Support required for safety management of research reactors especially those in extended shutdown

Tsuyoshi KUSUNOKI

Neutron Testing and Reactor Center
Oarai Reseach and Development Center
Japan Atomic Energy Agency

Contents

1. Introduction

- The Japan Materials Testing Reactor (JMTR) had been operated for 38 years with 165 cycles for various users since the first criticality in 1968.

- The JMTR has been in an extended shutdown period since August, 2006 for its refurbishment, and will restart in 2011.

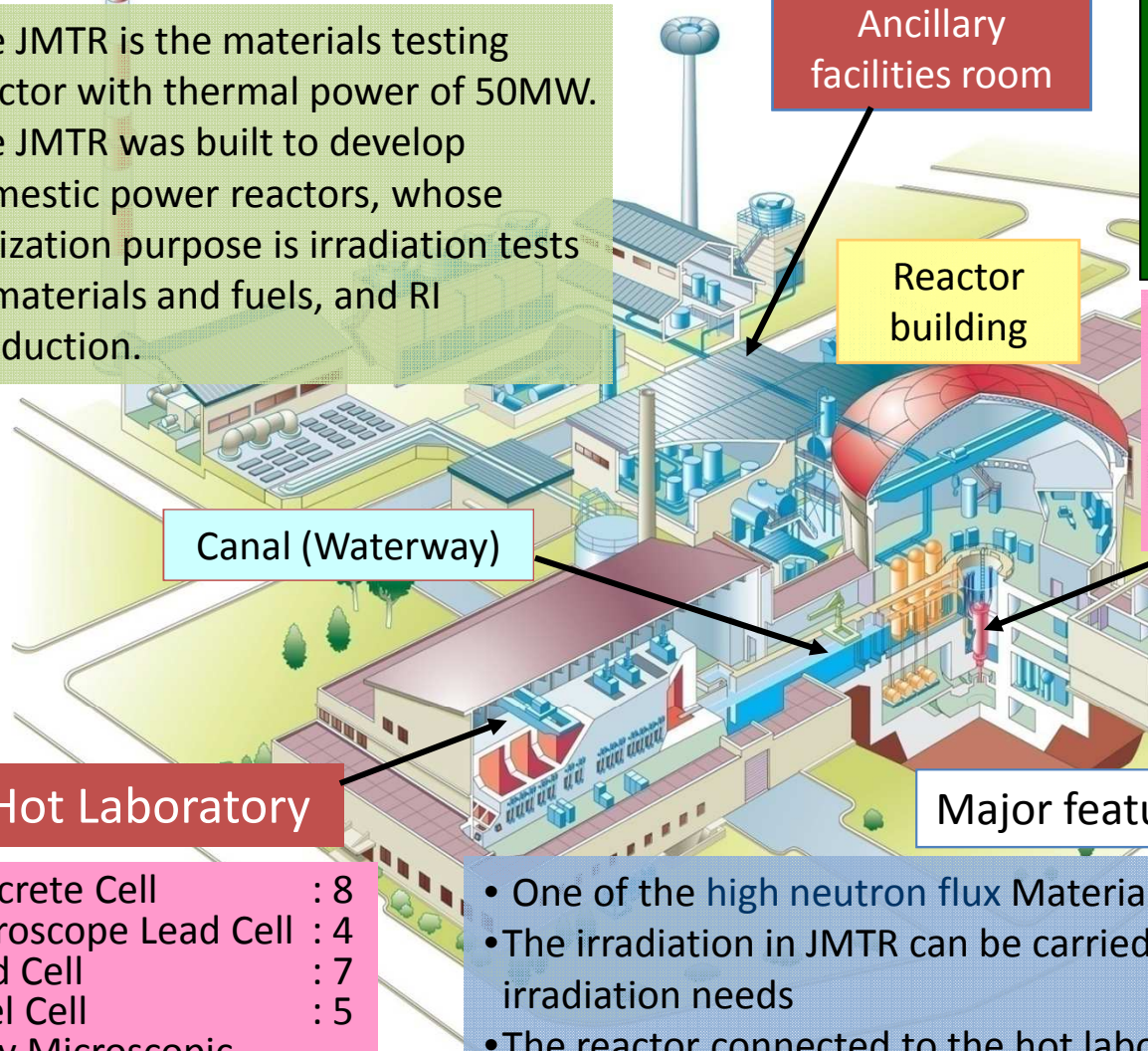
- In order to improve the reliability and the safety of the reactor, kinds of reviews and inspections were conducted in parallel to the refurbishment.

