Status of JRR-4 Modification Works

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ABSTRACT

Japan Research Reactor No.4 (JRR-4) is a light water moderated and cooled, enriched uranium ETR-type fuel used and swimming pool style reactor with thermal output of 3.5MW. Since the first criticality was achieved on January 28, 1965, many experiments have been continuously succeed for wide researcher by January 12,1996.

The modification works of JRR-4 were started in October 1996 for about core conversion, utilization facilities upgrading and renewal of some reactor systems. According to the framework of reduced enrichment research reactors program, the new fuel is manufactured as 20% lower enriched uranium silicide fuel without changing of structure and any size. The some utilization facilities are installed, a medical irradiation facility for BNCT, a modified NAA system for short life nuclides and a large pipe irradiation system. Furthermore many works are conducted such as the renewals of instrument and control system ,repairing of reactor building etc.

The project is on schedule at now ,and is expected to be re-critical in July 1998.

1. INTRODUCTION

JRR-4 was operated with safety and succeed a long term about 31 years for wide utilization such as nuclear shipment reactor shielding experiments, reactor physical experiment, nuclear material and fuel irradiation, radioisotope production, silicon transmutation doping, reactor training and so on. The total operating time is 29,377 hrs, and the total thermal power is 58,706 MWh.

JRR-4 core conversion with 20% lower enriched uranium silicide fuel was decided in 1995, under the world program of the Reduced Enrichment on Research and Test Reactors. The new fuel of 35 fuel elements is manufactured in USA.

On the basis of reactor core conversion, JRR-4 also carried out utilization facilities upgrading, reactor building seismic reinforcing, renewal of some reactor systems,

etc.. On the utilization of JRR-4, after JRR-2 closed in 1996, the mission of BNCT is transferred to JRR-4, and the new BNCT facility is installing in JRR-4. Other works is needed a nuclear activation analysis system and a large irradiation pipe for upgrading utilization. And modification works is also conducted many installation renewal for increasing safety requirement and aging of reactor system.

The project of modification works is regulated by Japanese authorities such about application for establishment, application for construction, pre-service inspection and license of operation.

This paper is described about the summary of licensing procedure and main modification works.

2. JRR-4 MODIFICATION LICENSSING

It took JRR-4 about two years to get Modification Permission License from the Science and Technology Agency(STA) of Japan.

Oct.,1994 Start of STA hearing for JRR-4 core conversion
#Sep.,1995 Submission of permission application to prime minister via STA.
to Feb.,1996 The first safety examination by STA
to Aug.,1996 The second safety examination by AEC and NSC
#Sep.,1996 Issue of Modification Permission
(AEC; Atomic Energy Commission of Japan
NSC; Nuclear Safety Commission of Japan)

After permission, the application of detailed design and construction procedure was submitted for approval to STA. And after approve, the application of pre--service inspection was submitted about items and schedule to STA,

The modification works was started on October, 1996, many pre-service inspection is carried out successfully about 40 times of 50^{th}.

3. MAIN MODIFICATION WORKS

3.1 Reactor Building

JRR-4 reactor building is constructed in 1963 which is reinforced concrete made with 25m x 20m x 26mH. The reconstruction of building is including seismic reinforcing, renewal of roof, large ceiling crane, ventilation system, lighting system and so on. Specially the roof renewal was carried out until December,1997 while reactor pool etc. was covered with temporary roof to control the radiation area.

According to the safety evaluation on new safety guide, the safety system is installed such as emergency air exhausting system with filter of Iodine and emergency electric power supply system(Two 100 kVA units)

3.2 Reactor Systems

Reactor systems are renewed to aging and upgrading which are reactor control and protection system, control rod driving mechanism, fuel failure monitoring system,

reactor pool gates, siphon-breaking valves, reactor operating aided system etc..

The instrument and control system is composed by process instrumentation system, nuclear instrumentation system, process radiation monitor system and reactor control system with two computer systems. These components is mounted in some monitor panels and reactor operation console in control room. The computer systems are named μ XL system for reactor operation supporting and VXI bus & Work station for data logging and reporting, and all application software used in JRR-4 are made by JRR-4 members.

The new nuclear instrumentation system are composed a fission counter for start-up channel, a compensated ionized chamber for leaner-N channel, two uncompensated ionized chamber for safety channel and a compensated ionized chamber for log-N/period channel.

The control rod for neutron absorber is stainless steel plate with 1.6% natural boron included and the control driving mechanism are renewed same design as old them.

