

Review of NRC Commission Papers on Regulatory Basis for Licensing and Regulating Reprocessing Facilities

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1. Introduction

Spent nuclear fuel (SNF) accumulated in nuclear power plant has been a serious issue in most countries with operating nuclear power plants. Direct disposal of SNF could be a solution of the problem but many countries including the Republic of Korea have had a hard time selecting a site for high level waste repository because of low public acceptance. SNF recycling technologies consisting of reprocessing and transmutation have been developed so as to reduce the final volume of the disposed radioactive waste and to diminish the radiotoxicity of the waste.

The Republic of Korea is now developing pyroprocessing and sodium-cooled fast reactor (SFR) technology to be used for the recycling of the wastes. KAERI has a plan to construct a pyroprocessing facility with a capacity of 30 tHM/y and a facility manufacturing TRU fuel for SFR by 2025. However, to license these facility and secure the safety, the current regulatory system related to SNF treatment needs to be improved and amended since the system has been developed focusing on facilities to examine irradiated nuclear materials.

The United States has also similar issues on reforming regulatory framework for reprocessing since 10CFR 50 for production facilities has been evolved into regulation of a nuclear power plant. U.S.NRC is endeavoring to find and resolve the regulatory gaps. NRC staff has published several commission papers (SECY) related to regulation of reprocessing. The SECY papers cover the gap analysis and direction to resolve.

In this paper, the SECY papers on reprocessing regulation are reviewed from a safety and licensing perspective.

2. History of the SECY papers on reprocessing

The SECY papers related to reprocessing have been published since 2006. In 2005, the House and Senate Appropriations Committees directed DOE to develop SNF recycling program. To prepare rulemaking and licensing activity for a full scale recycling facility including both reprocessing and fast reactors that DOE would design, NRC staff submitted SECY-06-0066 to request the approval of initiating interaction with DOE.

In 2006, the approach to the Global Nuclear Energy Partnership (GNEP) to demonstrate small-scale recycling facilities by industry was changed for developing recycling facilities such as reprocessing, fuel fabrication and advanced burner reactor (ABR). The staff issued SECY-07-0081 to provide regulatory options for these facilities and request approval of technical bases document and GNEP regulation development.

In 2008, the staff decided to put off developing regulatory bases on ABR and to focus on technical bases for reprocessing in response to DOE and industry needs. In SECY-08-0134, the staff represented three options for regulatory framework for licensing and regulation of reprocessing facilities: revision of 10CFR 50, revision of 10CFR 70 and development of a new 10CFR 7x.

In 2009, after the commissioners of NRC directed the staff to perform regulatory gap analysis for licensing recycling facilities in the Staff Requirements Memorandum (SRM) to SECY-07-0081, the staff derived 23 regulatory gaps and reported them in SECY-09-0082. Regulatory priority is assigned to each gap and the gaps are categorized according to 4 groups:

- Lack of regulations
- Existing regulations pose a significant hindrance or regulatory burden to effective and efficient licensing
- Gap resulting from potentially licensing a production facility under Part 70 (versus Part 50)
- Requirements exist, but modifications may be needed for clarity

In 2011, the staff submitted a draft regulatory basis document as an enclosure of SECY-11-0163 that addressed gaps with high and moderate priority derived in SECY-09-0082 and described the staff position to the gaps. In 2012, the Commission requested to address questions about the draft through SRM-SECY-110163.

In 2013, the staff published SECY-13-0093 to respond to the questions and to request the approval of developing a new 10CFR 7x as a regulatory framework for reprocessing facilities. The Commission approved the option to develop 10CFR 7x in SRM-SECY-13-0093 and directed to resolve gap 5 (safety assessment methodology) preferentially because of limited regulatory resources. The other gaps will be resolved step by step

3. Gap analysis results

The NRC staff identified 23 gaps and classified them into 3 groups according to the priority (high, moderate and low) in SECY-09-0082. Since the four gaps with low priority are not essential item to be resolved, they are not handled in SECY-11-0163, in which staff's proposed method of resolving the gaps are described. The 19 gaps with high and moderate priority can be categorized into 5 groups according to subject as follows:

- Regulatory framework and definition of terminology (gaps 1 and 6)
- Waste and environment (gaps 2, 3, 15, 16 and 19)
- Safety and licensing (gaps 5, 7, 9, 10 and 11)
- Safeguards and security (gaps 4, 8, 17 and 18)
- Financial protection requirements and fees (gaps 12, 13, 14)

In this section, the first three topics are described to focus on the safety issues rather than safeguards and the others.