- The experiences of the JMTR during the period could be shared with other organizations which currently or potentially have the similar situation.

2. Outline of JMTR

Purpose

The JMTR is the materials testing reactor with thermal power of 50MW. The JMTR was built to develop domestic power reactors, whose utilization purpose is irradiation tests of materials and fuels, and RI production.



Construction began : 1965 Apr.
First Criticality : 1968 Mar.
For user operation : 1970 Sep. to 2006 Aug.
Refurbishment : 2007 ~
Re-start operation : 2011 ~

- Thermal power : 50 MW
- Fast neutron flux : 4×10^{18} ($n/m^2/s$) (Maximum)
- Thermal neutron flux (Maximum) : 4×10^{18} ($n/m^2/s$)

Concrete Cell	: 8
Microscope Lead Cell	: 4
Lead Cell	: 7
Steel Cell	: 5
X-ray Microscopic analyzer	: 1

Major feature

- One of the high neutron flux Materials Testing Reactor in the world
- The irradiation in JMTR can be carried out in a wide variety of irradiation needs
- The reactor connected to the hot laboratory with the canal, it is easy and safe to transfer samples to the hot laboratory to carry out the PIE.

3. Periodic Safety Review (PSR)

- Based on the regulation in Japan, a Periodic Safety Review (PSR) for JMTR was carried out in 2004.
- Aging was evaluated based on the past maintenance record.
- The facilities, which were difficult to be replaced and important for safety, were investigated and evaluated whether they can maintain long-term safety operation or not.
- Improvement of maintenance activity and the 10-year maintenance plan was mentioned. <= From the result of the evaluation of the operation experience, investigation of the maintenance record and technical evaluation of equipment on aging.
- Result of PSR : Long term integrity of reactor facilities can be maintained by carrying out maintenance activity.

4. Refurbishment of JMTR Reactor Facility

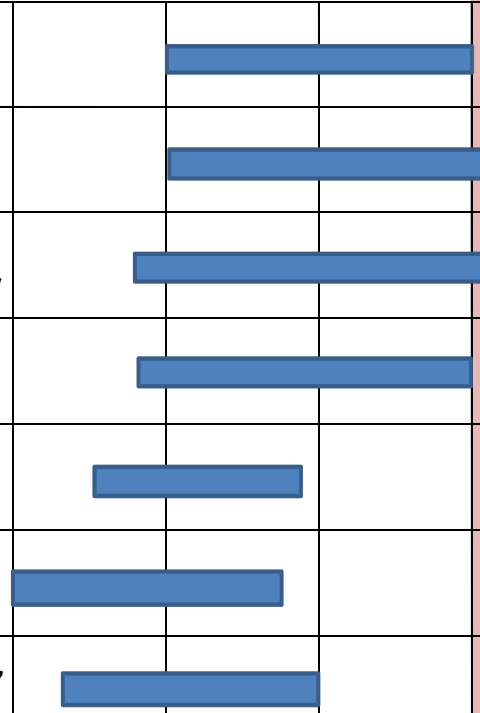
- JMTR was once categorized as one of the facilities to be shutdown in the middle-term plan of JAEA (2005).
- After that, the long term operation has been strongly requested by various users as it is the only irradiation testing reactor in Japan.
- JAEA decided the refurbishment and restart of the JMTR in Dec. 2006, and the refurbishment work has been carried out since 2007.
- It was confirmed that the integrity of almost all facilities was maintained in the PSR(2004).
- Then, necessary refurbishment schedule **for maintaining the stable operation** of the facility was planned.

