Establishment and Application of a National Recording Level in Korea

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ABSTRACT – This article analyzes data on the radiation doses of Korean nuclear power plant workers. The trend in the individual average annual doses during the period from 1998 to 2002 is compared between different exposure groups. Using the 2002 national dose data for Korean Nuclear Power Plants, the article discusses the effects of collective and individual doses for the doses below the LLD or 0.1 mSv.

INTRODUCTION

In Korea, the Korea Institute of Nuclear Safety (KINS) establishes reference levels such as the dose limit and it controls the occupational dosage for all radiation workers. KINS has been developing Web-based Korea Information System on Occupational Exposure (KISOE) since 2003. In 2002, around 22,000 workers participated in occupational radiation exposures in Korea. The number includes workers in the fields of industry, research, health care, education, public institutes and nuclear power plants.

Of the sixteen nuclear power plants (NPPs) that are operational Korea, twelve have a pressurized water reactor and four have heavy water reactors. They are located in Kori, Youngkang, Uljin and Wolsung. In 2002, the number of workers in the controlled area of these NPPs including personnel and external workers, was 11,004.

OCCUPATIONAL DOSE CONTROL IN KOREA

The Atomic Energy Act of Korea states that KINS is responsible for maintaining the occupational dose control. KINS operates a national accreditation program for personnel dosimetric services. In Korea, there are three external dosimetric service company for medical and industrial users of ionizing radiation and four internal processors for their own staff. The NPPs have their own dosimetric services, which have been approved by KINS.

Every three months, the dosimetric services report individual occupational doses to the national dose keeping center which is located at the Korea Radioisotope Association. A recording level is not applied. The measured data including data bellow the lower level of detection (LLD) are reported and kept as occupational doses.

To accurately compare the occupational doses for similar radiation works, the following requirements should be met. Firstly, the dose data should be measured with the same level of accuracy. Secondly, the same evaluation procedures should be applied for the correction and modification of the measured data.

Korea maintains the measurement accuracy of occupational doses through the dosimetry performance test program established in 1995. The program sets out the LLD as 0.1 mSv for thermoluminescent dosimeter (TLD) and assures the accuracy of measured data. Dosimetric services in Korea asses occupational doses with different LLD values. The dosimetric processors of NPPs maintain the LLD in the range of 0.04 to 0.07 mSv.

Decrease in occupational exposure at Korean NPPs

To study the exposure characteristics of radiation workers, the workers were divided into the following four groups based on annual dose ;

- Group 0 : zero
- Group 1 : 0.01 mSv/y to 0.29 mSv/y, which is below the constraint level for the general public
- Group 2 : less than 1 mSv/y
- group 3 : greater than and equal to 1 mSv/y.

The average individual occupational dose for all the workers and specific job categories is calculated and controlled to analyze the effectiveness of radiation protection. The collective doses for the five-year period from 1998 to 2002 at Korea's NPPs are shown in Table 1.

The average annual occupational dose for all radiation workers at NPPs decreased from 1.19 mSv/y in 1998 to 0.80 mSv/y in 2002. The dose reduction rate was around 10 percent per year between 1998 and 2002, with a total rate of 49 percent. For Group 3, however, the reduction rate was around 30 percent ranging from 4.42 mSv/y in 1998 to 3.24 mSv/y in 2002. This reduction is due more to improvements in the radiation work environment than to stricter control of high dose exposure. Nonetheless, long-term refueling techniques and the operation of a new reactor are the main reasons of the large reduction rate for all workers from 2001 to 2002.

ESTABLISHMENT AND APPLICATION OF A NATIONAL RECORDING LEVEL

For the dosimetric results of personnel, some workers complained that they never worked near radiation during dosimetric service period and that although the dosimeter had been kept at the back of a drawer their dosimetric result was not zero. On the other hand, some workers said that they worked a radiation work environment but their dose was always reported as zero. Such criticisms undermine confidence in the low dose measurement. To improve the reliability of low dose measurements and the consistency of analysis, a national recording level should be established and applied to occupational dose data.

