CURRENT STATUS OF JRR-3

MASAMI KINASE*, MASAJI ARAI and TAKESHI MARUO

Department of Research Reactors and Tandem Accelerator

Nuclear Science Research Institute, Japan Atomic Energy Agency

2-4, Sirakata-shirane, Tokai-mura, Naka-gun, Ibaraki 319-1195 - Japan

*kinase.masami@jaea.go.jp

ABSTRACT

JRR-3 at the Tokai-Shirakata site of JAEA was in its regular maintenance period, when the Great East Japan Earthquake took place on 11th March 2011. The reactor building with the solid foundations and the equipment important to safety survived the earthquake without serious damage, and no radioactive leakage has been occurred. Recovery works, check and test to confirm the integrity of all components and structures, and seismic assessment necessary for proving that the seismic loads which worked on a structure or component by the earthquake accommodated within its allowable stress have been carried out. After our recovery works and verification of the integrity of JRR-3, we confirmed that the integrity is ensured, and then reported the fact to the regulatory body. As another topic, the regulatory body will introduce new regulatory requirements for research reactors. Now, JRR-3 considers applying the new requirements for restart. This paper presents the current status of JRR-3 including the recovery works, seismic assessment and new regulatory requirements.

1. Introduction

JRR-3 (Japan Research Reactor No.3) is a light water cooled and moderated swimming pool type research reactor with nominal thermal power of 20MW. Reactor building contains reactor facilities such as a reactor pool, cooling system, instrumentation and control (I&C) system etc. Neutrons coming from the core are transported to a neutron guide hall and several neutron beam experiments are carried out in the hall. Secondary cooling tower receives heat generated in the core and emitted it to the atmosphere. Air with minor radioactivity in the reactor building is filtered and exhausted to the air through an exhaust stack.

JRR-3 suffered the great earth tremor not previously experienced when the Great East Japan Earthquake (hereinafter referred to "311 earthquake") with the seismic energy of magnitude 9.0 occurred on March 11, 2011. At that time, JRR-3 was undergoing regular periodical inspection and the reactor was not operated, but many maintenance people worked in the

reactor building. All workers and JAEA's staff –evacuated successfully just after feeling the strong earthquake. Although commercial electric supply was stopped, necessary minimum facilities were continuously operated with emergency electric generators.

2. Damage of JRR-3

It is very important to confirm immediately whether nuclear fuel materials and reactor confinement system are damaged or not. During the aftershocks for a few hours, the reactor pool, nuclear fuels and their storage facilities were checked visually and confirmed to keep their soundness. Although several small cracks were shown on the internal wall of reactor building, they did not result in adverse effect on the integrity of confinement and there was no release of radioactive materials to environment.

Some damages visually observed are shown at left side of Fig. 1. Ground around the buildings was sunk about 40cm. The buildings themselves did not sink since they are built on the bedrock. According to the ground sinking, an exhaust duct leading from the reactor building to a stack was slightly damaged at a connection. A liquid nitrogen storage tank, used for feeding nitrogen to experimental facilities, and electric transformers for secondary cooling system were also damaged and leaned. Some of the ceiling panels in the reactor building were dropped.

Recovery works have already been completed.

