Proposal of an ISO Standard: Classification of Transients and Accidents for Pressurized Water Reactors

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1. Introduction

Classification of the events for a nuclear power plant is a fundamental basis for defining nuclear safety functions, safety systems performing those functions, and specific acceptance criteria for safety analyses. Presently, the approaches for the event classification adopted by the nuclear suppliers are different, which makes a nuclear technology trade barrier. The IAEA and WENRA are making efforts to establish general requirements or guidelines on the classification of either plant states or defence-in-depth levels for the design of nuclear power plants. However, the requirements and guidelines do not provide the details for practical application to various types of commercial PWRs.

Therefore, further efforts should be made to develop specific requirements or guidelines of the event classification and related acceptance criteria that can be applied to the PWRs, considering the related requirements of the IAEA and other international organizations. The commercial reactor type having the highest world nuclear market share is the pressurized water reactor (PWR) currently. It is expected that the situation will not change for a long time until any type of the next generation (GEN IV) reactors can be commercialized and deployed widely. Thus, development of a harmonized international standard of the PWR event classification and acceptance criteria for reactor design is needed to promote and foster the global nuclear trade. There is no existing works including existing ISO or IEC deliverables to be affected by this proposed work.

Recently, Korea proposed a new ISO standardisation project to develop a harmonized or consolidated international standard for classifying the events in PWRs and for defining (or imposing) the acceptance criteria for reactor design and/or radiation protection corresponding to each event class [1]. This paper briefs the method with strategies for developing the standard, the current various practices of the PWR event classification and acceptance criteria developed or adopted by several organizations in USA and Europe, and a draft of the proposed standard.

2. Approach and Strategies [1]

The approach and strategies to develop a harmonized international standard of the PWR event classification and acceptance criteria are as follows:

(1) Survey of the practices of current PWR event classification and acceptance criteria in the nuclear supplying countries and the international organizations such as U.S.A., European Countries (Finland, England, Germany, France, etc.), Korea, Canada, Japan, and the International Organizations (IAEA, EUR, WENRA)
(2) Identification and assessment of typical anticipated operational occurrences and postulated events (design basis or extension accidents) that should be considered for the design of the conventional or evolutionary GEN III PWRs
(3) Classification of the events in terms of the expected frequency of initiating event occurrence and the radiological consequence (or dose limit)
(4) Establishment of the acceptance criteria for each event class in terms of the radiological consequence (or dose limit)
- Identification quantification of health objectives (QHO)
- Survey of national and international regulatory practice, e.g., NRC regulations in 10 CFR 20 and 10 CFR 50, EPA (Environmental Protection Agency) protective action guidelines, IAEA guidelines and International Commission of Radiation Protection (ICRP) recommendations
- Propose F-C curve based on health physics
- Establishment of the acceptance criteria for each class

(5) Preparation of a working draft of the international standard of the event classification and acceptance criteria for PWRs, which can be globally used
(6) Completion of the working draft based on the review comments from experts from the P-member countries
(7) Proposal of a committee draft of the ISO Standard of Event Classification for PWRs

3. Current Practices in Classification and Acceptance Criteria [1-3]

3.1 US Practice

The current practices in the PWR event classification and acceptance criteria developed or adopted by the American Society of Mechanical Engineers (ASME), American Nuclear Society (ANS), and the United States Nuclear Regulatory Commission (USNRC) are summarized in Table 1.

Table 1. US practices

Event/Rx-Yr	ASME	NRC	ANS		NRC	NRC
	(RG 1.48)	RG 1.70 (1978)	N18.2 (1973)	51.1 (1983)	10CFR50 RG 1.206 (2007)	DBE for TNF* NUREG-1860 (2007)
Planned Operations	Service Level A (Normal)	Normal	Condition I	PC-1	Normal	Normal
$1x10^{-1}$	Service Level B (Upset)	Moderate Frequency	Condition II	PC-2	Anticipated Operational Occurrences	Frequent
		Infrequent Incidents	Condition III	PC-3		
$1x10^{-2}$	Service Level C (Emergency)			PC-4	Accidents	Infrequent
$1x10^{-3}$						
$1x10^{-4}$		Limiting Faults	Condition IV			
$1x10^{-5}$	Service Level D (Faulted)			PC-5		Rare
$1x10^{-6}$				Not Consd.		

