Radiation Dose Effects into LCO in Technical Specification by Iodine in Hanul units 1,2

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1. Introduction

This study estimates the impact of the 1-th coolant system in NPP to the LCO (Limiting Condition of Operation) limits which is in the site boundary. An overall-site specific activity LCO is also evaluated and that is applicable to any nuclear site in Korea without additional analysis. Dose limit is merged into the effective dose from whole body and thyroid dose limits, that is possible to combine the two LCOs to a unified LCO. To estimate the limits, the radiation dose of one of the designed accidents should be chosen to check the radiation dose response. The selected accident is based on Seung Chan Lee's study at KHNP in 2011[1]. Using the selected accident, Iodine dose effect is reviewed depending on the LCO limiting responsibility and the specific behavior.

2. Methods

To evaluate the effect of radiation dose into the LCO of Technical Specification, some accidents are selected from the study of Seung Chan Lee at KHNP in 2011. The selected accident is the key element in evaluating the effect of radiation dose into the LCO.

2.1 Selection of Key Impact accident

From the study carried out by Lee et al., the selection process is summarized in Fig. 1.

Through the Fig.1, steam generator tube rupture (SGTR) is selected.

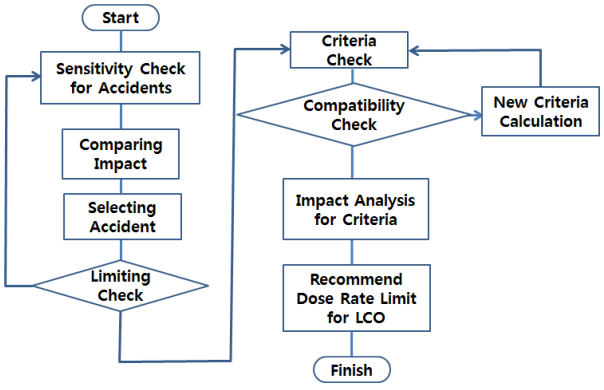

Fig. 1 Work frame for Dose rate in LCO recommendation [1].

This estimation considers three factors such as atmosphere dispersion factor, fuel failure, a specific iodine concentration written in Technical Specification of Hanul 1,2. Table 1 shows the basic parameters used in estimating the criteria of LCO in specific activity concentration.

Table 1. Basic Parameters for SGTR in Hanul 1,2

Input parameters	Value	
Thermal Power	2900	Mwt
Fuel Gap Activity Fraction	0.1	
Fuel Failure rate	0.01	
Radial Peaking factor	1.65	
RCS Inventory	1.84E+5	kg
Iodine Escape rate	1.30E-8	sec^{-1}
Iodine spiking factor(GIS)	500	
GIS equilibrium time	1800	sec
PIS Dose Equivalent Concentration	0 ~ 60	uCi/gram
GIS Dose Equivalent Concentration	0 ~ 1.0	uCi/gram
Secondary Coolant concentration	0.1	uCi/gram
EAB	700	m
Breathing rate	3.47E-4	m^3/sec
Atmospheric Dispersion Factor	1.96E-4	sec/m^3

2.2 Sensitivity Analysis

The sensitivity analysis is carried out using the data of Lee et al. [1].

The parameters used in sorting are time, specific concentration of RCS and radiation dose value.

Domestic LCO is 1.0uCi/g in Technical Specification. This value is considered to satisfy the dose rate limit of EAB (Exclusion Area Boundary) conservatively. All nuclear power plants are satisfied in this condition in the case of all designed accidents by safety analysis. In this study, to find the effect of radiation dose on the LCO in Technical Specification, current FSAR (Final Safety Analysis Report is used to check the responsibility of specific activity concentration of iodine in RCS. The data of Lee et al is sorted by time, activity concentration, EAB (Exclusion Area Boundary) dose rate for sensitivity effect. The selection process is summarized by Fig. 1.

Through the Fig.1, steam generator tube rupture (SGTR) is selected.

