Priorities for Addressing Severe Accident and L3PSA in Radiation Environmental Report

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1. Introduction

Radiation environmental report (RER) is one of main documents to be obtain the construction permit(CP), operating license(OL) and license renewal for nuclear power plants(NPPs).

Domestic rules[16] for the radiation environment impact assessment were enacted based on NUREG-0555[1], the guidance to the nuclear regulatory commission staff in implementing provisions of 10 CFR 51, "environmental protection regulations for domestic licensing and related regulatory functions", related to NPPs.

A revised document of NUREG-0555 was published in 2000 as NUREG-1555[2], Vol. 1 & 2. The related domestic rules[16,17] would have made some revisions in accordance with NUREG-1555 in 2016.

In this paper, we would introduce the new technical standards and review legal and technical issues on legislation.

2. Review on Priorities

2.1 NUREG-0555 verse NUREG-1555

NUREG-1555, "Environmental Standard Review Plan: Standard Review Plans for Environmental Reviews for Nuclear Power Plants", reflects new regulatory requirements and the NRC's experience with applications [2].

Table 1 shows the comparison results of NUREG-0555 and NUREG-1555.

2.2 Legal and Technical Issues

(1) Using AST

The proposed uses of AST(alternative source terms) should be evaluated to determine whether the proposed changes are consistent with the principle that sufficient safety margins and adequate defense in depth are maintained[8]. The proposed used of AST would also create the two integrity analyses of facility design basis, based on the previous source term and based on an AST, and the radiological acceptance criteria would also be different[8,9,14].

In Korea, accident source terms were evaluated based on both the previous source term and an AST in Shinkori units 3 & 4 NPPs [18].

(2) Considering Severe Accidents

The main legal issue of several changes is the consideration of severe accidents.

NSSC(Nuclear Safety and Security Commission) of Korea is going to legislate the accident management plan and to revise the related laws, guidelines and etc.[16,17] in this year.

NUREG-1537[6] identifies nine postulated accident categories which must be evaluated to determine the potential environmental impacts.

- Maximum Hypothetical Accident(MHA)
- Insertion of excess reactivity(ramp, step, startup, etc.)
- Loss of primary coolant
- Loss of primary coolant flow
- Mishandling or malfunction of fuel
- Experiment malfunction
- Loss of normal electrical power
- External events
- Mishandling or malfunction of equipment

Table 1. Comparison of NUREG-0555 & NUREG-1555

		NUREG-0555	NUREG-1555
Companion Guidelines		RG 4.2[3]	RG 4.2[3] RG 4.7[7]
DBAs[1)]	Source Terms	NUREG-0555 App. A[1]	Alternative Source Terms(AST) NUREG-1465[5] RG 1.183[8]
	Atmospheric Dispersion (χ/Q)	50th percentile normalized concentration	50th percentile normalized concentration
	Dose Criteria	10CFR20.1301[4] TEDE[2)] : 1 mSv in a year for public	10CFR50.34[13] TEDE : 250 mSv in the exclusion area for any 2 hour period
Severe Accidents		Not included	Included

1) Design Basis Accidents
2) TEDE : total effective dose equivalent to individuals

Radiation environmental impact assessment report (RER) is the document that requires public hearings. Therefore, it would take a lot of time to be converged the public and environmentalists's opinions and to meet the interests of residents. The public has seen the impacts of radiation accidents such as Fukushima accident and has concerned that there is an accident could happen in nearby nuclear power plant. Therefore it would be more difficult to understand them for severe accidents.

What are people's concerns? Most concerns in environmental impact assessment of William States LEE III 1 & 2 in South Carolina are as follows [10].

- Impact on water or air availability
- Jobs
- Other energy alternatives

According to the recent abroad environmental impact statement for the combined license for Enrico Fermi Unit 2, Chapter 5.11(environmental impacts of postulated accidents) consists of 4 paragraphs, design-basis accidents, severe accidents, severe accident mitigation alternatives, and summary[11]. Severe accidents paragraph includes the air/surface water/groundwater pathways and the severe accident impacts.

Severe accident assessment usually utilizes the probabilistic methodology, that is, probabilistic safety assessment(PSA). PSAs for NPP is known as "once-through" processes, progressing from a core damage(Level 1) analysis to an accident progression and source term analysis(Level 2) and then to an offsite consequences analysis(Level3)[9]. In level 1 and level 2 PSA (L1PSA, L2PSA), it is important whether the causes of potential accident scenarios clearly identified and their probabilities are validly entered or not.

