Analysis of Safety Classes Classification Criteria for I&C Systems on NPP

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1. Introduction

This paper investigates and reviews regulatory documents including laws and regulatory requirements of domestic and NRC related to the safety classes classification for I&C Systems on nuclear power plants, and presents the results of the analysis of the safety classes classification system of the domestic I&C systems.

2. Regulatory Standards for Safety Classes Classification

2.1 Domestic Regulatory Standards for Safety Classes Classification

Domestic laws and regulatory requirements related to the classification of safety classes of nuclear power plants are as follows.

- Article 2(Definition) of the Nuclear Safety Act :

The term “safety-related facilities” means the structures, systems, or components important to safety as set forth under the Regulation of the Nuclear Safety and Security Commission and to whom safety classes are assigned in accordance with the Regulation of the Nuclear Safety and Security Commission, among nuclear reactors and related facilities [1].

- Article 12 (Definition) of the Regulations on Technical Standards for Nuclear Reactor Facilities, Etc:

The term “safety facilities” means those facilities falling under any of the following, of which failure/damage may directly or indirectly impose a radiation hazard to the public: [2]

a. Facilities of the primary coolant system and safety-related instrumentation and control systems, other facilities necessary for safe operation of a nuclear reactor at normal operations, and the appurtenances thereof;
b. Emergency core cooling system, emergency shutdown system, and other facilities and their appurtenances necessary to ensure safety of a nuclear reactor at emergency conditions;
c. Nuclear reactor containment vessel; and
d. Emergency power supply system and its appurtenances.

The term “structures, systems, and components (SSCs) important to safety” means safety-related facilities among reactor facilities that are essential to safety in that they perform critical safety functions, and non-safety-related facilities whose failure may directly affect the performance of functions by safety-related facilities.

2.2 US NRC Regulatory Standards for Safety Classes Classification

Regulatory standards for safety class classification in the United States can be found in 10 CFR 21.3(1)(i), 10 CFR 50.2, 10 CFR 50.49(b)(1), and 10 CFR 100, App.A, VI(a)(1) and so on. These laws also define the meaning of "safety-related" without using the term "safety classes classification." According to this definition, "safety-related" SSCs refer to SSCs necessary to ensure the following matters during and after the Design Basis Event (DBE).

a. The integrity of the reactor coolant pressure boundary;
b. The capability to shut down the reactor and maintain it in a safe shutdown condition; or
c. The capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to those referred to in §§ 50.34(a)(1), 50.67(b)(2), or 100.11.

2.3 The Difference between Domestic Regulatory Standards and US NRC Regulatory Standards

The laws, regulatory requirements, and regulatory guidelines on the classification of domestic safety classes were prepared by referring to the NRC's regulatory documents and the US Technical Standards (ANSI), including the US Federal Regulatory Act (CFR), but are not exactly and clearly consistent.

Comparing the term “safety-related” in the US with the term “safety facilities” in Korea, the term “safety-related” in the US is more comprehensive. The definition of domestic safety facilities is very specific and does not deal with the mass release of radioactive substances into the surrounding environment. In addition, the definition of “structures, systems, and components important to safety” of domestic law is also omitted certain post-accident monitoring equipment compared to the 10 CFR 50.49 in the US.

3. Analysis of Safety Classes Classification Scheme

3.1 Safety Classes Classification from the Functional Perspective

The safety classes classification can be divided into safety-related and non-safety from the perspective of functions. The terms "important to safety" and

"augmented" are not about safety classes classification. For example, in case of 10 CFR 50.49, "Electric equipment import to safety" include 1) safety-related electric equipment, 2) non-safety-related electric equipment whose failure under postulated environmental conditions could prevent satisfactory accomplishment of safety functions, and 3) certain post-accident monitoring equipment. The augmented requirements is for the non-safety-related class, and applies to items that comply with the regulatory requirements imposed by the NRC or the licensing obligations presented by the licensee. The domestic classification method does not deal with augmented non-safety-related requirements. However, since the domestic regulatory system deals with Article 24 (Electric Power System) and Article 27 (Diversity Protection System) of the Regulations on Technical Standards for Nuclear Reactor Facilities, Etc. in preparation for loss of either onsite or offsite electric power systems and anticipated transients without scram, it can be considered that the non-safety class with augmented requirements and the corresponding design requirements are applied. Although nothing has been revealed superficially in regulatory documents, it can be seen that the enhanced requirements for non-safety-related classes and corresponding design requirements are being applied.