This estimation considers three factors such as atmosphere dispersion factor, fuel failure, a specific iodine concentration written in Technical Specification of Uljin 1,2. Table 1 shows the basic parameters used in estimating the criteria of LCO in specific activity concentration.

The terms are based on Hanul 1, 2 FSAR[2].

2.3 Radiation Dose Effect to LCO

To check the radiation dose effect, the specific activity for LCO is estimated using the limit criteria written on the Technical Specification of Hanul 1,2. The first estimation started from the general criteria 1.0uCi/gram. And the specific concentration of the 1-th coolant increase up to 100 uCi/gram. In this process, when the radiation dose result is beyond the criteria, the value is the new limit criteria of FSAR. The values are compared with the values of the other accident conditions such as Table 2.

Table 2. Accident Case for the limit criteria of SGTR in Hanul 1,2

Category of accident	Effective radiation dose limit [rem]
LOOP(GIS)	2.5
LOOP(PIS)	25
LOOP_ADV(GIS)	2.5
LOOP-ADV(PIS)	25

Here LOOP is the mean of Loss of Offsite Power.
The pre-existing iodine spike (PIS) and the event-generated iodine spike (GIS) are determined using the spiking factor 500. The spiking effect is reviewed in this study according to technical specifications (Tech. Spec.), dose limit, and the limiting condition of operation (LCO).

The some assumptions of the analysis are used as followings [1]:

1. Radiation dose of a SGTR is calculated using the following two cases:
   - GIS : Iodine spiking at the start of an accident
   - PIS : Iodine spiking at normal conditions
2. Dose equilibrium conditions are 1.0 uCi/gram in the primary coolant and 0.1 uCi/gram in the secondary coolant of the limiting condition of operation.
3. GIS spiking factor is 500.
4. In the PIS case, the dose equivalent I-131 concentration is 60 uCi/gram, according to the NPP technical specifications.
5. During the accident, the intact steam generator has the release rate of 0.6 gpm (2.27 L/ min).
6. The flashed condition is assumed to have a decontamination factor of 100.
7. Dose calculation includes the total release accumulation of the intact steam generator and the faulty steam generator.
8. In this study, the atmosphere dispersion factor is referenced from the FSAR.
9. The pathway between the system and environment has a decontamination factor of 1.
10. The continuous time is 8 hours (this time is sufficient to recover from the accident).

3. Results and Discussions

Table 3 presents the reached limit concentration of each cases of a SGTR.

Table 3. Estimation Results in Each Case

Category of accident	Dose limit [rem]	Technical Specification Approach Concentration [uCi/gram]
LOOP(GIS)	2.5	9.5
LOOP(PIS)	25	15.2
LOOP_ADV(GIS)	2.5	2.1
LOOP-ADV(PIS)	25	4.0

Table 3 shows that the 1-th specific activity concentration in Technical Specification is in the most severe condition as the case of LOOP(Loss of Offsite Power) plus ADV(Atmospheric Dump Valve) opening plus GIS(Event-Generated Iodine Spike).
From the results of Table3, in the current Technical Specification, 2.1times of Iodine concentration criteria is the dose limit concentration in EAB (Exclusion Area Boundary). These results are the same comparing with the dose estimation trend of NUREG-1431 and NUREG-1432.
For LCO in Technical Specification, analysis results of Hanul site show that the most sensitive case is the LOOP plus ADV plus GIS and in the case, the dose limit margin is about 110% in LCO.

4. Conclusions

In order to evaluate the radiation dose effect in Technical Specification of Hanul 1,2, SGTR is selected for some sensitivity analysis. From the results, in Hanul site, the case of LOOP plus ADV plus GIS is the most severe case and the dose limit margin is about 110% in LCO.

REFERENCES

[1] Seung Chan Lee et al, Spiking Effect in Steam Generator Tube Rupture Analysis at Hanul site, Transaction of the Korean Nuclear Society Autumn Meeting, Oct. 27-28, 2011.
[2] Final Safety Analysis Report, Hanul 1,2.
[3] Technical Specification, Hanul 1,2.