3.3 Utilization Systems

The BNCT facility are a neutron beam system which can use with thermal neutron, epi-thermal neutron and their mix-beam, wide irradiation room, irradiation monitoring room and pre-operation room. The neutron beam spectrum can be changed by D2O thickness in heavy water tank and cadmium shutter. Furthermore new prompt gamma-ray analysis system is installed in reactor side with super mirror guide tube. The main specification of JRR-4 BNCT facility on design is show as follows;

*Irradiation hole 20cm x 20cm
*Thermal flux mode >1x10^9 n/cm2/s
*Epi-thermal flux mode >0.5x10^9 n/cm^2/s
*Dose level from γ-ray up to 1 Sv

On the neutron transmutation doping(NTP), the diameter of large irradiation hole will change from 4 inches to 5.5 inches in order to larger NTP silicon. And on the neutron activation analysis(NAA), JRR-4 new NAA system can undertake analysis research for shorter life nuclides about one minute lifetime.

4. CONCLUSION

The modification works of many installations are conducting on each schedule smoothly and successfully. Many cold test work will be continuing until June, JRR-4 is expected to be achieved re-criticality in July 1998 on critical test. After then it will be carried out that is zero-power test, core characteristic performance test, power-up test.

JRR-4 will be one of most useful reactor for medical irradiation facility which can save many penitents with brain cancer in the world.

At last, the authors would like to express our great gratitude to each members of JRR-4 project group.

- First Critical : 28th January, 1965
- Max. Thermal Power : 3.5MW
- Max. Thermal Neutron Flux : $6x10^{13}$ $n/cm^2 \cdot s$
- Operation Mode : Daily Operation, 6hrs/Day