4.1 Selection of Renewal Facility

- Facilities that could be used without renewal will keep their integrity assessed by continuing current maintenance based on the PSR.
  - e.g., a reactor building, a reactor pressure vessel, a reactor pool lining, a grid plate and primary cooling pipes.
- The selection concepts for renewal facility ;
  - Replacement priority is given to facilities having aged and worn-out .
  - Priority is decided with special attention to safety concerns.
  - The availability of appropriate monitoring is an important factor in selecting facilities.
  - Facilities, whose replacement parts are no longer manufactured or not likely to be manufactured continuously in near future, are selected as renewal ones.
- Equipment to be renewed was designed to improve reliability and maintenance capabilities.

4.2 Renewal Procedure of Reactor Facilities

No.	Item	Year	2007	2008	2009	2010	2011 Re-operation	Status
1	Reactor	Beryllium frame, Gamma ray shielding						Renewed
2	Instrumentation and control system	Nuclear instruments, Process instruments, Safety guard circuit						Manufacturing
3	Rector cooling system	Primary cooling facility, Secondary cooling facility						Manufacturing Renewed
4	Radioactive waste disposal facility	Feed and exhaust air system, Drainage facility						Renewed
5	Power supply system	High voltage power supply control board, Transformer, Cables						Renewed
6	Boiler	Boiler, Refrigerator						Renewed
7	Pure water Production equipment	Degassed demineralizer, Regular demimeralizer						Renewed



- Components which are required to obtain “Approval of design and construction method”*, have been applied to the MEXT for approvals by March 2009.

  * Primary cooling system, secondary cooling system, UCL system, Process and control system, Reactor room air supply and exhaust system, Beryllium frame, Gamma ray shielding plate

