Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 26-28, 2012

Development of Web-Based Offsite Consequence Analysis Program and Periodic Risk Assessments for ILRT Extension

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1. Introduction

PSA is generally used to assess the relative risks posed by various types of operations and facilities, to understand the relative importance of the risk contributors, and to obtain insights on potential safety improvements. There is usually no pass-fail criterion that must be met to allow operations to continue. A major goal of PSA is to gain insights that can be used to either minimize the probability of accidents or to minimize the consequences of accidents that might occur. According to NUREG-1493[1] which applies the PSA concept to an ILRT interval extension, an ILRT interval was extended from three in ten years to one in ten years in almost all US nuclear power plants. In addition, NUREG-1493 stated that there is an imperceptible increase in risk associated with ILRT intervals up to twenty years. Since then, many licensees began to submit requests for one-time ILRT interval extensions of 15 years. To permit permanent 15-year ILRT intervals under the existing NRC guidance, it was necessary to develop a standard method for supporting the risk impact assessment. Thus, NEI[2] performed a project to develop a generic methodology for the risk impact assessment for ILRT interval extensions to 15 years using current performance data and risk informed guidance. The risk impact assessment is generally performed by MACCS II code, which was included in an international collaborative effort to compare predictions obtained from seven consequence codes: ARANO (Finland), CONDOR (UK), COSYMA (EU), LENA (Sweden), MACCS (United States), MECA2 (Spain), and OSCAAR (Japan). However, it costs lots of man-power and efforts on using the MACCS II code, especially on collecting raw data for input files and on converting the raw data format. Accordingly, the web-based OSCAP[3] based on MACCS II code was developed to focus on automatic processing algorithm for handling the main input files with meteorological data, population distribution data and source term data. It is considered that the web-based OSCAP could make man-powers required for the risk impact assessment considerably reduced, and could provide an advantage of analyzing CCDF (Complementary Cumulative Distribute Function), Early Fatality (EF), Latent Cancer Fatality (LF), average individual risk, etc. for Level 3 PSA. In addition, the web-based OSCAP was designed to have a function of “Documentation Assistance” according to the methodologies of NUREG-1493 and NEI Interim Guidance.

2. Web-Based Offsite Consequence Analysis Program on MACCSII Code

The web-based OSCAP was designed based on the MACCS II, which is generally used as a tool for an offsite consequence analysis. The MACCS II code uses Gaussian plume model as a basic atmospheric dispersion model, and provides a function of evaluating probabilistic population dose, which is required for extending ILRT intervals. For an atmospheric dispersion model, there are two representative models: one is Gaussian plume model proper to simple geographical features, and the other is Cal-Puff model appropriate for complex geographical features. The web-based OSCAP was designed to have an automatic processing module which converts the format of the raw data as below to the input data format of the MACCS II code.

- Core inventory data of the nuclides significantly affecting an off-site consequence analysis
- The number of plume, core inventory (long-term fuel), plume heat capacity, duration time, emergency response time, release fraction of the nuclide groups contained in each plume
- Hourly site specific data such as wind speed, atmospheric stability, rainfalls, etc.
- Population distribution data within 80 km from a site, which are generated on the basis of 16 compass directions
- Data related to economic cost estimation such as emergency response cost data, regional characteristics data, agricultural characteristic data, etc.

The web-based OSCAP is composed of three primary modules, which are consequence and risk analysis (CRA) module, database module and risk monitoring module. The CRA module provides a function of risk assessment based on the MACCS II code using the Gaussian Plume Model. According to NUREG-1493 and NEI methodologies, the risk assessment is performed by the CRA module using the results of Level 1 and 2 PSA including source term data. This module also gives a function of risk assessment considering evacuation scenarios. The database module was designed to manage meteorological information, population information and plant status information. Lastly, the risk monitoring module was developed to have a function of accident management using periodic risk monitoring, risk analysis display and data trend analysis. Figure 1 shows the main picture of web-based OSCAP.

Fig.1. Main picture of web-based OSCAP

3. Risk Assessment for ILRT Extension

Risk Assessment was performed for the meteorological input data and the population distribution input data using the web-based OSCAP. For the meteorological input data, it was performed by using the raw data collected from the reference site for the latest five years. For example, the annual average incidence of wind direction was analyzed by dividing the wind direction data collected in the reference site from 2007 to 2011 into the 16 compass directions, each being 22.5 degrees wide. Also, there are two general methodologies of the risk impact assessment for ILRT interval extensions, provided in NUREG-1493 and NEI interim report. Using OSCAP program, the risk impact assessments for reference plants were performed based on the method of NUREG-1493. Table 1 shows the results of the assessments.

Table 1. Results of the risk impact assessments based on the method of NUREG-1493.

Type of Risk	Risk Impacts (person·rem/year)
Risk(BL) (Baseline Risk)	5.44E+00
Risk(NL) (Nominal Leakage Risk)	1.34E-03
Risk Increase Rate (%)	0.02759

Secondly, risk assessments were performed by using the risk impact assessment program based on the methodology of NEI interim report. In this method, accident classes were divided into 3a (small leak corresponding to 10La; La means the leakage of containment intact case) and 3b (large leak corresponding to 35La), which presents the EPRI accident class information. As a result of applying 3% of the undetected leak probability, frequencies and doses according to accident class are presented in table 2.

Table 2. Results of the doses and the risk impacts of an undetected leak based on the method of NEI interim report

Accident Class	Frequency	Dose (person·rem)	Risk Impacts (person·rem/year)
Class 3a	2.04E-07	4.92E+03	1.00E-03
Class 3b	2.04E-08	1.72E+04	3.51E-04

3. Conclusions

The web-based OSCAP was developed based on MACCS II code, which could be used as a tool for evaluating risk according to extending ILRT intervals. The algorithm of the program gives an effect on reducing lots of efforts and working time to conduct the risk impact assessments and documentation. The program is composed of the database module, which stores huge amounts of data like meteorological data, population data, source term data, etc., and the CRA module, which performs the risk impact assessments using data of the DB module. Based on both methodologies of NUREG-1493 and NEI interim report, the risk impact assessments were performed by using the program. As developing the program, the following insights were elicited.

- Need to systematically manage the raw data collected from a meteorological tower at each site, and to standardize the format of the raw data from each site
- Need to improve the program to have a function of performing Level 3 PSA
- Need to improve the program to be web-based operated

Through developing the risk impact assessment program, the risk impacts, resulting from extending ILRT intervals, will be systematically performed and managed for a new nuclear power plant as well as operating ones in Korea. And, the program could be applied to establishing an accident management plan and emergency planning zone.

REFERENCES

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