Safety Classification of I&C Important to Safety Systems for APR1000

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1. Introduction

IEC 61226 and IEC 61513 classify instrumentation and control (I&C) functions according to their importance to the safety of nuclear power plants and the severity of the consequences resulting from their failure. The classification includes safety categories (A, B, and C) and safety classes (1, 2, and 3).

However, an I&C system generally comprises both safety functions and service functions, such as testing and monitoring functions, that are not directly assigned to safety functions.

For a complete and reliable I&C system design, these functions should also be appropriately classified into the relevant safety classes and functional categories in accordance with other applicable IEC standards.

This paper proposes a methodology for performing such classification to achieve a more practical, systematic, and comprehensive I&C system design.

2. Safety Classification for I&C

This section introduces IAEA, IEC approach for safety classification for structure, system and components in nuclear power plant.

2.1 IAEA approach to safety classification

IAEA SSR-2/1 specifies the following main safety classification criteria; Requirement 22: Safety classification. 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 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 [1].

IAEA SSG-30 provides guidelines for performing safety classification(SC) of SSR-2/1 SSCs[2]. Classified into SC-1, SC-2, and SC-3 according to the criteria in Section 5.34 of SSR-2/1;

Safety Class 1: SSC failure leads to "High severity",
Safety Class 2: SSC failure leads to "Medium severity",
Safety Class 3: SSC failure leads to "Low severity".

IAEA TECDOC-1787 provides implementation methods for each step of SSG-30 classification. IAEA, IEC categories and classes fit together as follows[3]:

IAEA Category 1 (safety class 1)	→	IEC Category A (safety class 1)
IAEA Category 2 (safety class 2)	→	IEC Category B (safety class 2)
IAEA Category 3 (safety class 3)	→	IEC Category C (safety class 3)

2.2 IEC approach to safety classification

IEC 61226, goes further than SSG-30 and provides categories that should be assigned to function important to safety illustrated as Fig 1[4]. It specifies the correlation between classes of I&C systems and categories I&C functions which is illustrated as Fig 2[4].

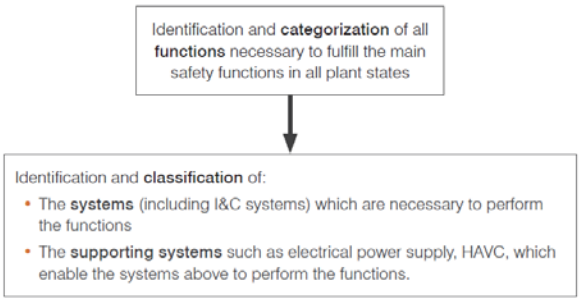


Fig. 1. Overall classification scheme of SSCs

Categories of I&C functions important to safety			Corresponding classes of I&C systems important to safety
A	(B)	(C)	1
	B	(C)	2
		C	3

Fig. 2. Correlation between classes of I&C systems and categories of I&C functions

According to IEC 61513, I&C system requirements should include the individual application function and the system service function. Application function is a function of an I&C system that performs a task related to the process being controlled rather than to the functioning of the system itself. The service functions, unlike the applications, are not directly related to the performance of process-related functions, but relate to specific activities on the system, including the functions

necessary for the configuration, validation, qualification, installation, commissioning, operation, periodic testing, maintenance, incorporation of design modification and security.

3. Function Categorization and Challenges for I&C

Classification of the I&C Important to Safety Systems is possible in accordance with SSG-30, TECDOC-1787 standards, presented in Table I. Table I shows the IAEA function categorization and the allocated I&C Important to Safety Systems in the sequence of event of small break loss of coolant accident (LOCA) taking account of (b), (d) in section 5.34 of SSR-2/1; however, monitoring and test to support the safety functions, generally included within the I&C safety systems, are not considered in this process.

Table I: Identification Function and I&C systems in the event of small break LOCA

	Safety Function	**IAEA Category (IEC Category)**	**APR1000 I&C system**
1	Reactor Trip	Cat. 1 (Cat. A)	PPS VBPSSS, HVAC
2	Turbine Trip	Cat. 2 (Cat. B)	PCS, TCS VBPSSS, HVAC
3	High Pressure Safety injection to RCS	Cat. 1 (Cat. A)	ESF-CCS (SIAS) VBPSSS, HVAC
4	Confine Containment	Cat. 1 (Cat. A)	ESF-CCS (CIAS) VBPSSS, HVAC
Reached *Controlled State*			
5	Residual Heat Removal (Manual)	Cat. 2 (Cat. B)	ESF-CCS ESCM QIAS VBPSSS, HVAC
Reached and maintained the *Safe state*			

I&C safety systems support not only their assigned safety functions but also operation and maintenance activities, which is none classified in SSG-30. The classification of these functions could be determined in accordance with applicable standards, including IEC 61226, IEC 61513, IEC 60709, and IEC 60671 or more.

For example, I&C safety system which has Category A function is subject to periodic testing in accordance with IEC 60671. Such a periodic test function may be classified as Category B or Category C in accordance with IEC 61226 and the allocated component (e.g., Maintenance and Test Panel) which serves its function would classified as associated circuit, according to IEC 60709. Therefore, The safety system which performs Category A, B, and C functions is classified as Safety Class 1, within the rules specified in Fig 2.

For the test-request function, it is assumed that the protection function performs independently of the MTP and that erroneous requests cannot impair the required protection function. Loss of the test-request function prevents test initiation but does not directly prevent protective action. Accordingly, Category B or Category C may be assigned, provided that the consequences of delayed fault detection are evaluated and the criteria for Category A are confirmed not to apply. Where this function is implemented within the Safety Class 1, the applicable Safety Class 1 requirements remain in force.

4. Conclusions

The approach for safety classification of I&C systems has been following the release of IAEA standard series[8], yet, these standards only fulfills the main safety function (i.e., “application function”) and mostly are corresponds to IEC category[3]. However, the other functions , which is called “service functions”[5], to be categorized in additionally needs comprehensive understanding with the relevant IEC standards.

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