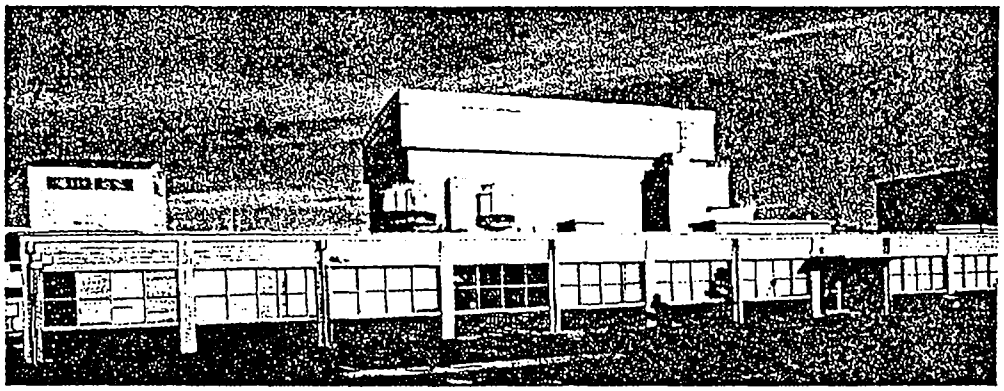


Fig.-1 Outline of JRR-4

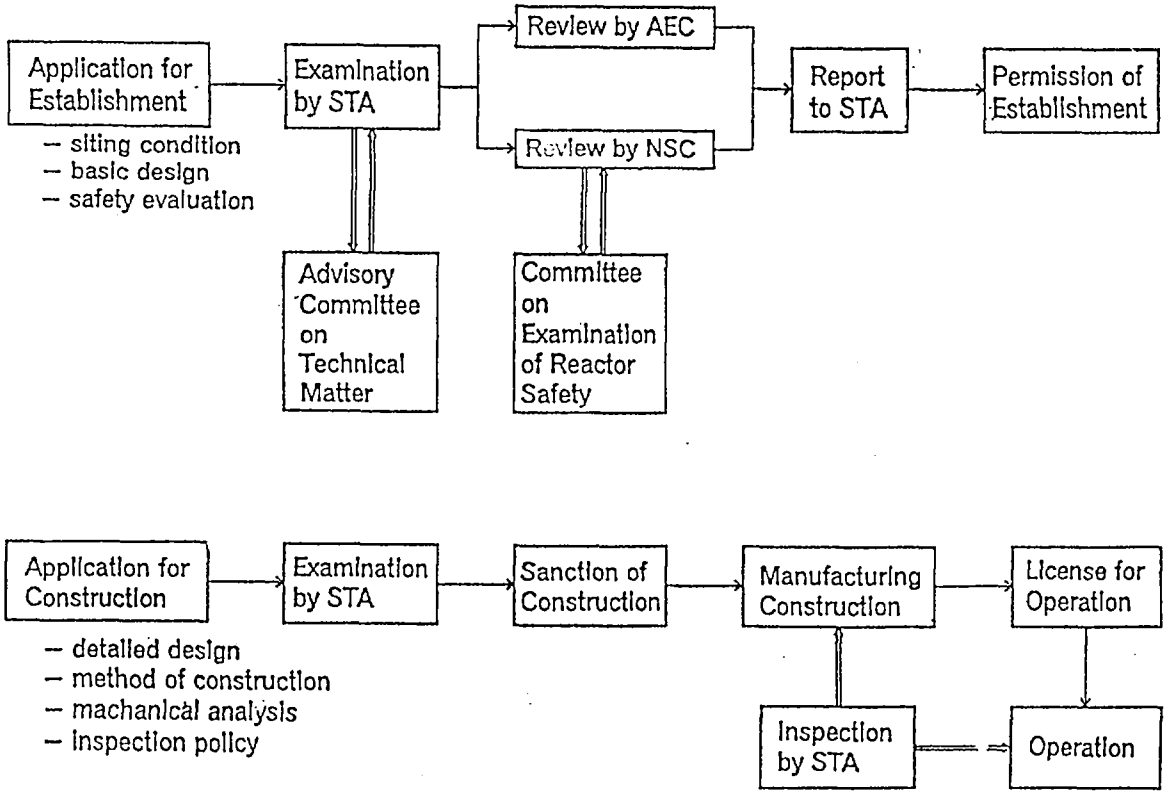
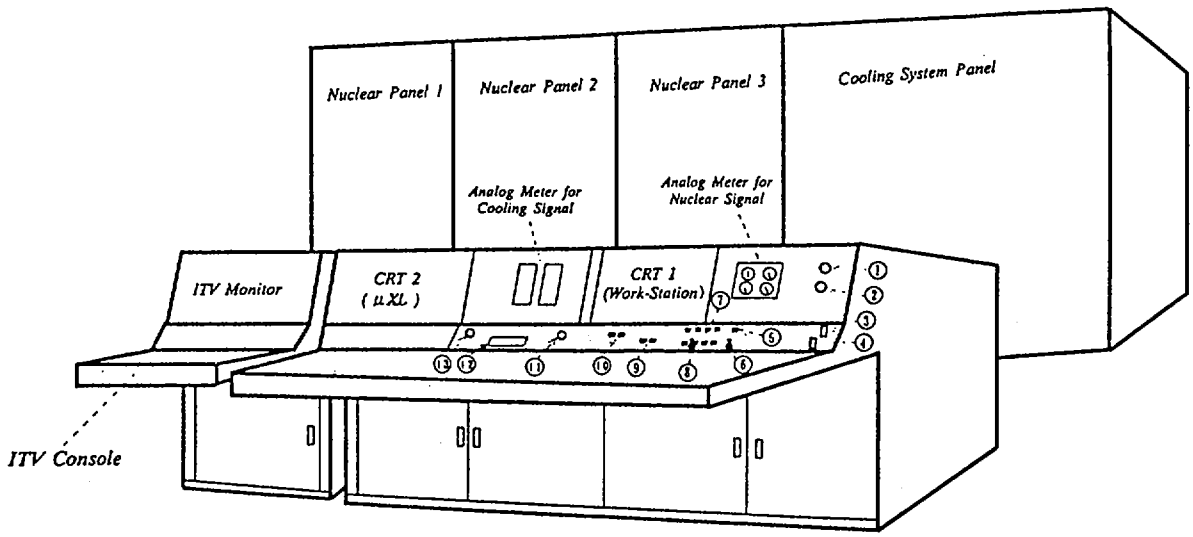


Fig.-2 Major Regulatory Process for Research Reactors



No.	Item	No.	Item	No.	Item
1	Manual Scram Switch	6	Regulating Rod Drive Switch	11	Power Demand
2	Backup Scram Switch	7	Sim rod Selector	12	Alarm Reset Switch
3	Main Switch	8	Sim rod Drive Switch	13	Manual Scram Switch
4	Operation Mode Switch	9	Auto - Manual Selector		
5	Control Rod Position(digital)	10	Power Range Selector		