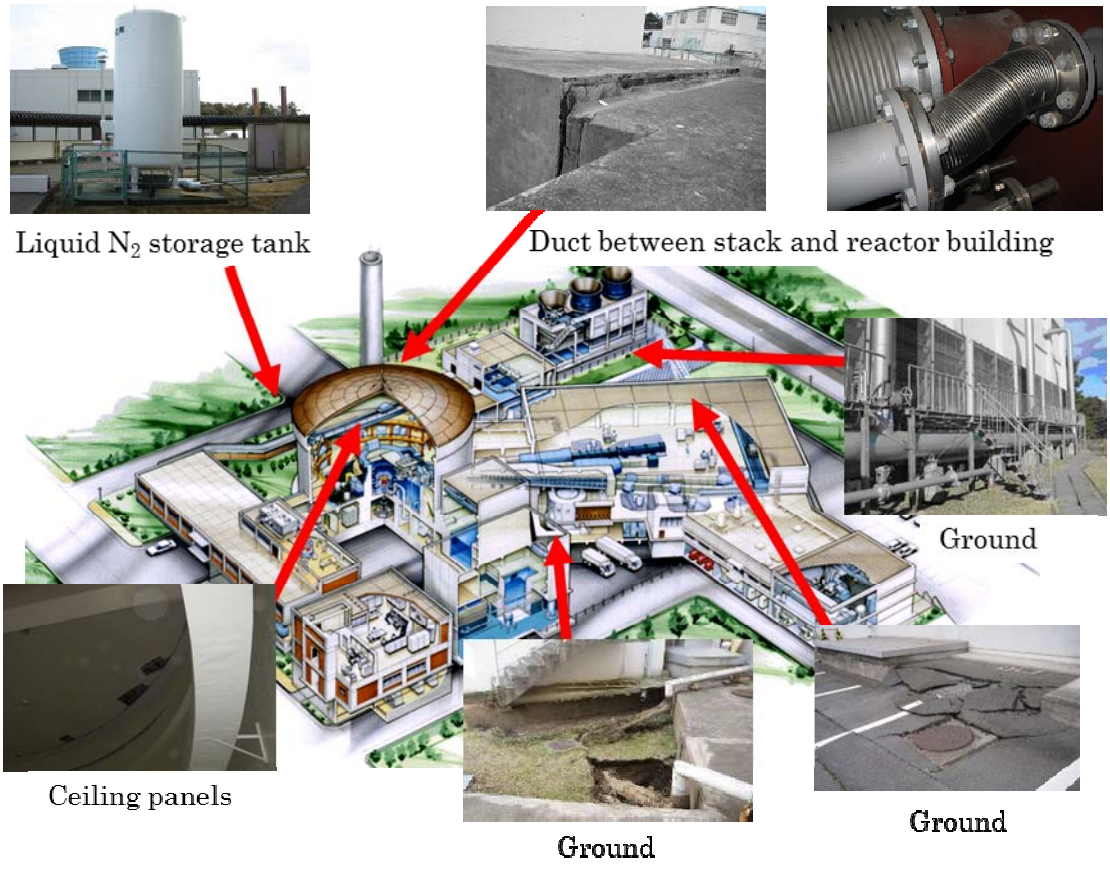


Fig.1. Some damages of JRR-3 observed after 311 earthquake

3. Verification of the Integrity

As the 311 earthquake measured larger seismic acceleration than that of seismic design of JRR-3, regulatory body demanded us to evaluate soundness of reactor facilities and report it by reactor re-operation. Several evaluation have been required such as (1) the impact in the event of station blackout, (2) check and test of all of the structure, systems and components (SSCs), and (3) seismic analysis in the light of the knowledge obtained from the 311 earthquake.

The results of the integrity were reported to regulatory body on November 2, 2012.

3.1 Impact of Station Blackout

When station blackout occurs, the reactor shuts down automatically. Figure 2 shows the maximum fuel surface temperature after the auto shutdown by station blackout. The reactor power drops to 1.4 MW immediately after a shutdown and decreases gradually. The core is cooled by free circulation of pumps for about 10 seconds and then cooled by natural circulation. The maximum fuel meat temperature reaches to 123 degrees in about 13 seconds, but falls below the criteria (400 degrees) completely. Then fuel meat temperature decreases gradually. This shows that integrity of core is kept even if station blackout occurs. Pool water evaporates very slightly and it takes about 40 days before the fuels exposed in air.

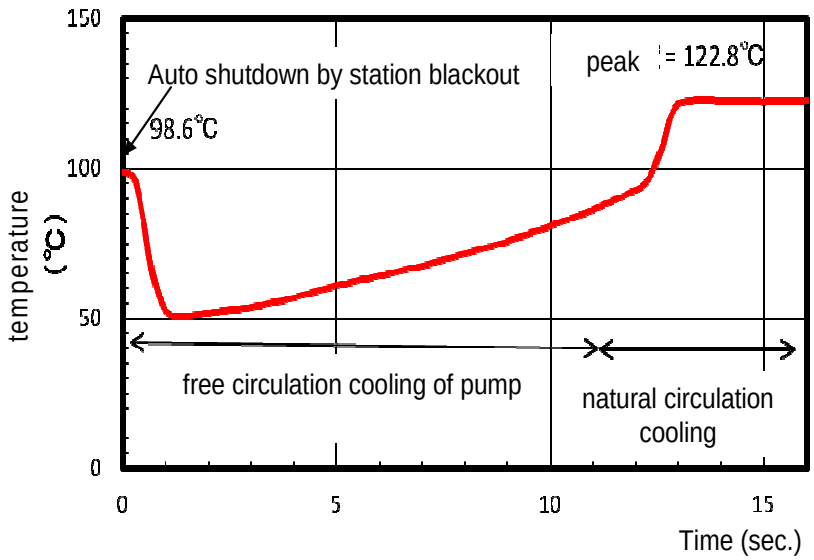


Fig.2. The maximum fuel surface temperature after the auto shutdown by station blackout

3.2 Check and Test of SSCs

Check and test of SSCs have been carried out as shown in Fig. 3. Deformation, buckling or crack of the structure was confirmed by visual observation, and deformation or loosening of a bolt and a nut was also checked. Soundness of the cooling system and I&C system etc.

needed for reactor re-operation were confirmed by the performance inspection. All of the check and test have been completed successfully.

