One piece removal of JRR-3

A.Kanenari & M.Suzuki
Japan Atomic Energy Research Institute, Tokai Research Establishment
J.Inaba, M.Watanabe, K.Sugihara & S.Taniguchi
Shimizu Construction Co., Ltd, Nuclear Power Department, Tokyo, Japan

SUMMARY

The Japan Research Reactor 3 (JRR-3), a research reactor of Japan Atomic Energy Research Institute with a thermal output of 10 megawatts, reaching the criticality in 1962, has been utilized for the production of radioisotope as well as for the development of reactor technologies. In order to match recent versatile and highly advanced researches, however, a decision was made to remove the old existing reactor and the equipment and pipings attached to it and to install a new reactor at the same spot. As a removal method for the reactor, the one piece removal, to remove the radio-activated core materials as one block enclosed in the biological shield concrete walls, has been developed for minimizing the workers exposure to radiation. The one piece removal of reactor, the world-first attempt of its kind is the total engineering forming a system all based on conventional technologies.

1. Introduction

The theme, how to handle life-expiring reactors, is now under earnest study in various countries in the world. In Japan, implementation of a variety of full-scale reactor disassembly tests has started, led by the Japan Atomic Energy Research Institute. Under such circumstances, a method to remove a reactor as one block without disassembling has been developed and applied to remove the reactor of JRR-3. The preparation work started in February 1986 and the reactor removal was successfully completed in November of the same year.
This paper describes planning, execution and results of the reactor removal of JRR-3.

2. Removal Planning

2.1 Basic planning

The reactor to be removed had fairly high radio-activated substances around the core even after the removal of fuel assemblies and coolant. The removal of the radio-activated reactor was planned based on the followings.

(1) Minimization of workers exposure to radiation
(2) Prevention of radioactive materials release to public
(3) Reduction in amount of radioactive wastes
(4) No serious damage on the structure for the reuse of building
(5) Use of existing technologies as much as possible
(6) Reasonable terms of work and cost

The general view of JRR-3 is shown in Fig. 1.

2.2 Outline of one piece removal

The results of studies based on the above led us to select a method, so-called "One Piece Removal", to remove the core of the reactor with biological shield walls as one block, as the most effective technique. Major temporary structures used for the one piece removal consist of a lift frame, a jacking up and down system and a horizontal transport system. The cross section of reactor removal system and the JRR-3 one piece removal schedule are shown in Fig. 2 and Fig. 3, respectively. A schematic drawing of one piece removal method is shown in Fig. 4.

2.3 Structural design

The temporary structures used for the reactor one piece removal, though receiving load limited to a certain period of time during the term of work, were designed based on the following, because of the importance of structures including the reactor.

(1) The safety factor for temporary steel structure, for example, jacking up and down system, horizontal transport system and temporary supports, should always be more than 3.

(2) The base shear factor of seismic force is 0.2 for the steel frame (same rate as ordinary building in Japan) and 0.1 for the reactor while suspended.

(3) The jacking up and down system is grouped into several systems, for composing a fail safe mechanism.
Fail safe concept is considered for oil jack system.

2.4 Confirmation test

Based on the above design, confirmation test was carried out by using a half scale model, upon completion of the basic deisgn, in order to assure the reliability and sefety of the one piece removal system. The obtained quantitative data was reflected to the actual design and work.

3. Work Method

3.1 Reactor separation

The reactor was cut from the structure of the building by means of continuous core boring method which allows acurate and secure cutting, hardly generates noise and vibration, and gives no bad influence on the building structure to be reused.

3.2 Reactor jacking up and down

The separated reactor was lifted up and down by center hole jacks (36 jacks of 100 ton capacity each) which has a well arranged load control mechanism and many experiences for lifting up and down ultra heavy objects. Because the reactor is a rigid body, a load equalizing system, shown in Fig. 5, was employed for distributing load to each jack uniformly. The fail safe concept was embodied by grouping the center hole jacks into 6 systems placed in symmetry. The safety of the system was thus secured even if one system broke down.

3.3 Horizontal reactor transport

The reactor suspended in the lift frame was horizontally transported by using rails, rollers and oil jacks, which make it easy to correct the transport direction and have many accomplishments proving to be economical. As a measure against the inertial force during horizontal transport or against the shaking caused by an earthquake, 4 spring dampers were installed between the reactor and lift frame.

4. Work Results

4.1 Reactor separation

For horizontal concrete cutting, 3 core boring machines were symmetrically placed and operated, with thorough control for cutting depth. Horizontal core boring of approximately 210 m long in total was completed in 11 days. The cooling water was recirculated to reduce an amount of radioactive wastes to be processed, and only the slurry in the water was deposited in the storage tank.
The reactor was vertically cut by continuous core boring of the floor of approximately 3 m thick around the reactor. The vertical cutting was performed by 7 core boring machines with good balance by monitoring the load transfer to the temporary supports. It took nearly a month to complete 259 core borings of approximately 820 m long in total.