Fig.-3 The new JRR-4 Operation Console

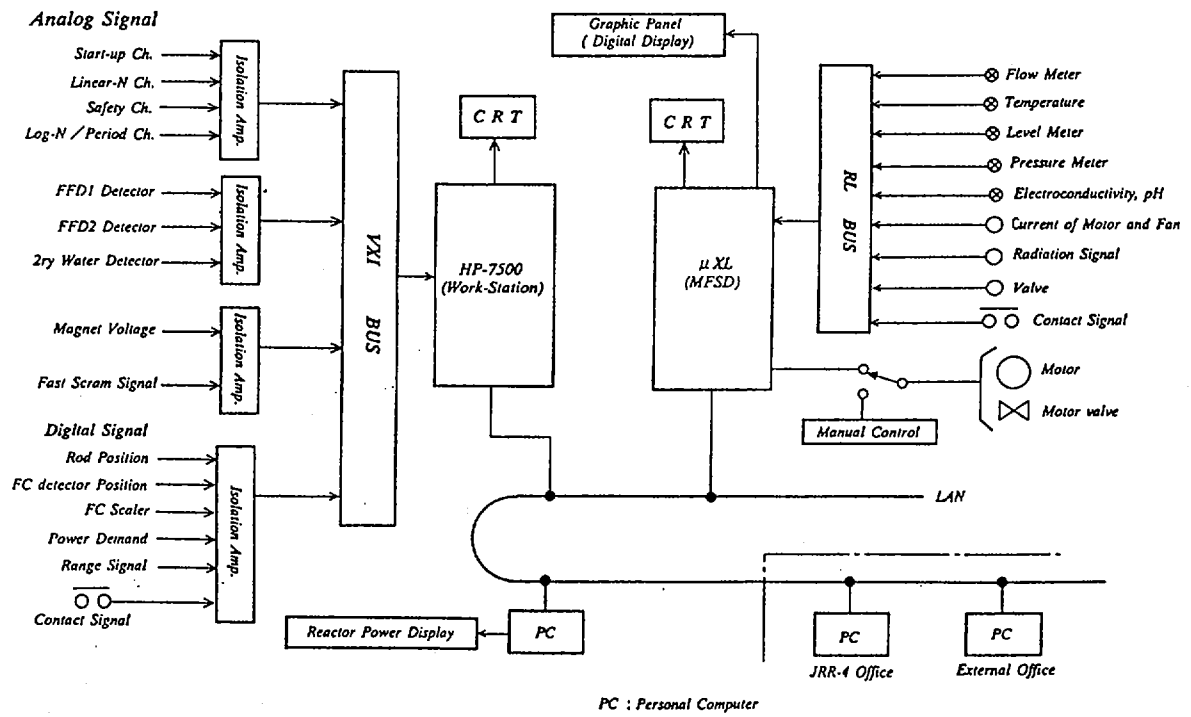


Fig.-4 The two JRR-4 Computer Systems

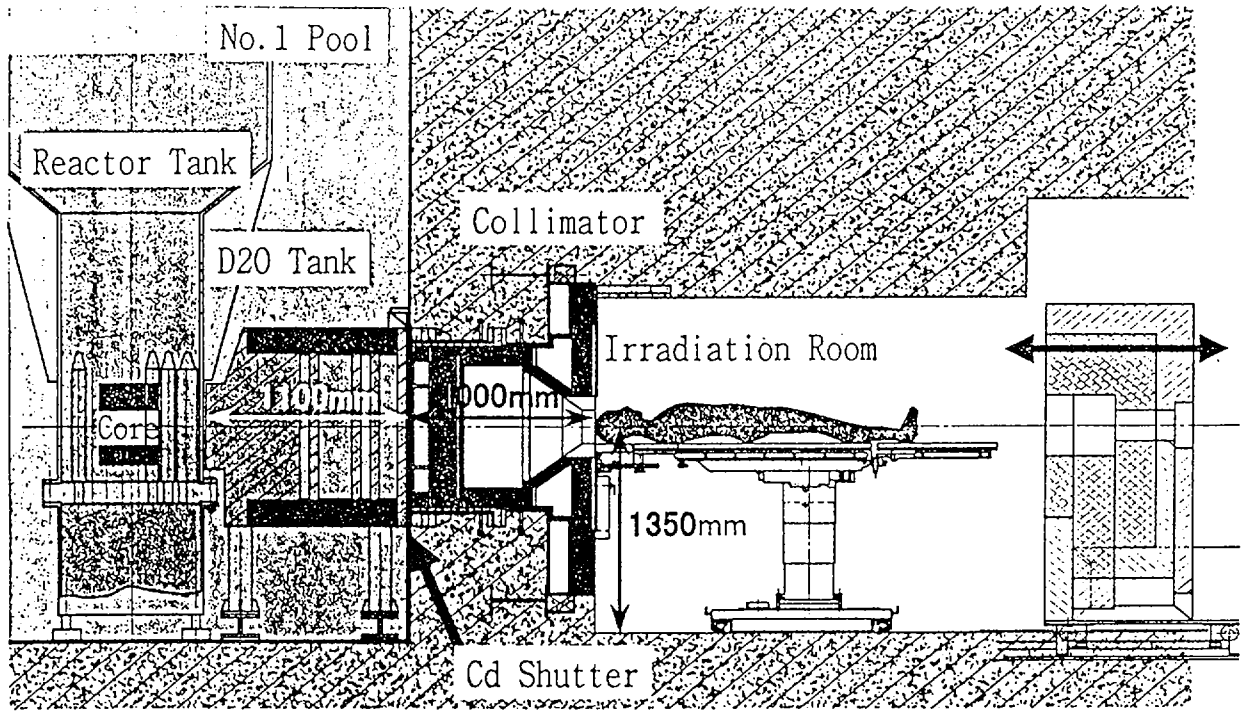


