Safety Analyses of Process and Facility for the ACP Demonstration

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1. Introduction

KAERI has focused on the project 'Development of Advanced Spent Fuel Conditioning Process (ACP)'. This ACP involves a reduction process of uranium oxide by a lithium metal in a high temperature molten salt bath. The successful implementation of this project will provide a promising solution for the effective management of spent fuel, and contribute to the establishment of a nuclear fuel cycle technology which is proliferation resistant and cost effective [1,2].

For the demonstration of this process, an experimental facility is essential. Figure 1 shows a cutoff view of the ACP Facility which has been developing in the KAERI.

Figure 1. A Cutoff View of the ACP Facility.

2. Safety Analyses of the ACP Process and Facility

The ACP facility was designed to treat the spent fuel with an initial enrichment of 3.5 %, a burnup of 43,000 MWd/MtU and a 10 years cooling time. One batch size of the ACP is 20 kg of spent fuel, and the maximum capacity being handled in the ACP Hot Cells is one batch of spent fuel, four ingots of uranium metal and two batches of waste molten salt.

2.1. Process Safety

The ACP electro-chemical processes treat the high level radioactive materials and chemically toxic materials. The process safety should be considered for the proper and safe operation of the ACP. There are four kinds of hazards and a various kinds of faults that may be encountered during the ACP operation. Every hazards and faults are analyzed and evaluated for the safe operation of the ACP and the results are adapted in the process design.

2.2. Environmental Safety

The ACP Hot Cells are an α-γ sealed type. The ventilation system for the ACP facility as part of the IMEF's system is designed to assure an air flow from the clean areas to the more radioactive areas. A maximum pressure differential of -37 mmAq should be maintained between the Hot Cell inside area and the intervention (Hot Cell rear) area. To give priority to the environmental safety, the radiation doses evaluation for the radioactive nuclides have been preliminarily performed in both the normal and an accident operation case. The evaluation results indicated some safe marginal values for the regulation limits and SAR limits of IMEF where the ACP facility will be located.

2.3. Radiation Shielding Safety

In the design step of the facility, the source term of the material being handled was carefully considered in the Hot Cell Wall shielding design. The gamma and neutron intensities were calculated by using the ORIGEN-2 and the SOURCES codes, respectively. The design criteria for working area and the maintenance area in the ACP facility are 0.01 mSv/h and 0.15 mSv/h.

2.4. Criticality Safety

The ACP is a dry process, but for conservatism the criticality safety was analyzed with the water condition. The 100 kg of spent fuel (initial enrichment : 3.5 wt%, burnup : 20 GWd/MtU, cooling time : 10 years) were analyzed for the case of a homogenized, sphere geometric and fully reflected condition surrounded by 30 cm thick of water for the criticality safety. The calculation was performed by the SCALE 4.4a code and the KENO V.a code using the ENDF 44-group Cross Section Library. The calculation results showed that the maximum Keff is 0.912.

2.5. Structural Safety

Seismic analysis for the whole IMEF building block including the ACP hot cells has been performed to verify the integrity of Hot Cell structure against a Design Basis Earthquake (DBE) and an Operating Basis Earthquake (OBE). The total displacements of the IMEF building were calculated by 22.9 mm and 10.0 mm for the vertical and horizontal directions, respectively. The displacements of the KMRR and the RIPF buildings contacted with the IMEF are 4.9 mm and 7.9 mm. Therefore, the total displacements of the KMRR and the RIPF buildings are 14.9 mm and 17.9 mm. The seismic gaps between these two buildings and the IMEF building were designed by 50 mm. Those values are larger than the displacements. Thus, the analysis shows that all buildings are safe under the seismic accident conditions.

3. Summary

The safety analyses and evaluation works on the process and facility for ACP demonstration have been performed. The several safety factors, such as the risk, environmental, radiation, structural, criticality, were analyzed. The analysis results confirmed the reliability of the safety on the ACP process and facility during normal and accident conditions.

REFERENCES

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