* TNF: Technology Neutral Framework

3.2 Practices of IAEA, Europe

The practices in the PWR event classification and acceptance criteria developed or adopted by the International Atomic Energy Agency (IAEA) or the European Union (EU) are summarized in Table 2.

Table 2. IAEA and Europe practices

Event/ Rx-Yr	IAEA INSAG-10 (1996)			WENRA('09 proposed for new reactor)		EUR (2001)		
	DiD	Plant Status		DiD	Plant Status			
Planned Operation	1	Normal Operation		1	Normal Operation	Design Basis Condition	Normal Operation(DBC1)	
	2	AOO		2	AOO		Incidents (DBC2)	
	3	DBA(single events)		3	Postulated single initiating events		Accident	Low Frequency (DBC3)
								Very Low Frequency (DBC4)
	4	Beyond DBA	Insignificant Fuel Damage		Selected Multiple Failure Events	Design Extension Condition (DEC)	Complex Sequence	
			Severe Accident	4	Postulated Core Melt Accident		Severe Accident	

4. Draft of the Proposed ISO Standard

A draft of the proposed ISO standard for the PWR event classification and acceptance criteria is summarized in Table 3.

Table 3. A draft of the proposed ISO standard

Event/Rx-Yr	Event classification		Physical barriers			Dose Limit* EAB, LPZ (Whole Body)
			Nuclear Fuel	RCS Pressure Boundaries	Containment	
$f \geq 1$	Normal Operation		No Failure	ASME Sec. III Service Level A	No failure	$x \leq \alpha$ [mSv/Yr]
$1 > f \geq 10^{-2}$	Anticipated Operational Occurrence (AOO)			Service Level B		$\alpha < x \leq \beta$ [mSv/Event]
$10^{-2} > f \geq 10^{-4}$	Design Basis Accident (DBA)	Class 1 DBA	Allowable Small Failure	Service Level C		$\beta < x \leq \gamma$ [mSv/Event]
$10^{-4} > f \geq 10^{-6}$		Class 2 DBA	Coolable Geometry (Limited damage with maintaining the shape for core cooling)	Service Level D		$\gamma < x \leq \delta$ [mSv/Event]
$10^{-6} > f$	Design Extension Accident (DEA)		Coolable Geometry (Maintenance of one or more physical barriers)			$\gamma < x \leq \delta$ [mSv/Event]
NA	Severe Accident		Safety Goal of Core Damage Frequency (CDF)	Safety Ggoal of Large Early Release Frequency (LERF)		NA

*A sample proposal: $\alpha = \beta = 1$, $\gamma = 25$, $\delta = 250$

5. Conclusions

This paper outlined the Korea's proposal for the development of an internationally harmonized standard for classifying the PWR events. The proposal was submitted as a New Work Item Proposal (NWIP), which was followed by the presentation at the 2015 ISO Technical Committee (TC) 85/ Sub-Committee (SC) 6 meeting. In January 2016, the ISO New Project (NP) ballot of the proposal was approved and the project was registered under ISO TC 85/SC6/working group (WG) 3 with the project number ISO/AWI 21146.

The proposed standard will affect all the relevant stakeholders such as reactor designers, vendors, suppliers, utilities, regulatory bodies, and publics of the leading countries in the area of nuclear industry as well as utilities, regulatory bodies, and publics of the newly entering (starting) countries. It is expected that all of the stakeholders will benefit from the proposed deliverable which provides an internationally harmonized standard for classifying the PWR events as follows:

- The reactor design bases for assuring safety and related technical information can be effectively communicated and shared among them resulting in enhancement of the global nuclear safety and fosterage of the global nuclear trade.
- The countries starting nuclear program can be provided with key technical bases for establishing the nuclear infrastructure efficiently.

REFERENCES

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