3.1 Regulatory framework and definition of terminology

Gap 1 (high priority) is about the regulatory framework options. This gap represents the limitation of the existing licensing process under 10CFR 50. In the current regulatory framework, the reprocessing facility is classified as a production facility and have to be licensed under 10CFR 50. However, since 10CFR 50 has been evolved to be mostly applicable to nuclear power plant, many exemptions would be required to apply to licensing reprocessing facility.

Gap 6 (high priority) is about definition of terminology related to reprocessing. In the existing 10CFR, definition of "reprocessing" is not defined but the term is used in several parts of 10 CFR. In addition, other reprocessing related terms such as recycling, vitrification and waste incidental to reprocessing would be needed to be newly defined or modified.

3.2 Waste and environment

Gap 2 (high priority) is about independent storage of high level waste (HLW). 10CFR 72 allows both an independent spent fuel storage installation (ISFSI) and monitored retrievable storage (MRS) installation for SNF. However, HLW from reprocessing can only be stored at MRS installation.

Gap 3 (high priority) is about waste incidental to reprocessing. In the Nuclear Waste Policy Act, high level waste is defined as "highly radioactive materials resulting from the reprocessing of SNF, including liquid waste produced directly in reprocessing and any solid

material derived from such liquid waste that contains fission products in sufficient concentrations." However, some waste stream resulting from reprocessing would not be highly radioactive and they could be disposed of in a near surface disposal. Therefore, practical classification on radioactive waste from reprocessing is required.

Gap 15 (moderate priority) is about waste confidence. NRC has determined that SNF from any reactor can be safely stored for at least 60 years and there would not be significant environmental impact during the storage. HLW from reprocessing would be required to be stored for several decades but it is questionable that the waste confidence for SNF can be expanded to include HLW.

Gap 16 (moderate priority) is about waste classification. Some radionuclides that would exist in reprocessing waste such as Kr-85 and isotopes from the lanthanide series are not in the waste classification tables of 10CFR 61.55.

Gap 19 is about effluent controls and monitoring. Most of radionuclides in reprocessing facilities would be in potentially mobile form such as liquids and gases. Therefore, regulations for effluents monitoring and control are required.

3.3 Safety and licensing

Gap 5 (high priority) is about safety and risk assessment methodology. Process characteristics of reprocessing consisting of a lot of chemical process are totally different to nuclear power plants. They would be similar to fuel cycle facilities but sources terms, the number of accident scenarios and the complexity of the operation are much greater than the front end fuel cycle facilities. Therefore, regulation under 10CFR 50 or 70 are not adequate to secure the safety of reprocessing facility.

Gap 7 (high priority) is about licensed operators and criteria for testing and licensing operators. The Atomic Energy Act (AEA) requires that production facilities have licensed operator. However, the existing 10CFR 55 could not be applied to reprocessing facility operators.

Gap 9 (high priority) is about baseline (general) design criteria. General design criteria for reprocessing plants do not exist. In 10CFR 70, baseline design criteria exist, but they are directed more toward the front end fuel cycle facilities with low radiological hazards.

Gap 10 (high priority) is about one-step licensing and inspection, testing and acceptance criteria. Regulatory system for one-step licensing does not exist. 10CFR 52 is not applicable for reprocessing facilities and 10CFR 70.23 do not also address reprocessing facilities.

Gap 11 (high priority) is about technical specification. AEA requires that production facilities have technical specifications. 10CFR 70 requires items relied on for safety (IROFS) and the integrated safety analysis (ISA)

instead of technical specifications. Requirements for technical specifications for reprocessing facilities already exist in 10CFR 50 but revision is needed to correspond to ISA and IROFS requirements.

4. Regulatory issues on licensing

In this section, two topics on regulatory framework and one topic on safety assessment methodology, which are represented in SECY-11-0163 Enclosure are described specifically.

4.1 Regulatory framework

The reprocessing facility is classified as a production facility licensed under 10CFR 50 but the safety characteristics are totally different from nuclear reactors because most of the reprocessing processes are chemical processes. The chemical process characteristics would be similar to the plutonium processing and fuel fabrication plants which are licensed under 10CFR 70. Therefore, it would be possible to apply existing or modified 10CFR 50 or 70 to license and regulate reprocessing facilities.

In SRM-SECY-13-0093, NRC determined to select the option of developing 10CFR 7x rather than the other options such as using existing 10CFR50 or amending 10CFR 50 or 70 because these options are inefficient to address the safety, security, and safeguards issues for reprocessing facilities. The reasons why the other options were denied are described as follows.

