Preliminary Studies on Re-establishment of Sensitivity Requirement for Measurement of Each Radionuclide in Gaseous Effluents Released from Nuclear Power Reactors

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1. Introduction

The technical specifications of nuclear power plants (NPPs) request the operators to measure radioactivity in gaseous effluent under the conditions with sufficiently low minimum sensitivity defined as lower limit of detection (LLD). Recently, based on the recommendations of the International Commission on Radiological Protection (ICRP), a series of domestic radiation protection regulations for effluent control (i.e., dose constraints, discharge limits, etc.) at the NPP have been revised. In this study, the adequacy of current nuclide-specific sensitivity requirements for gaseous effluent was verified with regard to the revised regulations for effluent control.

2. Methods and Results

2.1 Basic Assumptions and Methodology

In order to verify that a certain numerical regulatory limit determined by measurement is met, sufficient measurement conditions with low enough minimum sensitivity should be established [1]. In this context, five items of dose constraints and nuclide-specific effluent concentration limit (ECL), at the unrestricted area boundary, provided in the Notice No. 2002-23 of the Minister of Science and Technology (MOST) were regarded as regulatory discharge limits [2].

For more generalized assessment, annual average release rate of gaseous effluents from domestic NPPs in the period from 1999 to 2003 was calculated as 1.41E+9 m^3/y). In addition, a standard atmospheric dispersion coefficient (i.e., 1.87E-5 s/m^3) was derived from the five-year maximum site dispersion coefficients by weighting the number of units per site. Under the standard condition, the activity concentration of each radionuclide at the release point is assumed to be the same as the current sensitivity requirement. Table 1 shows the current domestic sensitivity requirements for gaseous effluent from NPPs, along with those of the U.S., Germany and Japan [3]. It is notable that the particulate detection limit of Korean NPP is upto ten-orders-of-magnitude higher than that of Japan.

Combining the above parameters and assumptions, maximum offsite dose to the members of the public and nuclide-specific activity concentration at the unrestricted area boundary were calculated by spread sheet and INDAC-W computer code [2].

Table 1. Comparison of Sensitivity Requirements of Some Countries for Measurement of Major Nuclides in Gaseous Effluent (Unit: Bq/m^3)

Nuclide	U.S.	Germany	Japan	Korea
Co-60	3.70E+06	3.00E-02	4.00E-04	3.70E+06
Cs-137	3.70E+06	3.00E-02	4.00E-04	3.70E+06
I-131	3.70E-02	2.00E-02	7.00E-03	3.70E-02
I-133	3.70E-02	2.00E-02	7.00E-02	3.70E+00
Ar-41	3.70E+06	-	2.00E+04	3.70E+06
Kr-85	3.70E+06	1.00E+04	2.00E+04	3.70E+06
Xe-133	3.70E+06	5.00E+02	2.00E+04	3.70E+06
Xe-133m	3.70E+06	-	2.00E+04	3.70E+06
Gross Gas	3.70E+04	1.00E+04	2.00E+04	3.70E+04
H-3	3.70E+04	1.00E+03	4.00E+01	3.70E+04
Sr-89	3.70E-01	1.00E-03	4.00E-04	3.70E-01
Sr-90	3.70E-01	1.00E-03	4.00E-04	3.70E-01

2.2 Concentration-Based Sensitivity Requirements

It is certain the minimum sensitivity requirement should be "a small fraction" of the related regulatory limit [4]. With regard to the above principle, 1% and/or 10% was temporally chosen as the guideline of "a small fraction". In order to derive concentration-based sensitivity requirements, the concentration at the release point which is equivalent to 1% and 10% of the ECL at the unrestricted area boundary was calculated for each radionuclide.

As shown in Figure 1, the present LLDs for particulates, except strontiums, are few-orders-of-magnitude higher than the concentration-based sensitivities. For most noble gases except for Kr-85, it also turns out that the release even at the LLD level may not assure the unrestricted area boundary concentration is below 1% or 10% of the ECL. But the gaps between the current LLDs and concentration-based sensitivity requirements are smaller than the particulates. In contrast, the current LLDs for iodines and strontiums are low enough to maintain the offsite concentration under the ECLs.

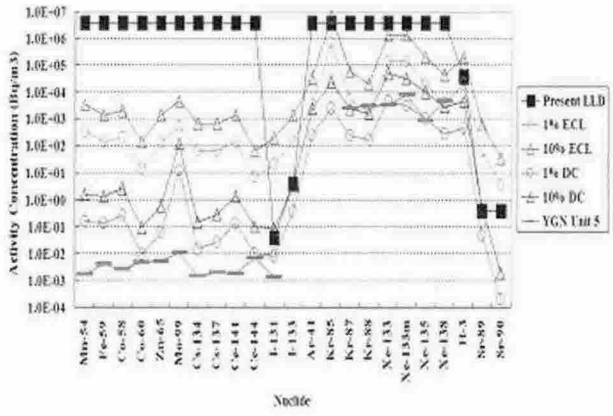

Figure 1. Comparison of present LLDs with Re-Calculated Concentration-Based and Offsite Dose-Based Sensitivity Requirements for Major Nuclides.

2.3 Offsite Dose-Based Sensitivity Requirements

To derive offsite dose-based sensitivity requirements, the nuclide-specific concentration at the release point which is equivalent to 1% and 10% of the five dose constraints such as: (1) gamma air dose, (2) beta air dose, (3) effective dose by direct exposure, (4) skin dose, and (5) organ equivalent dose.

For noble gases and particulates except Sr-89, it turns out that the effluent at the release-point concentration of current LLD may not ensure the offsite dose is below 1% or 10% of the dose constraints (see Figure 1). Especially, it is notable that the current LLDs for particulates are upto eight orders of magnitude high above the offsite dose-based sensitivities. In addition, the present LLD for tritium is one to two-orders-of-magnitude higher than the offsite dose-based sensitivities. However, the current LLDs for I-131, I-133, and Sr-89 are comparable to the offsite dose-based sensitivities derived from 10% of dose constraints.

2.4 Comparison to Actual Measurement Sensitivity

Along with deriving new sensitivity requirements, the results were compared to the measurement sensitivity actually attained at an NPP, Younggwang Unit 5, during the second quarter of the year 2004 [5].

The actual measurement sensitivity for particulates and I-131, ranging from 1.0E-3 to 1.0E-2 Bq/m^3, is low enough to assure offsite dose and concentration can be controlled below 1% of related regulatory discharge limits. Except for Kr-85, actual noble gas sensitivity is comparable to 1% or 10% of the regulatory limits. For Ar-41, Sr-89, Sr-90 and H-3, however, actual sensitivities were not obtained and excluded from the comparison.

3. Conclusion

It turns out that current LLD requirements for gaseous effluents from NPPs may not be low enough to ensure the compliance with revised regulations. Especially, it is notable the gaps between the current particulate LLDs and newly derived sensitivities are very high compared to other nuclides. The result of this study can be a good starting point for regulatory analysis to re-establish minimum sensitivity requirements for the domestic NPPs.

REFERENCES

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