Safety in Design on Pyroprocess Facilities

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1. Pyroprocess Facilities in KAERI

KAERI(Korea Atomic Energy Research Institute) has been developing a pyroprocess for a LWR spent fuel conditioning and its future reutilization in the Generation IV reactors. For the development of pyroprocess, two laboratory facilities, ACPF(Advanced spent fuel Conditioning Process Facility) and PRIDE(PyRoprocess Integrated inactive Demonstration) facility, were constructed in KAERI site. From 2001 to 2005, the ACPF for an electrolytic reduction of spent fuels was constructed. The ACPF has been used for a demonstration of an ACP since 2006. In 2007, the PRIDE facility, a mock-up facility for an engineering scale demonstration to cover a full pyroprocess, started for conceptual design. Basic and detailed design works were performed in 2008. From 2009 to 2011, the PRIDE facility has been constructed and tested.

1.1 ACPF

KAERI has focused on a project entitled "Development of an Advanced spent fuel Conditioning Process (ACP)", that is, the development and demonstration of an advanced spent fuel management process at a laboratory scale. This technology involves the process of an electrolytic reduction of uranium oxide in a high temperature LiCl-Li_2O molten salt bath. For a demonstration of the ACP technology several hot cells in which spent fuel can be treated safely are needed, so KAERI decided to use a spare cell line located in the basement floor of the IMEF (Irradiated Material Examination Facility) [1-3].

Fig. 1. Working Area View of the ACPF

1.2 PRIDE

Before the development of an active pyroprocess facility with an engineering scale capacity, KAERI needs to develop a mock-up test facility which can be operated with non-irradiated fuels. In order to fulfill this necessity, the PRIDE facility, a mock-up test facility, has been developing. This PRIDE facility has one large cell which includes the pre-treatment pyroprocesses such as decladding, voloxidation, and salt waste treatment processes and the main pyroproceses such as electrolytic reduction, electro-refining, electro-winning, and cathode processing. This cell inside will be maintained with argon environment. For maintaining a pure argon environment inside the cell, an argon purification and humidity control system also will be equipped. Figure 2 shows the front building view of the PRIDE facility [4].

Fig. 2. Front Building View of the PRIDE facility

1.3 Future Facility

If the engineering scale mock-up tests with non-irradiated fuels and the co-research between Korea and United States are performed successfully, the Korea Advanced Pyroprocess Facility (KAPF) will be developed for 9 years, from 2017 to 2025. This KAPF will have a treatment capacity of LWR spent fuel at 30 tonHM/year. This facility can be demonstrated by using active LWR spent fuels discharged from a commercial nuclear plant.

2. Safety in Design

US DOE Standard 1189 has been developed to show how project management, engineering design, and safety analyses can interact successfully. This standard provides the department's expectations for incorporating safety into the design process for new or major modifications to US DOE Hazard Category 1, 2, and 3 nuclear facilities, the intended purpose of which involves the handling of hazardous materials, both radiological and chemical, in a way that provides adequate protection for the public, workers, and the environment [5].

3. Implementation of DOE-STD-1189 on Future Pyroprocess Facility

3.1 Pre-conceptual Design Phase

Safety-in-design efforts must begin during the pre-conceptual phase of a potential design and construction project when initial planning activities occur. The project team must consider the Safety Design Guiding Principles and key concepts of this standard in the development of the project requirements to support the Mission Needs package [5]. In this phase there are no requirements for deliverables. For development of the KAPF, this pre-conceptual design phase will be able to start in 2017.

3.2 Conceptual Design Phase

Stage	DOE STD 1189 Deliverable Requirements	KAPF Deliverable Schedule
Conceptual Design	Perform pre-conceptual planning activities	Mar., 2018
	Prepare Mission Needs Statement	April, 2018
	Develop ROM estimates for MAR and release consequences	June, 2018
	Develop tailoring strategy Safety-in-Design	Oct., 2018
	Develop an DOE approved Safety Basis Strategy	Jan., 2019

3.3 Preliminary Design Phase

Stage	DOE STD 1189 Deliverable Requirements	KAPF Deliverable Schedule
Preliminary Design	Establish Integrated Project Team and SDIT	Mar., 2019
	Develop design/process alternatives analyses	Mar., 2019
	Update Safety Basis Strategy	April, 2019
	Perform Preliminary Project Execution Plan	June, 2019
	Incorporate safety controls into design	July, 2019
	Prepare Conceptual Safety Design Report	Oct., 2019
	DOE prepare Conceptual Safety Validation Report	Dec., 2019
	Prepare PHA(<Hazard Category 2 facilities) DOE approval	Feb., 2020

3.4 Final Design Phase

Stage	**DOE STD 1189 Deliverable Requirements**	**KAPF Deliverable Schedule**
Final Design	**Prepare Hazards Analysis Report**	**Mar., 2020**
	Update Safety Basis Strategy	**April, 2020**
	Revise design to incorporate definitive safety controls	**June, 2020**
	Prepare Preliminary Design Report	**Aug., 2020**
	Prepare Preliminary Safety Design Report	**Aug., 2021**
	DOE prepare Preliminary Safety Validation Report	**Dec., 2021**
	Establish Performance Baseline	**Jan., 2022**

3.5 Construction Phase

Stage	**DOE STD 1189 Deliverable Requirements**	**KAPF Deliverable Schedule**
Start of Construction	**Prepare Final Design Report**	**Mar., 2022**
	Revise Hazards Analysis if required	**April, 2022**
	Update Safety Basis Strategy if required	**Oct., 2022**
	Prepare Preliminary Documented Safety Analysis	**Dec., 2022**
	DOE prepare Safety Evaluation Report	**June, 2023**
	Update Hazards Analysis Report (<Hazard Category 3 facilities)	**Dec., 2023**

3.6 Operation Phase

Stage	**DOE STD 1189 Deliverable Requirements**	**KAPF Deliverable Schedule**
Start of Operation or Project Closeout	**Issue Checkout, Testing and Commissioning Plan**	**Mar., 2025**
	Issue Transition to Operation Plan	**Mar., 2025**
	Complete Readiness Assessment or Operational Readiness Review	**June, 2025**
	Finalize Hazard Analysis Report	**Oct., 2025**
	Prepare DSA and TSR	**Dec., 2025**
	DOE prepare SER	**Feb., 2026**

4. Conclusions

US DOE-STD-1189 can apply to the design and construction processes of the KAPF. Followings were found in this study;

- Estimated time line of the KAPF
- Deliverable requirements and schedules for developing of the KAPF
- Safety integration strategy in design processes for developing of the KAPF

REFERENCES

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