When RER deals with severe accidents, the interest of public and environmentalists is offsite dose, the result of level 3 PSA(L3PSA). L3PSA was not practiced officially in Korea because no strict regulatory requirements exist. Many countries also have similar circumstances [12].

There are many potential PSA technology challenges affecting L3PSA results. Table 2 shows the potential L3PSA technology challenges [9].

The most important challenge in RER is how to treat multi-unit/source and multi-site interactions. In Korea, there are a number of units in same site and site is adjacent to the residence. The impact analysis result, treated multi-unit/source and multi-site interactions and that the assessment uncertainty is complemented by the conservative assumptions of input data, should meet the criteria. Although it meet the criteria, it is not easy to persuade the public who think that someday accidents are happen and it will cause damage and who have no the probabilistic concept.

It needs the development of strategy and roadmap to evaluate the risk of multi-unit accidents and failure case and the impacts of inter-unit shared systems and common events. However, it is the most urgent task to develop how to understand the public for severe accident and probabilistic concept. It may need a regular and continuing education for the severe accident concept, probabilistic assessment method and conservative assumptions for severe accident, how to interpret the assessment results, the probability of an severe accident, severe accident mitigation alternatives (SAMAs) and etc..

Table 2. Potential L3PSA technology challenges[9]

Topic/Area	Challenges
Level 1/2/3 PSA	- Extending the PSA scope to address : a) multiple units and sites, b) post-accident shutdown risk, and c) on- and off-site emergency response organizations - Treatment of the feedback from offsite consequences to plant decision making - Improving realism of accident progression modeling - Addressing long-duration scenarios - Characterizing uncertainty in phenomenological codes
High Level Waste	- Treatment of competing resource demands associated with multi-source scenarios
Low Level Waste	- Treatment of wastewater concerns on operator actions - Treatment of aqueous transport of wastewater and consequences(public safety, environmental, and economic)
Metrics	- Development of appropriate risk metrics for multi-unit/source and multi-site scenarios
Risk Perception & Communication	- Treatment of the psychological impact on operators, experts, and decision makers - Treatment of anticipated non-radiation related fatalities and health effects in evacuation decision making
PSA Tools	- Ability of PSA codes to solve detailed, multi-source models in reasonable timeframes
Uncertainty & Sensitivity Analysis	- Consistent characterization of model uncertainties associated with phenomenological code predictions (severe progression, earthquake/tsunami prediction, atmospheric transport)
Multiple Unit & Sites	- Treatment of multi-unit and multi-source interactions - Treatment of multi-site interactions - Development of appropriate risk metrics for multi-unit/source and multi-site scenarios
Emergency Preparedness and Response	- Treatment of non-radiation related fatalities and health effects, and impact of anticipated effects in evacuation decision making - Probabilistic treatment of failures in on-site/offsite emergency response

When the environmental report deals with severe accidents, SAMAs should be addressed and also performed cost-beneficial analysis for SAMAs.

SAMAs cost-beneficial analysis constitutes a systematic and comprehensive process for identifying potential plant improvements, evaluating the implementation costs and risk reduction for each SAMA, and determining which SAMAs may be cost beneficial to be implemented [15]. Cost estimates include costs associated with following items [15].

- Engineering support including study, design, and project management
- Contract engineering support including field engineers and planners
- Materials and equipment
- Plant craft labor
- her support including quality control(QC), training, and operations department
- her contract support including security, health physics, and radwaste processing and storage

3. Conclusions

There are three legal and technical issues on revised legislation that includes severe accidents and L3PSA results in RER.

First, it may need a regular and continuing education for the severe accident concept, probabilistic assessment method and conservative assumptions for severe accident, how to interpret the assessment results, the probability of a severe accident, SAMA and etc. to obtain the public understanding for severe accident.

Second, it needs the development of strategy and technology not only to evaluate the risk of multi-unit accidents and failure case and the impacts of inter-unit shared systems and common events for the probabilistic assessment of severe accidents but also to solve many potential L3PSA challenges.

Finally, the cost-beneficial SAMAs analysis would be added in radiation environmental impact and severe accident impact analysis.

It is reasonable to include the severe accident and L3PSA analysis results in RER in the public health and environmental aspects. However, the appropriate public education and the related technology development must be considered as a priority. Otherwise the contents of severe accidents and L3PSA in RER will be a cause of constant disputes between operators and residents or environmentalists.

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