Fig.-5 Cross sectional view of Neutron Beam Facility

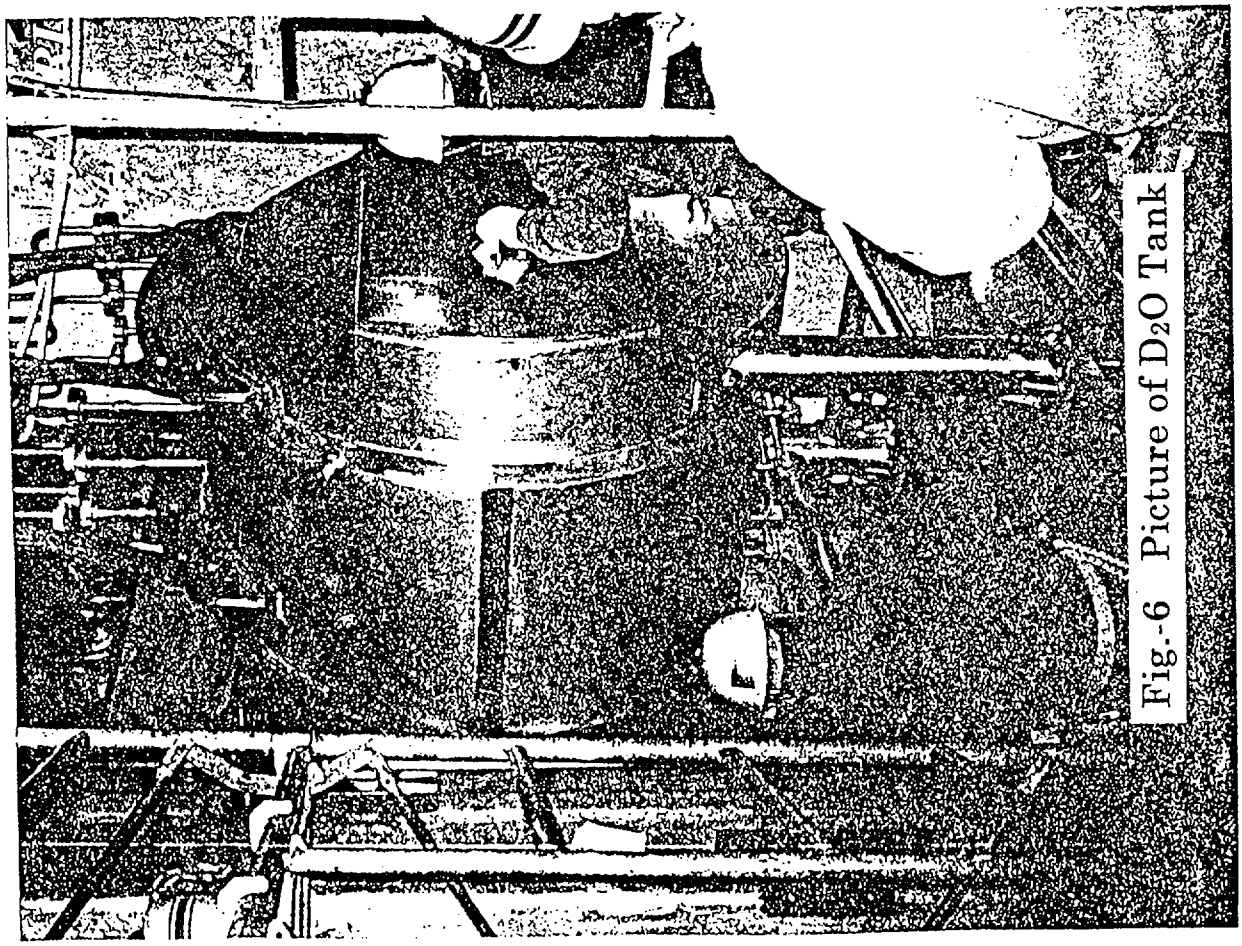


Fig.-6 Picture of D_2O Tank