A Study on the regulation improvement through the analysis of domestic and international categorization and licensing process for large particle accelerator

Da-Yeong Gwon [a], Yeo-Ryeong Jeon [a], Yong-Min Kim [a*], Nam-Suk Jung [b], Hee-Seock Lee [b]
[a]*Department of Radiological Science, Catholic University of Daegu, Hayang-ro 13-13, Hayang-eup, Gyeongsan-si, Gyeongbuk, 712-702, Korea.*
[b]*Pohang Accelerator Laboratory, POSTECH, 80 Jigokro-127-beongil, Nam-gu, Pohang, Gyeongbuk, 790-834, Korea*
[*]*Corresponding author: ymkim17@cu.ac.kr*

1. Introduction

In case of the particle accelerators, material interaction phenomena such as neutron production, activation and Bremsstrahlung radiation could be occurred depending on accelerating particles, energy, acceleration types and so on. [1] For this reason, many foreign countries use separate criteria and regulation procedure according to the categorization of accelerators. [2,3,4] However, there is no categorization of accelerators in Rep. of Korea. In Korea, nuclear and radiation related facilities are divided into 4 groups: 1) Nuclear Reactor and related facilities, 2) Nuclear fuel cycle, nuclear material facilities, 3) Disposal and transport, 4) Radioisotope and radiation generating devices related facilities. All accelerator facilities are categorized as group 4 regardless of their size and type. For facilities that belong to group 1 and 2, Radiation Environmental Impact Assessment Report(REIR) and Preliminary Decommissioning Plan Report(PDPR) should be submitted in construction licensing stage, but there are no rules about above documents for large particle accelerator facilities. Facilities that belong to 4) RI and RG, only two documents of Radiation Safety Report(RSR) and Safety Control Regulation(SCR) are submitted in licensing stage. Because there is no detailed guidelines according to facilities type, properties of each facility are not considered in preparation and licensing process. [5] Therefore, we aim to draw improvements of licensing process and regulation through the analysis of criteria for categorization of particle accelerator and comparison of licensing related documents such as Radiation Safety Report.

2. Foreign categorization of accelerator facilities

2.1 Canada [2,3]

Accelerator facilities in Canada are divided largely into two categories(Class I and Class Ⅱ) according to energy of particles. Class I is divided into two (Class IA, Class IB). Class IA includes reactor facility and Class IB includes high-power accelerators with facilities that handle, process or store large quantities of nuclear substances. Accelerator facilities that belong to Class Ⅱ divided as follows.

- any particle accelerator that is capable of producing nuclear energy and has a beam energy of less than 50 MeV for beams of particles with a mass less than or equal to 4 amu
- any particle accelerator that is capable of producing nuclear energy and has a beam energy of no more than 15 MeV/amu for beams of particles with a mass greater than 4 amu
- any particle accelerator that is capable of producing nuclear energy and has a beam

Accelerator facilities that exceed the above criteria are belong to Class IB. In case of Class IB, there are three stages of licensing process of preparation of site, Construction, and Operation unlike Class II of one stage.

2.2 Brazil [1]

Particle accelerators and radiation generating devices are divided into four groups according to energy band until the maximum level of 50 MeV in Brazil. Energy bands for each group are presented in Table I. Each group must meet the specific requirements of its licensing stage. Depending on the group, some licensing stages are exempt according to their risk. The most critical group(7-D) must meet all of the steps as shown in Table I.

Table I: Energy bands and Licensing stages for accelerator groups in Brazil [1]

Standards Groups	Energy Bands	Licensing stage*						
		ST	CT	PC	CM	OP	MD	DC
7-A	E ≤ 100 keV			○		○		○
7-B	100 keV < E ≤ 600 keV			○		○		○
7-C	600 keV < E ≤ 50 MeV		○	○		○	○	○
7-D	E > 50 MeV	○	○	○	○	○	○	○

*ST : Siting, CT : Construction, PC : Procurement of accelerator items, CM : Commissioning, OP : Operation, MD : Modifications of the safety issues, DC : Decommissioning

2.3 Others [1]

Besides Canada and Brazil, accelerator facilities divided into 3 (Spain) or 2 groups (Argentina, India) as shown in Table Ⅱ. Classification standards for

accelerator facilities is 200 keV (Spain), 1 MeV (Argentina), 10 MeV(India).