4.2 Reactor jacking up and down

The reactor weighing nearly 2,200 tons was lifted up 3.7 m in a time as long as approximately 15 hours. The jacking up was performed by controlling the stroke of all jacks, equalizers and subcylinders which are the devices to distributes load to each jack uniformly and the axial force of 12 representative step rods. The each step rod axial force was within 10% of the average when the jacks were idle as well as while they were working, being very stable with small fluctuation. (See Fig. 6 and Fig.7)
The reactor was jacked down, under control similar to the jacking up process, into the reactor storage space approximately 13.5 m below in 3 days.

4.3 Horizontal reactor transport

The lifted reactor together with the lift frame was horizontally transported to the place above the reactor storage space 33.6 m away in 7 days at a speed as slow as about 5 m a day. During the horizontal transportation, the propelling force and the stroke of jacks at right and left were controlled and the straightness of the lift frame was monitored by laser theodolite. The transport direction was corrected by means of adjustment of the propelling force of jacks at right and left and correction of roller direction. The reactor was transported accurately to the fixed location. Propelling force required for pushing the reactor and the lift frame (approximately 2,500 tons in total weight) was about 80 tons and the coefficient of rolling friction of the rollers was 0.128 cm (λ = 80 x 4 / 2500).

4.4 Radiation control

Worker's exposure to radiation was under detection limit of the film badge during one piece reactor removal.

5. Conclusion

The removal of reactor JRR-3 was safely and securely implemented by the one piece removal with minimal worker exposure to radiation, in a short term of work. This work gives further grounds for the reliability and safety of the one piece removal.

6. Acknowledgments

The authors would like to express their appreciation to H. Sakurai and N. Ohnishi, of Tokai Research Establishment of Japan Atomic Energy Research Institute, and S. Suzuki, T. Nagase, A. Iwatani and F. Ohtsubo of Nuclear Power Division of Shimizu Construction Co., Ltd. as well as persons concerned.

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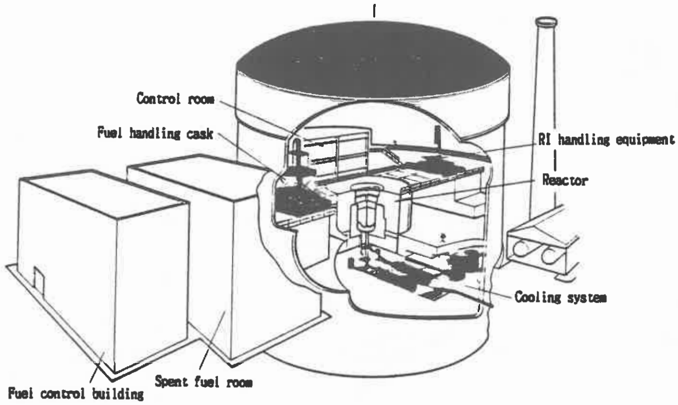

