantle. Safe storage with surveillance for a long term (30-50 years), then removing.
- Safe storage with surveillance, removing partly, disposing specially the reactor core (sealing up the reactor core part inside biological shielding structure for safekeeping for about 100 years, than disposing it by use of the technology at that time).

We have gained the study considering:

- There are the large volume of the graphite reactor core, a great quantity of structural materials, heavy strong radioactivity, no repository for strong radioactive solid waste and no method for us to treat and dispose strong radioactive graphite;
- The plant is located in a barren desert area with sparse population. It is not necessary for "unrestricted use " of plant site;
- The reactor core is located under ground level and the level of ground water is quite deep;
- Long term burying of the reactor core on the spot is economically reasonable and feasible in technique and the nuclear safety assessment can be easily passed.

The final selected scheme for the graphite reactor decommissioning is decided into three stages including four periods:

<u>Stage I (period 1 and 2)</u>

Period 1: Preparatory period for safe storage with surveillance about 3 years. In this period, the engineering decommissioning conditions will be prepared. The connection between reactor core and primary loop system will be cut off. The radioactivity levels will reach the permissible values.

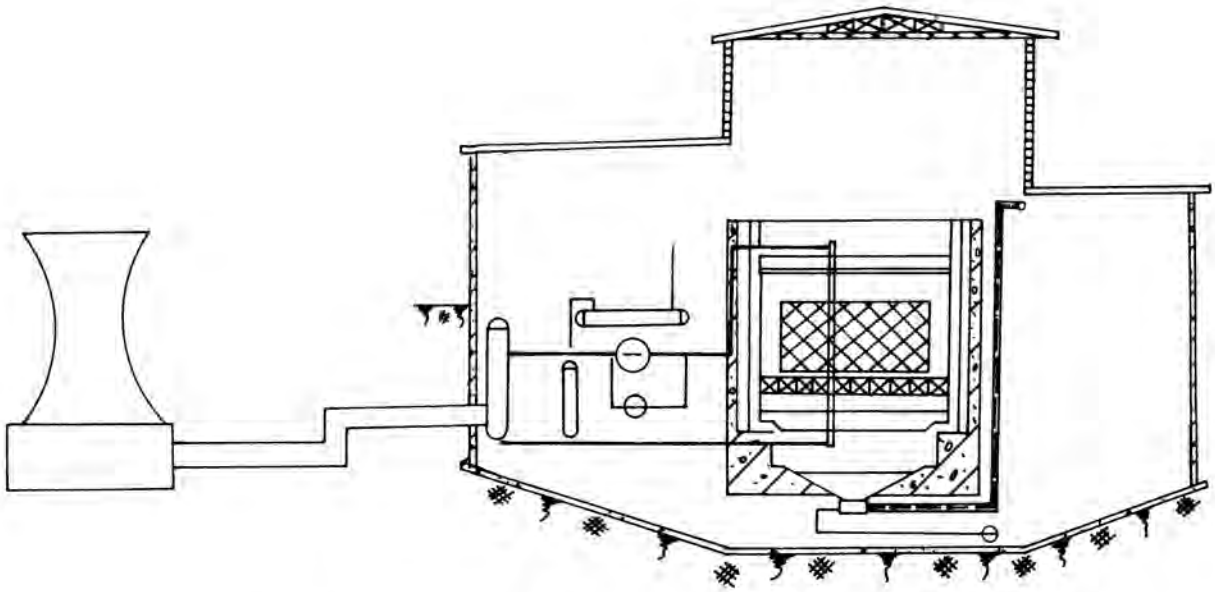

Fig. 1. Simplified view of the Graphite Reactor Building.

Period 2: Period of safe storage with surveillance for about 5 years. In this period, the main work to be done are as follows:

- All the dose monitors in the building come into operation with regular inspection.
- New added dose monitors and temperature indicators installed in the core come into operation.
- Drainage under ground comes into operation.
- Ventilation system in the reactor building works regularly.
- General survey of dose and nuclide analyses are regularly conducted.

Stage II (period 3)

Period 3: Period of partly removing for 5 to 7 years. In this period, the main work that has to be done is as follows:

- According to the removing procedures and stipulations, the peripheral devices and structures of the facility and loop systems will be removed, and all the openings of the biological shielding will be plugged up.
- Various disassembled devices in the decommissioning will be treated and disposed (removing, disassembling, volume reduction, packing, transportation, disposal, and so on).