Table Ⅱ: Categorization standards of accelerator facilities from abroad

Country	Categorization	Energy Band
Spain	1st Category	-
	2nd Category	E > 200 keV
	3rd Category	E ≤ 200 keV
Argentina	Class Ⅰ	E > 1 MeV
	Class Ⅱ	E ≤ 1 MeV
India		E > 10 MeV
		E ≤ 10 MeV

3. Analysis of licensing process and safety related documents from abroad

As stated above, many foreign countries adopt different licensing stages by categorization of accelerators. In Canada, there is difference in licensing stages and deadlines according to particle energy. In case of high energy accelerator, the contents of public information and disclosure program, preliminary decommissioning plan, and financial guarantee should be included in application documents. [6]

In Sweden, licensing of large particle accelerator is processed under three different laws (Radiation Protection Act. / Environmental Code Act. / Planning and Building Act.). In order to apply permission to construct, Preliminary Safety Assessment Report (PSAR) and Environmental Impact Assessment Report (EIA) should be submitted to Swedish Radiation Safety Authorities and Environmental Court respectively. PSAR should contain following contents. [4]

- overall technical concept
- potential risks and the mitigation of those risks
- waste management of the radioactive material

After the application of EIA, court hearing is held before permission. Licensing process for ESS(European Spallation Sources) construction in Sweden are given in Figure 1. [4]

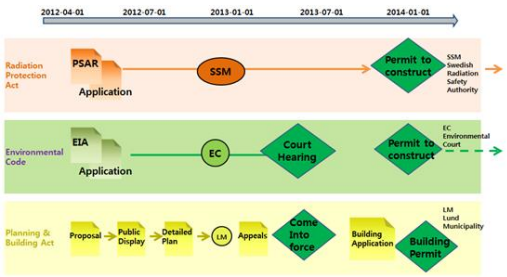

Fig. 1. Licensing process for ESS(European Spallation Sources).

The contents of ESS Preliminary Safety Analysis Report(PSAR) are as follows: 1) Introduction, 2) Site description, 3) Design rules, 4) Description of the facility & function, 5) Radiological hazards & safety functions, 6) Emissions, 7) Radioactive waste, 8) Radiation protection, 9) Operation of the facility. The details of main contents related to large particle accelerator safety are as follows. [7]

- Site Description: Natural phenomena hazards, External man-made threats, Environmental analyses, and so on.
- Design Rules: Radiation safety analyses & methodologies, Calculation codes & nuclear data implemented for radiation protection, Shielding and Activation calculation principles, and so on.
- Radioactive Waste: Decommissioning waste, Operational waste management, Waste sources, and so on.
- Operation of the facility: Quality assurance program, Accelerator safety envelope, and so on.

In the United State, Contractor Requirements Document (CRD) are submitted to achieve the license of accelerators. CRD includes a SAD (safety assessment document) and ASE (Accelerator Safety Envelope). ASE is a separate document to ensure the safe operation in particle accelerators facilities. The contents of ASE are 1) Introduction, 2) Assumptions and Credited controls, 3) Credited control systems, 4) Credited control testing and Inspection, 5) Non-routine operational considerations. Also, the system to protect not only against radiation but also ODH/flammable gas/fire/smoke inhalation hazards should be described in ASE. ASE is reviewed during the Accelerator Readiness Review (ARR) process, approved ASE must be permanently maintained. [8]

4. Categorization of accelerator facilities and Radiation Safety Report in Rep. of Korea [5]

As described above, there is no categorization for accelerator facilities in Rep. of Korea. All accelerator facilities are included as RI and RG facilities regardless of the magnitude of risks. There is only one general guidelines of the Radiation Safety Report regardless of the type of facilities. Because there is no separated format on large particle accelerator facilities, the contents of Radiation Safety Report are general and abstract. Due to the absence of separated guidelines and the possibility of arbitrary omit on item, there is a possibility of occurrence of confusion and confliction. It is necessary to provide the detailed contents related to safety envelope on large particle accelerator. From the comparison of safety related documents, several items derived to revise the contents of Radiation Safety Reports on large particle accelerator. The items are as follows.

- More detailed site description including environmental analyses
- More detailed design rules such as Calculation Codes & Nuclear Data Implemented for

Radiation Protection, Activation Calculation Principles
- Preliminary Decommissioning Plan (Expected waste, Estimated costs)
- Waste management with the consideration of activation
- Quality Assurance Program

5. Conclusions

If we set up the categorization of accelerator facilities, we can expect the effective and safe construction and operation of the large accelerator facilities on the licensing and operation process. Similarly to other counties' criteria, 50 MeV of particle energy could be used as energy band of large particle accelerator.

According to categorization, it is necessary to adopt graded licensing stages and separated safety documents. In case of large particle accelerators, it is appropriate to divide the licensing stages to construction and operation. Before construction of large particle accelerator, the following contents are considered and reviewed.

- environmental assessment according to construction and operation
- facility design to decrease the environment impact and activation
- review of calculation code for shielding and activation analysis
- preliminary decommissioning plan
- public court hearing

Currently, there is no official public hearing process on accelerator facilities. However, the involvement of stakeholder will be increasingly significant through the public hearing in preparation stages. Also, it is necessary to consider on the adoption of Preliminary Decommissioning Plan Report(PDPR). We currently submit PDPR in case of reactor and related facilities, nuclear fuel cycle, and nuclear material facilities. Depending on the energy of particle accelerators, it is necessary to prepare the decontamination and decommissioning for the decrease of current and future burden from radioactive waste. From the arrangement of separated guidelines on safety documents according to the categorization of accelerator facilities, the reduction of confusion and confliction during the licensing process are expected.

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