Introduction to South Africa's Safety Classification

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1. Introduction

The safety functions of nuclear reactor facilities such as research reactors have to be maintained for all initiating events, incidents and accidents. From the position of licensee, it is a very important issue and design challenge to meet the licensing requirements for the final goal of proper safety functions from nuclear regulator. This paper intends to introduce and understand South Africa's licensing requirements and processing for safety classification of SSCs. South Africa's licensing requirements are shown in Table 1. Three categories A, B and C are categorized based on the occurrence frequency and the dose limitation of worker and public exposure. The Defense-in-Depth (DiD) and ALARA principle are forced to apply to a nuclear reactor facility design. Also, South Africa's safety and quality class compare with that of ANSI 51.1.

Table 1 South Africa's licensing requirements

	Requirements
Category A	Occurrence Frequency $\geq 10^{-2}$ per year 20 m Sv per year to worker 250 μ Sv per year to public Application of the ALARA and DiD
Category B	10^{-2} per year > Occurrence Frequency ≥ 10^{-6} per year 50 m Sv per event to worker 50 m Sv for total accumulated does per event to public Application of the ALARA and DiD
Category C	10^{-6} per year > Occurrence Frequency 5 x 10^{-5} y^{-1} fatalities and 10^{-5} y^{-1} average fatalities to worker 5 x 10^{-6} y^{-1} peak fatalities and 10^{-8} y^{-1} average fatalities to public Application of the ALARA principle

2. Safety Functions and Classification

For the identification of safety functions, three types of safety functions are categorized MSF, PSF and SSF. This is a hierarchical structures and liked from SSF (low rank) to MSF (high rank) in terms of functionality. The Main Safety Functions (MSFs) of facilities are shielding, radioactive material confinement ensuring the protection of workers, the public, and the environment, criticality control, heat removal, and reactivity control. Plant Safety Functions (PSFs) are the output from a functional analysis performed on plant states. Plant states are defined operational state/condition (NO(DiD Level 1)), AOO(DiD Level 2)) and accident state/condition (DBA(DiD Level 3), BDBA(DiD Level 4), and BDBA(DiD Level 5)). PSFs are defined in terms of the functionality required by the respective plant to either prevent or mitigate a PIE/IE and its activity status during the various plant states. The PSF is linked to the relevant MSF that it supports. SSC Safety Functions (SSFs) are the output from a functional analysis performed at the SSC level. SSFs are defined in terms of the functionality required by the respective SSC to either prevent or mitigate a PIE/IE. Defining SSFs also assists in determining the DiD level for each SSF. The SSF is linked to the relevant PSF that it supports.

3. SSCs' Safety Classification Approach

The SSCs' safety classification is implemented as shown in Figures 1 & 2. The processing of the safety classification consists of main three steps. The first step is determination of the hazard level of facility. The second step is the safety assessment. The final step is a functional categorization and safety classification. Figure 1 depicts the relationship between HL and the safety classification of SSCs. A product with nuclear safety implication is nuclear fuel and SSCs involved in the reactor facility are considered as nuclear hazards.