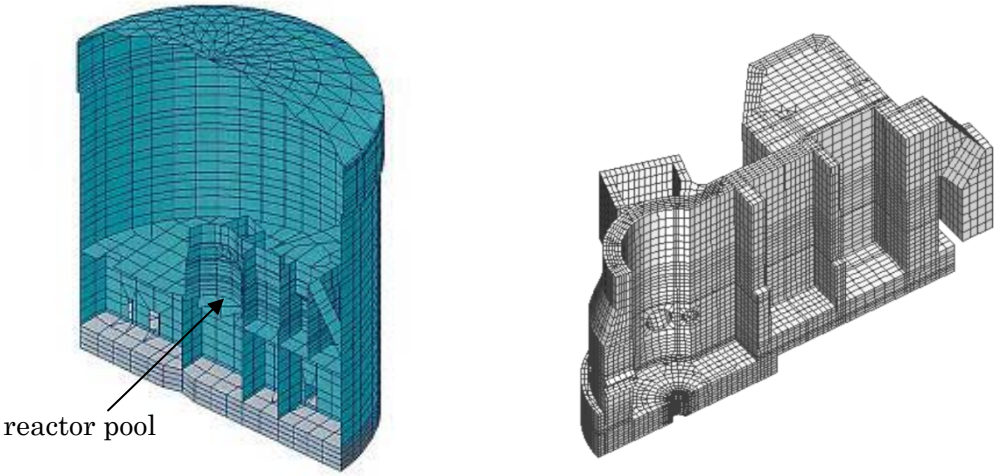
Fig.3. An example of check and test

3.3 Seismic analysis for evaluation of facilities soundness

The 3.11 earthquake registered 9.0 on the Richter scale, and the intensity was a lower 6 at Tokai. The maximum seismic acceleration of 1183 cm/s^2 in horizontal and of 512 cm/s^2 in vertical were observed at JRR-3. Those are larger seismic acceleration than that of seismic design of JRR-3. Seismic analysis has been carried out in order to confirm the JRR-3 would have been resistant with the 311 earthquake adequately.

Items of evaluation of structure using 3D FEM simulation are (1) stability evaluation of the reactor building basics ground, (2) seismic safety evaluation of reactor building, (3) core covering function evaluation of reactor pool, and (4) seismic safety evaluation of roof truss. Fig.4 shows the example of the evaluation model.

As a result of having evaluated these, we confirmed that the seismic safety of JRR-3 was secured.



(a) reactor building (b) reactor pool

Fig.4. 3D FEM model for seismic analysis

The seismic safety for components and their supporting structure were evaluated by the response magnification method. Table 1 shows result of evaluation. The initiation stress is very smaller than the evaluation criterion, because each component is designed with a sufficient margin. We confirmed that each component had enough strength to be proof against 311 earthquake.

Kind of components	Initiation stress (N/mm2)	Evaluation criterion (N/mm2)
Standard Fuel Element	4	54
Follower Fuel Element	18	74
Beryllium Reflector	3	112
Heavy Water Tank	13	58
Neutron Absorber	571	1272
Control Rod Guide Tube	6	123
Horizontal Beam Tube	59	135

Table 1 Result of evaluation

4. Nuclear Safety Regulation System and Regulatory Requirements

4.1 New Regulatory Organization

Nuclear Regulation Authority (NRA) was established in June, 2012, as an external organization of the Ministry of Environment in view of separating the function of nuclear regulation and nuclear promotion, separating the nuclear safety regulation section of the Nuclear and Industry Safety Agency (NISA) from the Ministry of Economy, Trade and Industry (METI) and integrating the function of the Nuclear Safety Commission (NSC). The NRA Commissioners can exercise an independent, neutral and fair role, based on their own expertise.

Aiming to integrate nuclear regulation functions, the NRA is in charge of safety regulation on the use of reactors and nuclear fuel materials, security, safeguards, environmental monitoring and radioisotopes regulation.

4.2 Revision of Reactor Regulation Act

In response to the accident at TEPCO's Fukushima Daiichi NPS, the Reactor Regulation Act was revised by the Supplementary Provisions of the Act for Establishment of the NRA, for the purpose of introducing new regulations based on 'lessons learned' availability of the latest technical knowledge.

The revision include (1) new regulation on severe accidents, (2) adoption of the latest technical knowledge and introduction of the "backfit system" under which already authorized nuclear facilities are also required to conform to new regulatory requirements, (3) introduction of an approval system for the extension of operational periods, and (4) integration of all safety

regulations on power reactors into the Reactor Regulation Act.

4.3 New Regulatory Requirements for RR

Public comments were sought from July 25 to August 15, 2013, with regard to the draft of the new Regulatory Requirements for RR in response to the revision of Reactor Regulation Act. They shall come into force by December 18, 2013.

The requirements include (1) measures to prevent core damage and mitigation of radioactive materials release in case of assuming beyond design basis accidents, (2) safety measures against natural phenomena (e.g., tornados, forest fire) and external man-made hazards (e.g., an aircraft crash), and (3) strengthening of standards concerning earthquake and tsunamis in particular.

5. Conclusion

Damages by the 311 earthquake have not diminished the safety of the JRR-3. Recovery works mainly for ground sinking have been carried out smoothly. The SSCs needed for reactor operation have been checked to be reusable without major repair. Seismic assessment shows that the seismic loads which worked on all structures and components by the 311 earthquake accommodated within their allowable stress. We are planning to restart JRR-3 service operation after the regulatory confirmation of conformity to the new regulatory requirements.