A Study on Method of Safety Classification about Nuclear Facility

Won Joon Chang*, Young Gill Yune, Jeong Yoo, Seung-Ho Cho
Korea Institute of Nuclear Safety, 19 Gueseong, Yuseong, Daejeon, Korea, 305-338
**Corresponding author: rawing@kins.re.kr*

1. Introduction

As appears by recent accident of Fukusima, low safety classification of equipment (emergency diesel generator, spent fuel storage pool) have a major impact as the accident conditions. It's necessary to give a supplementary revision about definition of safety functions and safety classification in Korea. And conducting research on the safety classification is necessary to nuclear safety and public acceptance.

The need to classify equipment in a nuclear power plant according to its importance to safety has been recognized since the early days of reactor design and operation. The existing methods for safety classification of structures, systems and components (SSCs) have evolved in this light of lessons learnt during the design and operation of existing plants, mainly with light water reactors. Although the concept of a safety function as being what must be accomplished for safety has been understood for many years, and examples based on experience have been provided, the process by which safety functions can be derived from the general safety objectives has not been described. Therefore, it was mainly from experience and analysis of specific designs that classification systems identified those SSCs that were deemed to be of the highest importance in maintaining safe operation, such as the continuing integrity of the primary pressure boundary, and classified them at the highest level.[1]

The purpose of safety classification in a nuclear power plant is to identify and categorize the safety functions and to identify and classify the related SSC items on the basis of their safety significance. This will ensure that the appropriate engineering design rules are determined for each safety class, so that SSCs are designed, manufactured, constructed, installed, commissioned, quality assured, maintained, tested and inspected to standards appropriate to their safety significance. ASME (American Society of Mechanical Engineers) [2] requires designers to undertake a number of steps to perform safety classification and to justify the assignment of SSCs to safety classes.

2. Methods and Results

The definition of safety functions and the method of safety classification(IAEA safety requirements, NRC requirements and domestic requirements) are investigated and analyzed.

2.1 The definition of safety functions

In case of IAEA, definition of safety function is mentioned to requirement 4 of SSR-2/1 and in case of Korea, article 3 in notices of NSSS (Nuclear Safety and Security Commision) (2012-9) states safety function. IAEA's safety functions are defined by function, domestic and NRC definition are defined by the instrument. Presently, domestic definition of safety function is not sufficient to define the safety functions of spent fuel storage pool. So, safety function should be made clear at rule 2(definition) in order to distinct basis of using Regulation on Technical Standards for Nuclear Reactor Facilities, etc..

Table I: Definition of safety function

IAEA standard	Notice of NSSS
Fulfillment of the following fundamental safety functions for a nuclear power plant shall be ensured for all plant states: (i) control of reactivity, (ii) removal of heat from the reactor and from the fuel store and (iii) confinement of radioactive material, shielding against radiation and control of planned radioactive releases, as well as limitation of accidental radioactive releases.)	The term "safety function" means any function that is necessary to ensure: (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 plant conditions that could result in potential off-site exposures defined in the "Technical Standards for the Locations, Structures and Installations of Nuclear Reactor Facilities"

2.2 Comparison of definitions of terms

IAEA terms are based on the radioactive material and radiation protection. And NRC terms are based on reactor coolant system. So the other similar terms are used interchangeably. A typical example is safety related item. In IAEA, safety related item means an item important to safety that is not part of a safety system. In NRC safety related item means a system important to safety, provided to ensure the safe shutdown of the reactor or the residual heat removal from the core, or to limit the consequences of anticipated operational occurrences and design basis accidents.

2.3 Method of safety classification

IAEA and domestic safety classification method is as follows.

Table II: Method of safety classification

IAEA standard	Notice of NSSS
All items important to safety shall be identified and shall be classified on the basis of their function and their safety significance. 5.34. The method for classifying the safety significance of items important to safety shall be based primarily on deterministic methods complemented, where appropriate, by probabilistic	Article 4 (General Requirements) General requirements for Safety Class shall be as follows: 1. Safety Class 1, 2, 3 or NNS shall be assigned to all the equipment of nuclear reactor facilities in accordance with this Notice; 2. Where more than one system is capable of accomplishing a nuclear safety function and one of

methods, with due account taken of factors such as: (a) The safety function(s) to be performed by the item; (b) The consequences of failure to perform a safety function; (c) The frequency with which the item will be called upon to perform a safety function; (d) The time following a postulated initiating event at which, or the period for which, the item will be called upon to perform a safety function. 5.35. The design shall be such as to ensure that any interference between items important to safety will be prevented, and in particular that any failure of items important to safety in a system in a lower safety class will not propagate to a system in a higher safety class. 5.36. Equipment that performs multiple functions shall be classified in a safety class that is consistent with the most important function performed by the equipment.	the systems, on its own, satisfies all the nuclear safety-related requirements (e.g. redundancy, diversity, and capacity), the designer may classify the latter to the corresponding Safety Class and the others as NNS; 3. The designer may impose more stringent design requirements than those imposed upon one facility corresponding to the applicable class. If this option is chosen, the designer shall retain the original class designation; 4. The designer may optionally provide two or more pieces of equipment to separately meet multiple environmental qualification requirements of SC-2 or SC-3 equipment for events, where one equipment need not meet such separated qualification requirements simultaneously; 5. In case the function of an equipment is degraded due to failure of the support, the support shall be classified to a class corresponding to the function of the equipment, and in case the failed support does not affect the function of the equipment, the support shall be classified to a class corresponding to its own function; 6. The interface boundary connected to the equipments which have different Safety Class shall be assigned to the more stringent Safety Class corresponding to functions of the connected equipment. In case, however, the result of analyses of interface boundary interaction confirms its appropriateness, the interface boundary may be assigned to the lower Safety Class; 7. If the failure of Safety Class or NNS equipment connected to other Safety Class equipment could prevent the latter equipment from accomplishing its nuclear safety function, an interface barrier or isolation device shall be provided to protect the latter equipment; and 8. Where a single item of equipment, or a portion thereof, provides two or more functions of different classes, it shall be classified to the more stringent class.

IAEA method of safety classification is mentioned at SSR-2/1. Domestic method is reflected in ‘regulation on technical standards, for Nuclear Reactor Facilities, Etc. rule 3’, ‘notice of NSSS 2012-9’, ‘KINS regulatory standards 3.2’. Classification using probabilistic method should be discussed something in depth because domestic regulatory framework is based on deterministic method.

3. Conclusions

In the case of IAEA, probabilistic method is applied to the safety classification based on deterministic methods. In the case of NRC, probabilistic methods are additionally be applied. If deterministic safety classification is perfect, the IAEA's approach seems ideal. But, if equipment that does not perform safety function receive class 2 of safety classification through risk assessment, it is necessary to supplement requirement about missed equipment. In the case of domestic, nonsafety-related and safety-significant equipment should be managed under special management.

Comparison results of safety classification between domestic standard and IAEA standard will feed into future domestic standard for safety classification. Development of the domestic requirements should be performed considering IAEA and international requirements. If domestic safety requirement reflect the definition of safety function on IAEA, notice of NSSS should be corrected. Development of the domestic requirements should be performed considering IAEA and international requirements.

REFERENCES

[1] DS 367 Safety Classification of Structures, Systems and Components in NPPs, IAEA.

[2] AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Boiler and Pressure Vessel Code, Section III: Rules of the Construction of Nuclear Facility Components, ASME, Fairfield NJ (2010).

[3] Regulation on Technical Standards for Nuclear Reactor Facilities, Etc.

[4] Notice of Nuclear Safety and Security Commission, 2012-09

[5] KINS regulatory standards chapter 3