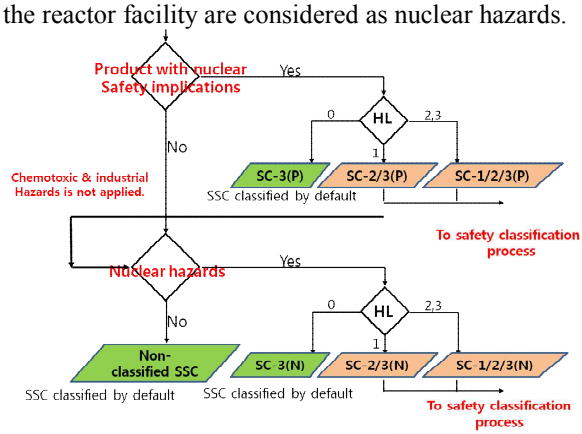

Figure 1 Determination of hazard level

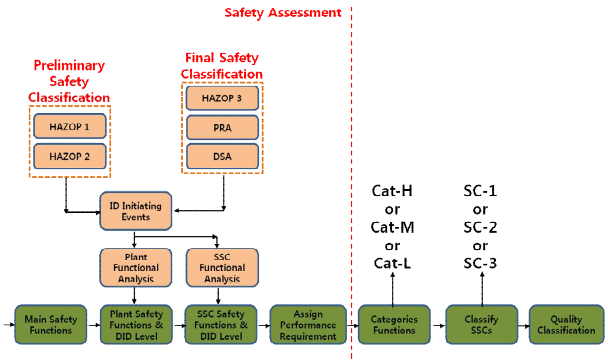

Figure 2 Safety classification process

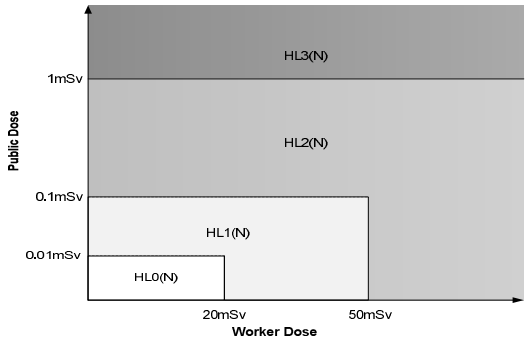

Figure 3 Hazard level

The safety classification of SSCs depends on the HL of the specific facility or the section of a facility. Hazard level is defined based on worker and public dose limitation as shown in Figure 3 and preliminarily identified through conservative methods, engineering experiences and a qualitative evaluation. If the SSCs are more than hazard level 1, the SSCs are potentially categorized into three classifications SC-1/2 or SC-3. In case of hazard level 0, it is determined whether some SSCs are non-classified SSCs through an ALARA review. After the determination of the hazard level, the classification processing of SSCs is linked to the safety assessment step as shown in Figure 2. The safety assessment is integrated into a safety concept evaluation such as DiD, safety margin, multiple barrier and engineering practices, as well as a safety analysis such as graded hazard analysis, deterministic/probability safety analysis. A preliminary SSC safety classification is performed at the beginning of the basic engineering phase. The input data to be used may be of a qualitative nature (typically HAZOP 1 & 2 reports). The purpose of a preliminary safety classification is to ensure that the correct resources are assigned to SSCs design, to ensure the focus is directed where required and to guide the procurement effort of long lead items. A final SSC safety classification is performed at the end of the basic engineering phase (post HAZOP 3). The input data to be used is of a quantitative nature as provided by the deterministic-, probabilistic risk assessments and the HAZOP 3. The determined SSC safety classification is assessed in aspect to the performance requirements such as parameters, criteria, tolerances, design codes & standards, design & safety & operating limits, fail safe state. Three levels of safety functional categorizations are defined for SSFs i.e. Cat-H(high significance with regards to safety), Cat-M(moderate significance) and Cat-L(low significance). Cat-L is considered in the ALARA review of a facility. This functional categorization which determined by safety assessment is plotted in the Figure 4. There is a direct relationship between the level of safety categorization of SSFs and the safety classification of SSCs as shown in Figure 5. In cases where only one SSC provides certain functionality, there is a one-to-one relationship as depicted by the principal line. In cases where two or more SSCs, it is as depicted by the contribute line.

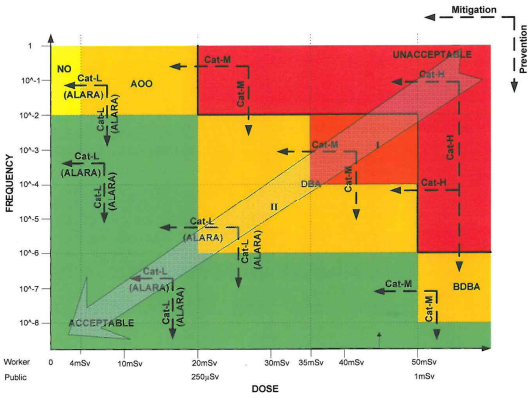

Figure 4 Nuclear Safety Criteria

The safety classification of the SSCs is possible to be downgraded only one level. Functions categorized as Cat-L are assigned a SSC classification of lower than SC-3.

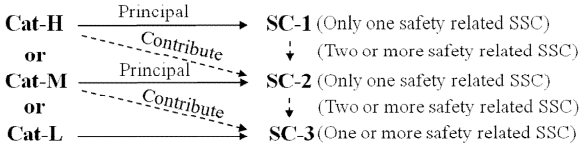

Figure 5 Determination of safety classification

4. Summary

In South Africa, there are two main safety classification methods: the preliminary safety classification is based on the qualitative outputs from the HAZOP 1 and 2 in the beginning of basic design. The final safety classification is based on the qualitative and quantitative outputs from the HAZOP 3, DSA and PRA in the end of basic design phase. Hazard level and PIE/IE are identified by two methods. The SSC's functional categorization is plotted in nuclear safety criteria (Figure 4) and the assessment processing is iterated to be mitigated and prevented. Table 2 is comparison of ANSI 51.1 and South Africa's safety and quality class.

Table 2 Comparison ANSI 51.1 and South Africa's safety and quality class

ANSI 51.1	JRTR Quality Class	S. Africa Safety Class	S. Africa Quality Class
SC-1	Q(NQA-1)	Not Applied	Not Applied
SC-2	Q(NQA-1)	Not Applied	Not Applied
SC-3	Q(NQA-1)	Safety class 1	Level 1
NNS	T(selected requirement)	Safety class 2	Level 2
NNS	S(Commercial)	Safety class 3	Level 3

Acknowledgements

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