4.3 Major renewed Equipment by March 2010

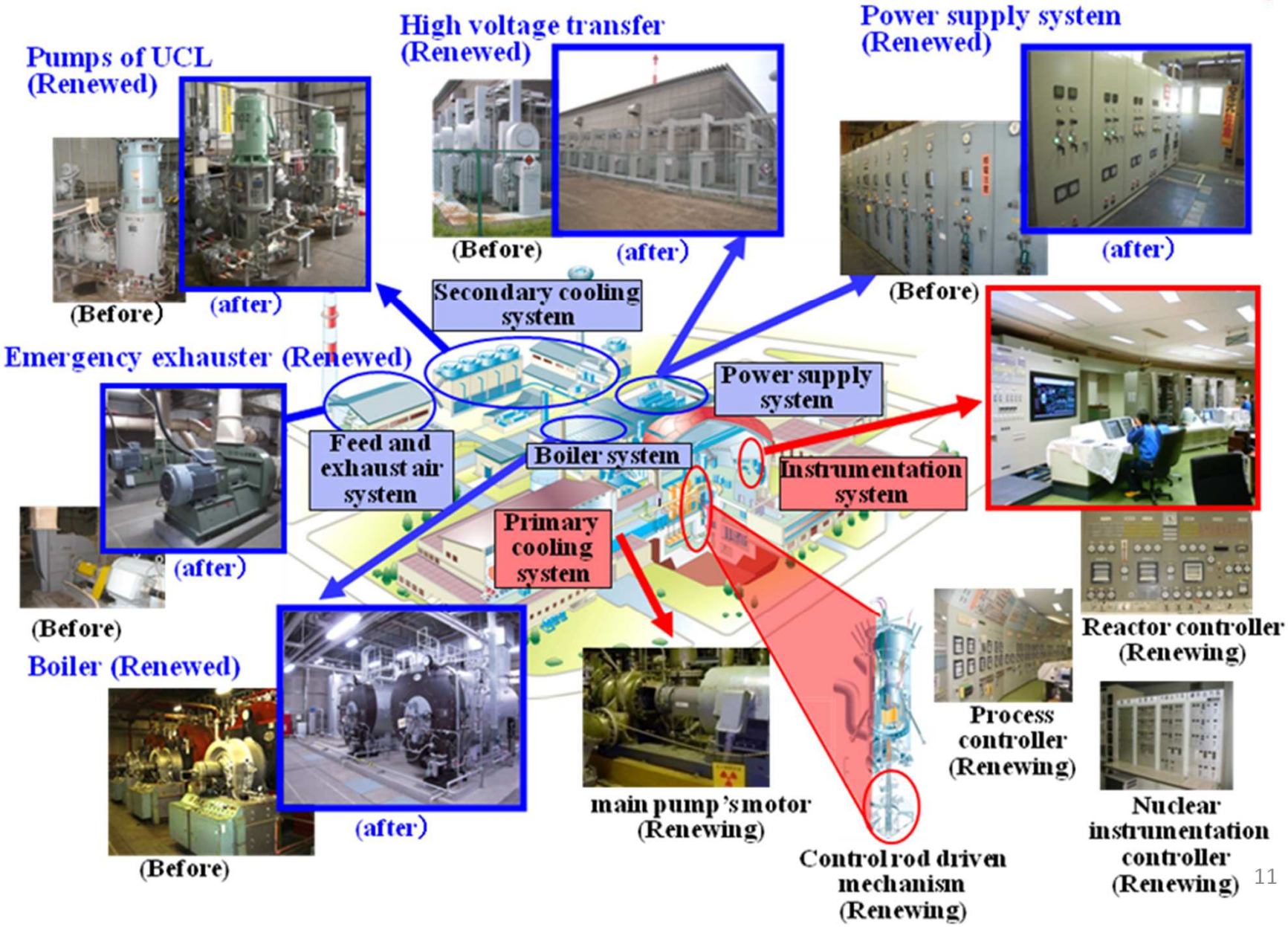
- Power supply system ;
  - Improvement : compaction of control board, digitization of the relay, the insertion of the dehumidifier in the control, incombustible cable
- Refrigerator for cooling of the reactor building;
  - Improvement : operation cost can be reduced
- Feed and exhaust air system of the radioactive waste disposal facility
  - Improvement : number of component was reduced
    => Maintenance and operation management are simplified, and reduction of the trouble is expected.
  - the approval procedure to the regulatory authority in May, 2008
  - pre-operational inspection, in March, 2009

4.4 Renewing Equipment

- Instrumentation and control system
  - Their reliability was improved by reinforcing with the provision for the noise mixture and the break in the circuit.
  - Equipment will be upgraded to improve operational efficiency and visibility in creating better man-machine interface.
  - approval procedure in March, 2008
  - Approval in June, 2009
  - Renewal work is undergoing.

- Primary cooling system
  - the main circulating pump motors, filler pump including motor, main electric valve's drive mechanism and so on
  - approval procedure in February, 2009
  - Approval in March, 2009.
  - Renewal work is undergoing.

4.5 Renewal Equipment



5. Safety Management During Reactor Operating Period (1/2)

- As for the safety management in the reactor operating period, the operational management of the reactor facility, the radiation control and so on are important.

- Operational management of the reactor facility
  - The purpose is to maintain the integrity and reliability of facilities and equipment for the safety and the steady operation of the reactor.
  - In order to achieve this purpose, the owner's voluntary periodical inspection and daily inspection for facilities were carried out .
  - The voluntary periodical inspection has been performed with the annual plan for the JMTR.
  - The annual plan of maintenance includes inspection contents and frequencies of inspection in consideration of the importance, the service conditions, the operating time, the structures, the past operating records of the equipment.

