Safety reassessment of Egyptian second research reactor post Fukushima accident

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Abstract

— In the light of Fukushima accident, reassessments of Egyptian second research reactor number two have been done. It shows that all of the basic safety functions are fulfilled during the extreme events. Review and updating of the safety analysis after in-core irradiation for LEU targets to produce Mo-99. Ensure that operation and limits conditions (OLCs) are maintained as they approved by the current operating license. Review the emergency power supply and Uninterrupted Power Supply System (UPS) systems. Review of the emergency preparedness and the emergency equipment. There are recommendations for enhancing the safety during normal and emergency cases.

1. Introduction

The immediate cause of the Fukushima accident was the melting of the reactor core that happened as a result of the consequences of the great earthquake and tsunami. During this process, the Zirconium of the fuel cladding reacted with the water producing a large amount of Hydrogen. This hydrogen, combined with the volatile radioactive materials, leaked out of the containment vessels and entered into the reactor buildings resulting explosions. This accident increased the attention of the world to make a reassessment to the nuclear facilities. The main objective of this reassessment is to evaluate the robustness of the existing reactor protection, in terms of design features against the impact of extreme events, with an emphasis on fulfillment of the basic safety functions to avoid accidents like that happened in Fukushima. it is possible to summarize the lessons to be learned from the accident under several areas and topics such as: 1) the seismic design; 2) the tsunami effect; 3) the station blackout effect; 4) the station safety design; 5) loss of ultimate heat sink; 6) spent fuel storage pools design; 7) regulations and organization/crisis management. The loss of emergency power resulted in melting of the fuel in the reactors cores and overheating of the fuel in the spent fuel pools, caused a release of radioactive materials to the surrounding region and a severe long-term contamination of thousands of square kilometers [1-14].

2. ETRR-2 actions taken after Fukushima accident

— After Fukushima accident, the flowing action taken at Egyptian second research reactor (ETRR-2). Review and updating of the safety analysis after in-core irradiation for LEU targets to produce Mo-99. Ensure that operation and limits conditions (OLCs) are maintained as they approved by the current operating license [10,15]. Review the emergency power supply and Uninterrupted Power Supply System (UPS) systems. Review of the emergency preparedness and the emergency equipment. Study the interaction of the reactor associated facilities (ET-RR-2, fuel fabrication plant and Radioisotopes Production Plant). Review of the operator response to the design basis accidents and radiological emergency. Complete loss of all electrical power supply (off-site, on-site and batteries). Loss of ultimate heat sink. Review the off-site emergency response including management of severe accident. External Events (extreme earthquakes, extreme weather conditions craft crash). Internal Events (internal flooding, fire). Security events. Review of the site accessibility. Existing communications means. Review the postulated initiating events covered by the safety analysis in SAR and IAEANS-R-4. Events may happen with experimental devices.

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2.1. Reassessment of the site

— In 1992 Egypt had an earth quick hence; the Egyptian atomic energy modified the contract with INVAP Company to include extreme earthquake (peak to peak acceleration greater than 0.2 G). However, ETRR-2 site has Low probability of earthquakes and volcanoes. Low probability of radiation spread by wind. Enough distance from accommodations. Enough distance from seas and oceans.

— **2.2. Reassessment of the building**

— Reassessment of ETRR-2 building shows that:

— Earthquake resistance, submarine doors (to mitigate LOCA), radiation spread resistance, and Air confinement (reactor hall ventilation system and non conventional area ventilation system) to prevent radioactive materials release to the environment. Emergency doors (in all the reactor building).

— **2.3. Reassessment of radiation protection**

— ETRR-2 has advanced equipment for all type of radiation, failure detectors for the components that may cause radiation release (fuel element cladding failure detector, secondary water detector to detect any failure or leakage from primary circuit to secondary circuit. High level of training on radiation protection and safety culture, and periodic calibration for all the detectors.

— **2.4. Reassessment of emergency preparedness and response**

Update and repeating the emergency plan training periodically. Verify the good connections internally and between the reactor and the different centers and authorities to ensure a good coordination and rapid response in case of emergency. Good monitoring system. Manual and automatic fire detection. However, the shortage detected recovered such as some area is out of the ambulance range, and evacuation alarm does not work in some areas.

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— **3. safety features of ETRR-2**

Main design features of ETRR-2 are Redundancy, Diversity, Fail safe, Physical separation, Negative reactivity temperature coefficient

— **3.1. Safety systems in ETRR-2**

— First shutdown system has six control rods (plate type) although four control rods is enough to shutdown the reactor safely (redundancy). Second shutdown system is four tanks of Gadolinium nitrate solution in case there is SCRAM signal and two control rods of six control rods are not reached to bottom position (fully inserted in the core) after one second the Gadolinium solution inserted in four chambers surrounding the core (Beryllium reflectors out of them) and reflector saving becomes zero and reactor went subcritical hence, reactor shutdown safely (diversity). Chimney water injection system has four tanks that will be triggered in case of LOCA, cover the core by water.

— Evacuation alarm triggers in case of LOCA to give an order for the worker to evacuate the building according to the roles, hence, the shift supervisor with the operators handling the reactor from secondary control room in the entrance of the reactor building (relatively low radiation area).

— **3.2. Availability and safety**

— In spite of the importance of availability, it must be limited to levels that keep the reactor operation in safe mode. This limitation of the availability is very important to avoid the human errors. This principle is very clear in the design of the logic systems of ETRR-2. It makes the reactor operation impossible without verifying all of the safety conditions.

— **3.3. Design basis accident**s

— The reactor design must take all of the expected accidents and their scenarios into consideration to adopt the principle of defense in depth in the design. In ETRR-2, this principle is very clear and adopted with the higher levels of safety multiple barriers and recovery actions. There is a quick reference emergency guide that can be used by the reactor operation group to verify the safety functions easily and quickly in case of emergency.

— **3.4. Design basis accident**s **in ETRR-2**

— The design basis accidents in ETRR-2 are, Loss of offsite power supply accident (LOPS), Loss of flow accident (LOFA), Loss of heat sinks (LOHS), Loss of coolant accident from pool (Pool LOCA), Core loss of coolant accident (Core LOCA). Fast reactivity insertion, Low reactivity insertion, and Coolant channel blockage.

- **3.5. Electric power supply system**

- Electric power supply system has multiple classes for the electric system such as, Class (A) (UPS), Class (B) Diesel generators and Class (C) External power supply.

- **4. Conclusion**

The reassessment of ETRR-2 shows that all of the basic safety functions are fulfilled during the extreme events. However, reassessment recommendations are Periodic tests for safety and safety related systems. Ensure training and periodic retraining of the workers. Periodic emergency drills must be done and detecting the shortage and malfunctions in the emergency plan, equipment, communications and personal. Power of diesel generators should be increase from 500 K.W to 600 K.W to include the feeding of fire pumps in case of loss of site power supply. Pay attention to preventive maintenance for the safety systems and related equipments according to maintenance plan.

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