Fig. 1 General view of JRR-3

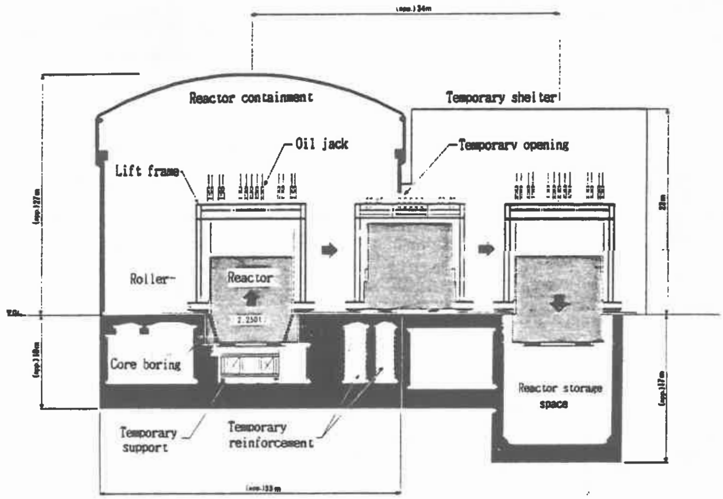

Fig. 2 Cross section of reactor removal system

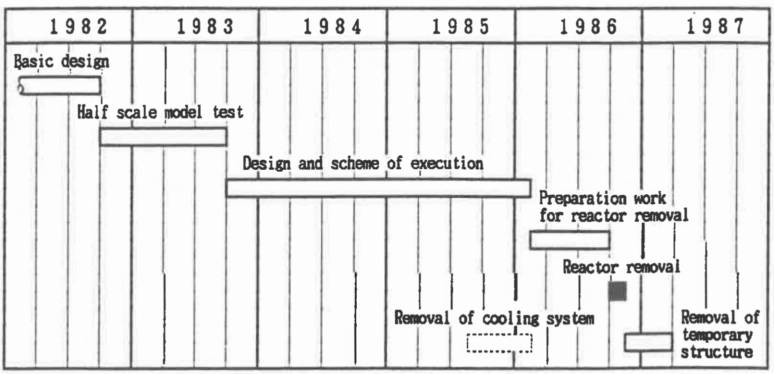

Fig. 3 JRR-3 one piece removal schedule

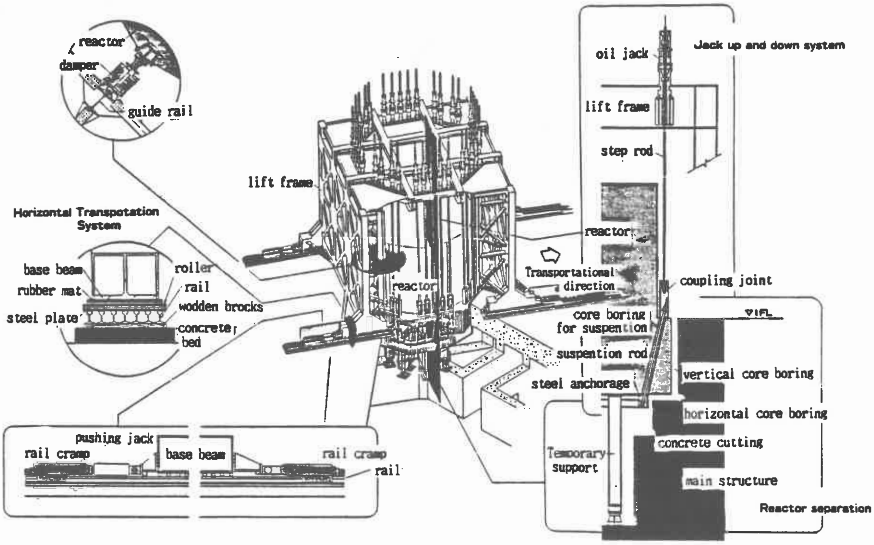

Fig. 4 Schematic drawing of one piece removal method

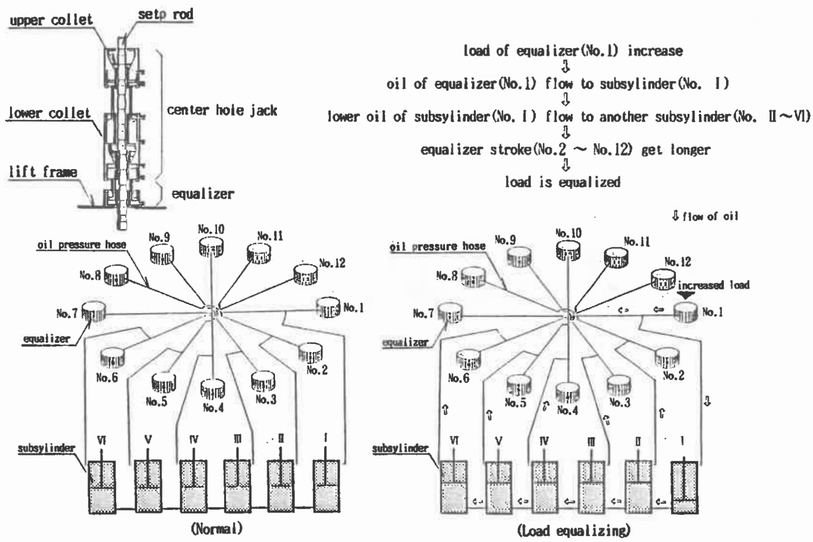

Fig. 5 Load equalizing system

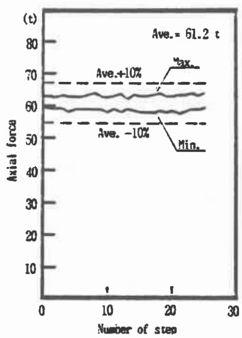

Fig. 6 Axial force of step rod in jacking up

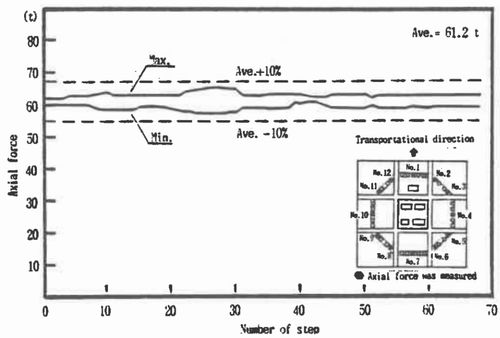

Fig. 7 Axial force of step rod in jacking down