Stage III (period 4)

Period 4: Period for the final disposal for about 100 years. In this period, the reactor core part on the inside of the biological shielding will be buried in the ground on the spot for a long period (about 100 years). But the possibility for disassembling and removing the core will be retained. The final disposing measure will be taken about 100 years later, depending on the state-of-art technology at that time.

The three stage situations for decommissioning are shown in Fig.2.

PRINCIPLES FOR DECONTAMINATION AND DISMANTLEMENT

Based on the radioactive contamination levels, the reactor building is divided into four zones:

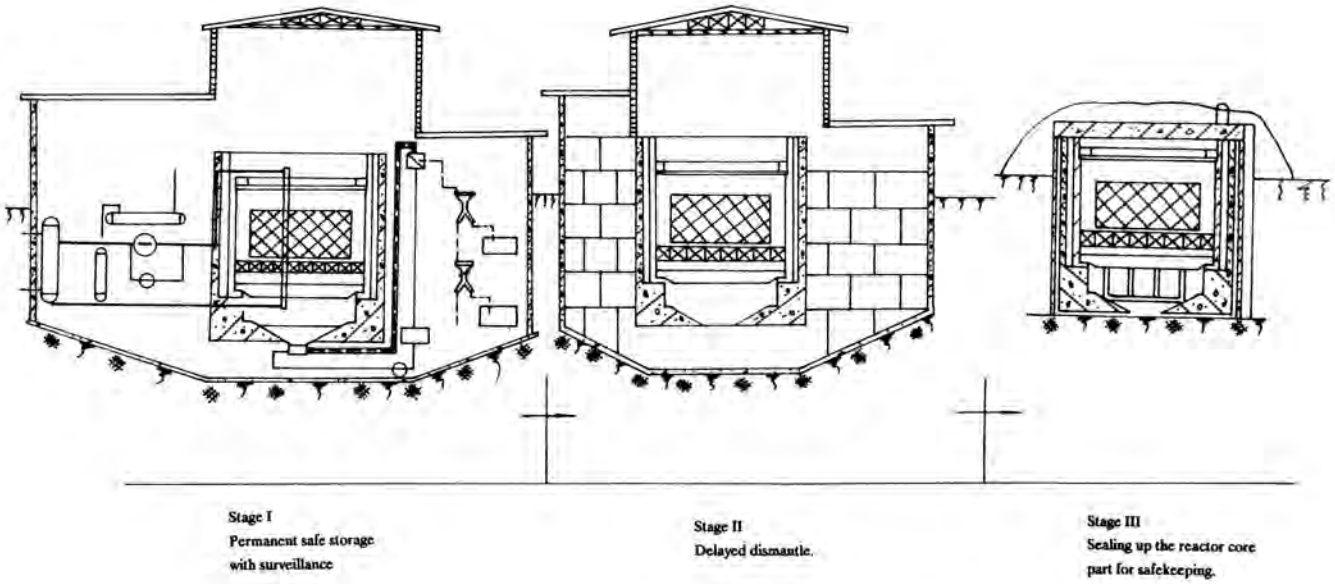

Fig. 2. Three stage situations for the reactor decommissioning.

- Zone 1---the reactor core part inside the biological shielding. There are high induced radioactivity as well as fission products and other contaminated materials.
- Zone 2---the hall above the reactor, fuel storage pool and other rooms. In this zone, there are ordinary contaminations and fission product pollution.
- Zone 3---the rooms of primary cooling loop and main device. The contamination level in this zone is ordinary.
- Zone 4---the control stand, room for workers on duty and other clean working areas.

Devices and loop system component will be basically zone-wise removed, and appropriate attention will be paid to the completeness of systems. For removing the ventilation, power supply, water supply and discharge, communication and dose monitoring systems, however, more attention has to be paid to their completeness. The removing work for these systems will be carried out in the late decommissioning process. The removing sequence is from Zone 4 to Zone 1.