Revising 10CFR 50 has focused on issues on light water reactor safety, so existing 10CFR 50 could not address the characteristics and safety requirements of reprocessing facilities. Therefore, to apply existing 10CFR 50 to the reprocessing facilities would require a lot of exemptions of the provisions that have been developed only for nuclear power plants and be highly complicated and inefficient.

Amending 10CFR 50 would raise similar problems. The current 10CFR 50 is already confusing because it has been used for nuclear power plants, research and test reactors, so many applicants and licensees understand 10CFR 50 as a code for nuclear reactors. Therefore, adding or revising the provisions on reprocessing facilities in 10CFR 50 would result in licensees' confusion about the current 10CFR 50. Because reprocessing facility is classified as a production facility, requirements such as technical specification and operator licensing are needed for reprocessing facilities to be licensed by AEA, whereas 10CFR 70 does not include these requirements. Therefore, amending 10CFR 70 to include these requirements in that code would also cause licensees' confusion.

4.2 Scope of 10CFR 7x

In SECY-11-0163 Enclosure, the scope of reprocessing operation was discussed. Some facilities related to reprocessing such as fuel fabrication facility and SNF storage would be co-located with reprocessing facility. In existing regulatory framework, SNF storage is regulated under 10CFR 72 and fuel fabrication under 10CFR 70. NRC staff's position is to use existing regulations for reprocessing related facilities and processes except reprocessing facilities, if these facilities and processes operated near the reprocessing facility can be regulated safely under existing regulation. On the other hand, industries support the idea of licensing and regulating all reprocessing related facilities under a new 10CFR 7x. For example, SNF storage is now regulated under 10CFR 72, but operations for loading SNF storage casks are regulated under 10CFR 50, which could cause confusion to licensees. The staff is endeavoring to decide whether existing regulations can be applied for reprocessing related facilities.

4.3 Safety assessment methodology

Radiological hazard characteristics of reprocessing facilities would be similar to the case of nuclear power plants regulated under 10CFR 50, but process characteristics would be close to fuel cycle facilities regulated under 10CFR 70.

When safety analysis of nuclear power plants is conducted under 10CFR 50, a single design basis accident (DBA) that can address all other accidents is considered. However, because reprocessing facility has multitude of complex processes, a single DBA approach would not be appropriate to cover all accidents that could occur in reprocessing facilities.

10CFR 70 regulating fuel cycle facilities includes an integrated safety analysis (ISA) approach. ISA approach has been developed primarily for the facility handling special nuclear materials containing enriched uranium and low-enriched uranium. However, reprocessing facilities have much more radionuclide source terms, higher dose impacts than this facility, so many accident scenarios and consequences can exceed bounds of 10CFR 70.61.

The Advisory Committee on Reactor Safeguards (ACRS) recommended that a probabilistic risk assessment (PRA) would benefit to complex facilities with high consequence events so as to treat rigorously dependencies and human error. The NRC staff has an equivalent opinion that PRA should be used. However, because of lack of experiences on reprocessing facility operation, operating data are not accumulated enough to support PRA methods. For that reason, the staff consider to apply hybrid ISA-PRA method at the initial stage of rulemaking for reprocessing facilities. The hybrid ISA-PRA approach uses PRA method to assess high or very high consequence events and has four main themes:

- Quantify to the extent practical
- Identify all accident sequences, and categorize them by consequence
- Apply PRA methodologies to high and very high consequence events and calculate risk
- Apply safety controls and applicable design changes to reduce and minimize total risk from the reprocessing facility

[9] U.S.NRC, Reprocessing Regulatory Framework - status and next steps, SECY-13-0093, 2013.

[10] U.S.NRC, Staff Requirements - SECY-13-0093 - Reprocessing Regulatory Framework - status and next steps, SRM-SECY-13-0093, 2013.

5. Conclusions

Status of reprocessing facility regulations developed by U.S.NRC was reviewed based on SECY papers. U.S.NRC has approved the development of a new rule referred to notionally as "10CFR Part 7x". Existing 10CFR 50 and 70 has been evolved mainly for nuclear power plants and fuel cycle facilities whose radiological hazard is much lower than reprocessing plants respectively. U.S.NRC also derived many regulatory gaps including safety assessment methods, technical specification, general design criteria and waste classification and continue to develop the regulatory framework limited in scope to the resolution of Gap 5 "safety and risk assessment methodologies and considerations for a reprocessing facility".

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