5. Safety Management During Reactor Operating Period (2/2)

- The radiation dose exposed to the personnel
  - The radiation dose exposed to the personnel engaged in radiation work is restricted by laws and regulations.
  - Efforts are made to reduce the exposure based on the ALARA spirit.
  - Management of working environment by the radiation control division
    - measures the dose equivalent rate, the surface density and so on once a week based on the operational safety program.
    - continuously monitors the radiation, the radioactivity level, etc. within the radiation control area.
    - Calibrate the radiation monitors and the survey monitors in every period of the facility's periodical inspection

- Periodical Inspection
  - According to the law in Japan, "any licensee of reactor operation shall, pursuant to the provision of the ordinance of the competent ministry, undergo an annual inspection by the competent minister concerning the performance of the reactor facilities specified by Cabinet Order".
  - The periodical inspection on the JMTR during operating period was carried out from August to November annually.

6. Safety Management During Reactor Renewal Period (1/4)

- The safety management of the reactor during the extended shutdown period for renewal is carried out in a way different from that of the reactor operation period.

- In facility maintenance during reactor renewal period, facilities are classified into two groups;
  - (1) facilities needed to keep the function continuously during renewal period
  - (2) facilities not needed to keep the function continuously during renewal period
- Maintenance work and periodical inspections, including those by the regulatory authority, are carried out based on the special classification.
- Under the renewal work, special attention should be taken into account work with the special measure.

6. Safety Management During Reactor Renewal Period (2/4)

- Periodical Inspection
  - The inspection is carried out on the equipment whose function must be kept continuously during the long-term shutdown period.
  - Major inspection items for JMTR in the extended shutdown
    - the visual inspection of the new fuel storage facility,
    - the non-criticality inspection and the storage ability verification inspection for the spent fuel storage facility,
    - the leakage inspection in the reactor building and the leakage inspection of the pressure vessel,
    - the leak check of the main circulation system and so on.
  - The periodical inspection is carried out every period, not exceeding one year.
  - The MEXT carries out the periodical inspection of research reactors in Japan directly based on the law.

6. Safety Management During Reactor Renewal Period (3/4)

- Voluntary periodical inspection
  - Examinations of the facilities in a wider range during the periodical inspection period.
    - Inspections on emergency shutdown for the instrumentation and control system facility
    - the performance examination for the emergency shutdown (once or more in every month)
    - the leakage inspection of the pressure vessel
    - the visual inspection of the nuclear fuel storage equipment
    - the calibration inspection of the measuring gauges for the nuclear instrumentation, the process instrumentation, the radiation monitors of the cooling system and so on
  - Omitted items ;
    - When there is no operation and if it is clear that fuels are taken out of the reactor core during the reactor shutdown period,
    - the calibration on the temperature difference indicator between reactor inlet and outlet, the thermal output meter, the primary cooling water monitor and so on.

6. Safety Management During Reactor Renewal Period (4/4)

- Notes of work with special measures
  - In accordance with occupational safety and health laws, it is required to assume the special measures for particular work
    - the radiation exposure work,
    - the high-place work,
    - work with risk of hypoxia in the closed place,
    - The heavy component handling work and the asbestos removal work
  - Attention should be paid to the work with the renewal of the main equipment and the instrument.
    - The exchange work of the Beryllium frame and the Gamma ray shielding plate
    - The exchange work of the motor of the main circulating pump and the emergency pump
    - The lining repair work of the secondary cooling system pipes inside

7. Summary

- The JMTR operated for 38 years and the refurbishment work started in 2007.
- Equipment to be renewed was selected based on the evaluation on its damage and wear in terms of aging, significance in safety functions, safety-related maintenance experiences, in order to enhance the operational capability.
- During the refurbishment period in the extended shutdown, facilities were classified into a special manner from viewpoints whether their functions are required even in the refurbishment period.
- Maintenance work and periodical inspections by the regulatory authority are carried out based on the special classification in the extended shutdown period.
- Long-term safety operation of the JMTR will be realized by the refurbishment on the appropriate components with the justified inspection and the renewal work.