We have evaluated and chosen the decontamination technology according to the following factors:

- The requests for maintenance conditions of systems and devices are not serious. The only request is that the decommissioning operations are not influenced.
- The period of decontamination process should not last too long.
- The decontamination process should have better redeposition feature.
- The decontamination expenditure (manpower, reagent, electrical power and so on) should be reasonable.
- The volume of secondary liquid waste should not be too large.

Because the main purpose for us is to gain high decontamination factors, not to maintain the performance of systems and devices and not to protect the materials from corrosion and damage. We have chosen chemical decontamination technology as the main method for decontamination in decommissioning the reactor. The expected decontamination factor (DF) is about 10, the secondary waste quantity is around 10%.

RADIATION PROTECTION AND SAFETY

In the whole process from closing the reactor to completing decommissioning program, we will plan and manage

it according to the codes and regulation of our country on nuclear safety and the ALARA principle of the dose limitation system recommended by the International Commission on Radiological Protection (ICRP). For this reason, we have made a complete investigations on the dose contribution in the nuclear facility, evaluated the present devices and qualified the operators so that the persons who are engaged in decommissioning can enter the radioactive areas to work. We have also stipulated that a person who works in a certain area has to wear protective clothes, dosimeter and protector of respiration for him to protect from radiation exposure and contaminated dust. To avoid accidentally entering the controlled areas, we have adopted some special measures, for example, putting up pales, marks, road blocks, special inspections etc.

The preliminary environmental impact assessment shows that the exposure dose suffered by the public will be lower than 0.1% radiation from natural radioaction sources in environment.

TREATMENT AND DISPOSAL OF RADIOACTIVE WASTE

Besides the graphite in core, the waste generated in the decommissioning of the reactor includes:

- the metal structures like the activated aluminum alloy pressurized tubes, the radioactive metal wastes like contaminated piping and devices, the contaminated concrete structures of plant building and non-radioactive wastes, for example, uncontaminated devices and plant building concrete.

The principle for the treatment and disposal of radioactive waste generated in the decommissioning is to ensure that the public safety and ecological environment will not be damaged.

In order to research and develop the technologies for disposing the radioactive waste in decommissioning reactors and other nuclear facilities, we put emphasis on the following items:

- Evaluating the technology and economy of packing containers for activated waste and loading and sealing containers for dismantled devices to determine the structural parameters of the selected containers.
- To perform volume reduction under high-pressure, a comparison for technology and economy on purchasing related equipment is being taken.
- Extended test on the cement solidification of contaminated concrete pieces are being performed to demonstrate the reliability of process parameters.
- Because the reactor is located in a barren desert area and the ground water level is very low, shallow ground burying technology is adopted to dispose low level waste. For solving the problems occurring in the burying technology, a series of measures are employed, among them, improving the original disposal site, enhancing the hermetic seal, reducing the possibility of water leaking into ditch and adding covering.

WORK IN THE FUTURE

Today, a series of reactors and other nuclear facilities have gone into their decommissioning stages in China. Therefore, we have to actively carry out the projects related to decontamination and decommissioning in various aspects. Because we started the work later, many relevant studies are at their beginning stages. For the time being the main items we are working on are as follows:

- Making out the criteria and codes applicable to decommissioning.
- Studying the decontamination technology on the contaminated equipment and materials which contain high chromium content.
- Selecting and evaluating the volume reduction devices for metal waste and the special equipment and remote-controlled tools for taking off devices and removing systems.
- Studying the measurements for ensuring safety for long-term burying of the graphite reactor core on the spot and the permanent disposal scheme.
- Establishing the quality assurance system for decommissioning projects.
- Establishing the expenditure estimation method and associated computer codes.
- Finding the way for reusing the stainless steel tubes with little radioactive contamination.
- Working out a training program and implementation of the program.

We believe that the experience gained from the decommissioning of nuclear facilities and other industrial facilities in the last 35 years is very valuable. The new technology, devices and methods developed from on-site studies, tests and demonstrations are a benefit for safe and effective decommissioning of our reactors. Especially, in the last few years, the instructive technical documents worked out under the IAEA's leading and organization have instructive meanings. We are interested in international exchanges in science and technology. We hope to absorb international experiences and carry out successfully our decontamination and decommissioning tasks. We would like to make our contribution to protecting environment and the public's health and safety.

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