Manufacturing and Construction of Fresh Fuel Storage Rack for a Research Reactor

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1. Introduction

The objective of this study is to provide the manufacturing and construction information regarding the Fresh Fuel Storage Rack (FFSR). The main function of a FFSR is to store and protect the 2core new fuel assemblies for the operation of the research reactor. The FFSR is classified into safety class NNS and seismic category I according with ANSI 51.1 [1] and Regulatory Guide 1.29 [2].

2. Design

2.1 Structure

The fresh fuel assemblies are stored in a dedicated room under safeguards arrangements. Generally, the fresh fuel storage room is located on the same floor as upper area of the reactor concrete island and indicated clearly with a tag attached in front of the door. The door of fresh fuel storage room is designed with considering the physical protection.

The fresh fuel assemblies are stored in a rack made of stainless steel and the storage rack is installed in the fresh fuel storage room. The fresh fuel facility provides fresh fuel assemblies with dry storage space. General design requirements of the fresh fuel storage facilities are given in the ANSI-57.3 [3].

The pitch among fuel assemblies is calculated under the adverse effects of fuel handling accident or conditions. The evaluated maximum the effective neutron multiplication factor should exceed the criteria ($k_{eff} < 0.9$). The uncertainties are reflected in the design calculation phase. The fresh fuel storage rack has the storage capacity for 2cores. The storage cell cover which lies on the storage cell pipe is to protect the external impact and not to be covered with the dust. The fresh fuel storage rack has four holes for eyebolts on upper area of the rack to remove and install the rack.

All surfaces that come into contact with fuel assemblies are made of austenitic stainless steel. These materials are resistant to corrosion. As shown in the Figure 1, the fresh fuel storage rack consists of storage cells and various plates/frames. The upper and lower support block which plays part in mounting of the fuel assembly is inserted in the storage cell. The fresh fuel storage rack is securely fixed on the floor of the fresh fuel storage room by four anchor bolts and can withstand the OBE and SSE loads.

Fig. 1. Configuration of fresh fuel storage rack

Stainless steel is used for structural material of the fresh fuel storage rack to prevent corrosion. And stainless steel has good resistivity against radiation. Surveillance equipment is installed at the physical protection door for the security of fresh fuel assemblies. Fig. 1 represents the manufacturing configuration of fresh fuel storage rack.

2.2 Analysis

To evaluate the structural integrity of the fresh fuel storage rack, the response spectrum analysis has been performed under the seismic loads of OBE(Operating Basis Earthquake) and SSE(Safe Shutdown Earthquake) by using ANSYS software. The elements used in the analysis model are shell and solid element. The fixed boundary condition is imposed on the anchor bolt position for structural analysis.

The fresh fuel storage rack is designed to withstand seismic load and other loads during earthquake. The structural integrity of the fresh fuel storage rack is

evaluated in accordance with ASME Section III, Subsection NF [4]. Computer Code used for this analysis is ANSYS version 15.0.0. Dead load and seismic load is considered in load condition and added mass is included in the analysis.

The response spectrum analysis is performed for seismic analysis of the fresh fuel storage rack. The response spectrum analysis is performed by using each directional floor response spectrum. The number of modes considered in mode combination is 300ea. Other modes beyond the 300th mode are considered by using the missing mass method. Fig. 2 shows the finite element model of fresh fuel storage rack.

It is confirmed through a structural analysis that the fresh fuel storage rack maintains its structural integrity against the design loads.

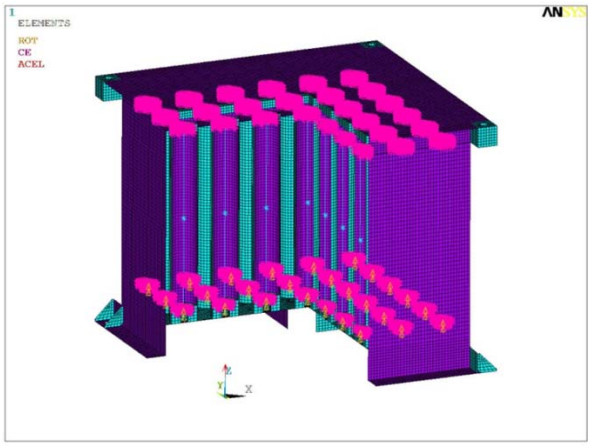

Fig. 2. FEM model of fresh fuel storage rack

3. Construction

3.1 Fabrication

The fresh fuel storage rack is fabricated in accordance with the ASME Section III, Subsection NF. Additional attention is paid to the protection of stainless steel from contamination and damage.

3.2 Inspection and Test

The fresh fuel storage rack is inspected and pre-assembled to verify proper fit, clearance, and integrity.

3.3 Installation

The fresh fuel storage rack is installed in the fresh fuel storage room with the physical protection door in the reactor building. The fresh fuel storage rack is fixed by 4 anchor bolts. The leveling is adjusted inserting shim plate between brackets and anchor bolts. Prior to arrival of the FFSR, a receiving area shall be established where the FFSR can be removed from the shipping vehicle and upended. Suitable devices are required to prevent damage to the FFSR or floor surface, if necessary. The physical protection door must be completed and operable to lock the fresh fuel storage room. The overhead crane of the reactor building must be completed and operable. A tool to install FFSR shall be prepared and tested by the Installer. The eyebolts shall be engaged with the FFSR at the top area of the four corner position. Fig. 3 shows the installation configuration of fresh fuel storage rack.

Fig. 3. Installation configuration of fresh fuel storage rack

4. Summary

Design, manufacturing, and construction of the fresh fuel storage rack are introduced. The analysis is performed to confirm the structural intensity of the fresh fuel storage rack under the seismic loads.

The fresh fuel storage rack designed for storage of fresh fuel assemblies should be manufactured and installed with consideration of predicted number of fresh fuel assemblies, structural integrity, resistivity to corrosion and radiation, cleaning, and workability. This study is expected to provide the designer, manufacturer and installer of fresh fuel storage rack with benefit information.

Acknowledgements

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