3.2 Safety Classes Classification from the Design Perspective

After classifying it into safety-related or non-safety-related functions from a functional perspective, determine how to implement it in each technical field from a design perspective: quality, machinery, electricity, earthquake resistance, or environmental verification. The primary purpose of classifying grades from a design perspective is to determine which design and quality requirements to apply when designing SSCs. In Korea, the safety classes classification from a design perspective can be found in Article 12 (Safety Classes and Standards) of the Regulations on Technical Standards for Nuclear Reactor Facilities, Etc., No. 2018-06 (Reactor.15) (Regulation on the Safety Classification and the Applicable Codes for Nuclear Reactor Facilities) of the Notices of the Nuclear Safety and Security Commission, KINS/RG-N03.03 (Equipment Qualification for Safety-related I&C and Electric System), KINS/RG-N08.01 (Safety Classes for I&C Systems), and KINS/RG-N09.07 (Independence for Safety-related Electric Systems) etc[3][4].

Article 12 (Safety Classes and Standards) of the Regulations on Technical Standards for Nuclear Reactor Facilities, Etc. stipulates that “Structures, systems, and components important to safety shall be designed, fabricated, installed, tested, and inspected in accordance with the importance of safety functions to be performed”.

The Notice of the Nuclear Safety and Security Commission No. 2018-06 was enacted referring to ANSI/ANS-51, and all equipment in a reactor facility are classified into safety class 1, 2, or 3, and non-nuclear safety. According to this reference standard, safety I&C and electrical equipment are classified as safety class 3.

The classification scheme of the I&C system in KINS Regulatory Guide KINS/RG-N08.01[5] is the classification from a design perspective. The safety classes of domestic I&C systems were classified into IC 1, IC 2, and IC 3. IC 1, IC 2, and IC 3 correspond to design basis events, special events, and systems for normal operation, respectively. This classification was adopted for application to domestic nuclear facilities in consideration of the complexity of digital equipment, the use of software, and difficulties in applying physical independence standards as digital equipment is installed in nuclear power plants. In the case of the United States, there is no classification for the I&C systems, but it is classified into Class 1E or Non-class 1E.

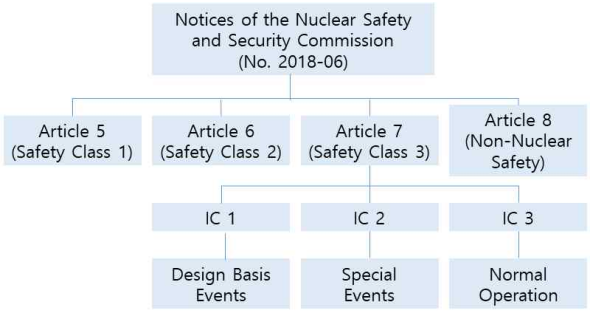

Fig 1. Domestic I&C System Safety Class Classification

3.3 Safety Classes Classification from the Procurement Perspective

From a purchase point of view, classes are classified into safety-related, commercial-grade, and non-safety-related. Safety-related items are purchased in accordance with the Regulations on Technical Standards for Nuclear Reactor Facilities, Etc, Section 4, Quality Assurance regarding Construction and are subject to Article 15-2 (Reporting of Contracts on Safety-related Facilities), Article 15-3(Reporting of Nonconformance) of Nuclear Safety Act, and No. 2018-02(Reactor.40) (Regulation on the Reporting of Noncompliance) of Notices of the Nuclear Safety and Security Commission.

Commercial-grade items are purchased in accordance with KINS/RG-N17.12 (Quality verification of commercial-grade items for alternative use of safety-related items). Commercial grade dedication is an acceptance process which shall be performed to provide reasonable assurance that a commercial-grade item, which is purchased to replace a specific safety-related facility.

This reflects the purpose of the US 10 CFR 21 Act. Non-safety-related purchases refer to purchases of items not used in safety-related fields.

4. Conclusions

This paper reviewed the regulatory positions on safety classes classification applied to nuclear power plants based on domestic laws, regulatory requirements, and regulatory guidelines in preparation for US laws and regulatory requirements. The review of the class classification methods were approached in the functional perspective, design perspective, and purchase perspective.

This paper is expected to be of help in understanding the safety classes classification systems for I&C systems in Korea and US.

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REFERENCES

[1] Nuclear Safety Act, Article 2 “Definition”
[2] Regulations on Technical Standards for Nuclear Reactor Facilities, Etc, Article 12 “Definition”
[3] Regulations on Technical Standards for Nuclear Reactor Facilities, Etc., Article 12 “Safety Classes and Standards”
[4] Notices of the Nuclear Safety and Security Commission, 2018-06 (Reactor.15) “Regulation on the Safety Classification and the Applicable Codes for Nuclear Reactor Facilities”
[5] KINS/RG-N08.01, “Safety Classes for I&C Systems”