Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, November 2-3, 2006

Safety Review of Cernavoda Unit 2 Fuel Handling System

Tae Woon Kim, Bo Wook Rhee, Jin Hee Park, Joo Hwan Park.
Korea Atomic Energy Research Institute
150 Dukjin-Don, Yusong-Gu, Daejon 305-353, Korea
bwrhee@kaeri.re.kr
Lee Myung Kee*, Cho Yoon Sang* , Park Wan Gue**
KHNP Overseas Project Department, Wolsong NPP***

1. Introduction

European Union (EU) required the Safety Level of Cernavoda Unit 2 be comparable to those of the other European NPPs[1]. One of the technical items subject to this requirement is the safety review for the Fuel Handling System and Waste Management Systems. The On-Power Refuelling System is a system unique to the CANDU type of NPP as CANDU uses the natural uranium and heavy water moderator/coolant, and thus require daily refueling of fresh fuel to maintain criticality due to small excess reactivity. Because of the importance of this system to the reactor operation and EU country nuclear experts unfamiliarity with this on-power refuelling system, EU requested Romania to perform a Safety Evaluation of these two systems separately from the conventional Safety Analysis covering all the Design Bases Accidents.

2. Review of Fuel Handling System Design

The Design Characteristics of these two systems of the Cernavoda Units 1 and 2, Wolsong Units 1, and 2/3/4 were all reviewed to understand the design characteristics of Cernavoda Unit 2. The year of the project starting dates are as follows; the Wolsong Unit 1 1979, the Cernavoda Unit 1 1982, Wolsong 2/3/4 1986, the Cernavoda Unit 2 Reconstruction project started 1995. As for the design of Fuel Handling System the Cernavoda Unit 2 design is the same as that of Wolsong Unit 1 and the Cernavoda Unit 1. However Wolsong Units 2/3/4 design is a little bit advanced than that of the other CANDU-6 plants.
The subsystems reviewed are: FM head, FM snout assembly, Snout Clamping Mechanism, Leak Detection System, FM Magazine, Ram Assembly, Fuel Separators, FM D2O Supply System, FM D2O Comtrol System, FM Oil Hydraulic System, FM Bridge, Carriage and Catenary System, FM Bridge Drives and Brakes, Spent Fuel Transfer System, Spent Fuel Ports, Spent Fuel Discharge Elevators and Drives, and etc.

3. Review of Event History Docket

Event records related to the fuel handling systems are collected and reviewed to identify the safety and operational characteristics of the fuel handling system of CANDU-6 plant. Event data base is formed from the CANDU Owners Group(COG) Event Records and INPO, WANO, IAEA data bases and Wolsong NPPs Operational experiences. A failure trend analysis was performed in a subsystem-wise and operation mode-wise of the fuel handling system. The operation modes are separated as On-Reactor Fuelling Mode, Off-Reactor Operation Mode, and Spent Fuel Port Discharge and Fresh Fuel Loading Modes. The subsystems considered are D_2O Supply System, D_2O Control System, Oil Hydraulics System, Instrument Air System, Electrical System, C&I System. The operational events for fueling handling systems are also categorized as Maintenance error, Operation Error, and System Mechanical Error, etc.

4. Failure Mode and Effect Analysis

For the whole fuel handling system, the failure mode and effect analysis (FMEA) is performed for the each function of the system,, the operational flow circuits of each function according to each operation mode. The functions considered are; D_2O supply and return circuit, C-Ram and Separator Actuation Circuit, B-Ram and L-Ram Seals Supply Circuits, D_2O pressure Control, D_2O Temperature Control, D_2O Flow Control, D_2O Level Control, Oil Hydraulic Supply function which drive Snout Clamping, B-Ram and L-Ram Actuation, FM Carriage Drives. The operation modes considered are;
High pressure Fuel Changing mode, Park Mode, Fresh Fuel Receiving Mode, Spent Fuel Discharge Mode.

The failure effects considered are the mechanical failure of the fuel bundles, loss of D_2O inventory, and loss of clamping which result in plant shutdown due to the inoperable fuelling machine and/or the excessive radiation release.

5. Preliminary Conclusions

The most severe event scenarios were found to be as follows;

A. The break of the fuel channel end fitting accompanying the ejection of 12 irradiated fuel bundles.
B. Loss of Coolant Accidents when FM is on- or off-reactor condition due to spurious withdrawal of FM.
C. Mechanical Damage of two irradiated fuel bundles when being dropped to the discharge bay from the port.

However these kinds of severe accidents are rarely possible from the review results of the Event History Docket.

REFERENCES

[1] "NPP CERNAVODA 2 Comments to the documents provided for the EIA", Antonio Wenisch, and et. al., Austrian Institute for Applied Ecology, Vienna, November 2002.

[2] EURATOM, Cernavoda 2 Nuclear Safety Expert Project, "Task 5, Task 6, Task 10 – Safety Evaluation Report", A.F.Parsons, NNC Limited, December 2001

[3] Appendix A.8, Fuel Handling System Reliability Analysis, 86-03600-PSA-001.

[4] Cernavoda U2 FSAR Chapter 9. Fuel Storage and Handling

[5] Wolsong 2/3/4 PSA report, 86-03600-PSA-001-Rev0-PSA Report