To accurately compare the occupational doses of workers at NPPs, especially among nations that use international database such as the ISOE, the same evaluation procedures should be applied in the correction and modification of the

measured data. In Korea's Atomic Energy Act, a requirement exits only for the LLD, 0.1 mSv (TLD) or 0.15 mSv (Film) per measured period, but not for the recording level (RL). The personal dosimeter used in NPPs is the TLD ; it has an LLD below 0.07 mSv/month. This study analyzes the effects of applying a national RL to the 2002 individual and collective doses in the following cases :

- The RL is set at 0.1 mSv which is a minimum requirement for TL dosimeter's the LLD of TLDs in Korea.
- The RL is set at 0.07 mSv which is a realistically maintained level of LLD.

The results are presented in Table 2 and Table 3.

RESULTS AND DISCUSSION

Table 2 presents the number of workers for each group, along with the number of workers following the application of the RL. Although Table 2 shows 50 percent of all workers received zero doses, the number of zero-dose workers increased by nearly 10 percent after the RL of 0.1 mSv had been applied. However, 67 percent of these workers belonged to Group 0 or Group 1 (dose < 0.3 mSv/y) regardless of whether the RL was applied.

After the RL had been applied, around 35 percent of the workers in Group 2 and Group 3 (dose $\geq$ 0.3 mSv/y) recorded a change in their individual annual dose. The difference between the cases with and without the RL is calculated for all workers using the following formula:

$$\%CV = (E_{NR} - E_{AR}) / E_{AR} , \quad (1)$$

where E_{NR} is the dose before the RL is applied and E_{AR} is the dose after the RL is applied.

The personnel doses are analyzed with the workers whose doses are being changed by the application of RL of 0.1 mSv and the results are follows:

- The average personnel dose decrease is shown as 20 %CV in Group 2 and 4 %CV in Group 3.
- The maximum individual dose decrease is 0.77 mSv/y in Group 1.

Only 0.02 mSv/y and 0.04 mSv/y of the average annual dose were decreased for all workers by applying an RL as 0.07 mSv and 0.1 mSv respectively. For dose-changed workers, the average of dose decrease is 0.06 mSv/y and 0.1 mSv/y. With an RL of 0.07 mSv and 0.1 mSv, the decreased amounts in the unit of collective dose are 110 and 230 man-mSv, respectively, from 8,790 man-mSv.

When the RL is applied, the amount change in the collective dose is relatively small in a national recording system. In establishing a national RL; however, the following points should be considered::

- The individual doses close to the RL (several cases they are believed to be exposed by actual sources and it is called as Assured Dose in this paper) should not be neglected
- The information on the uncertainty which would be raised by the application of the RL (sometimes called as a latent annual dose) should be described in an information sheet for worker.

In conclusion, the RL of 0.1 mSv for a measuring period is not a suitable in Korea because the assured dose (0.39 mSv/y) will be discriminated as zero dose and the maximum individual dose is shown to be decreased as 0.77 mSv/y. A value of 0.07 mSv is recognized as a reasonable level for the national RL. The latent annual dose for a zero dose is 0.05 mSv/y (max. 0.19 mSv/y) and for a non-zero dose is 0.06 mSv/y (max. 0.43 mSv/y).

Table 1. Average individual dose per year at Korean NPPs for the period 1998 to 2002

Year	All			Group 2 and 3			Group 3		
	Collective dose (man-Sv)	No. of workers (person)	Average Dose (mSv)	Collective dose (man-Sv)	No. of workers (person)	Average Dose (mSv)	Collective dose (man-Sv)	No. of workers (person)	Average Dose (mSv)
1998	13.64	11,448	1.19	13.43	4,081	3.29	12.76	2,888	4.42
1999	11.83	10,727	1.10	11.62	4,149	2.80	10.83	2,886	3.75
2000	10.79	10,835	1.00	9.20	3,769	2.44	9.64	2,757	3.50
2001	10.10	11,077	0.91	8.54	3,534	2.42	8.89	2,523	3.52
2002	8.79	11,004	0.80	7.37	3,286	2.24	8.61	2,396	3.24

Table 2. Number of workers by applying the RL for each group.

Reporting Level	No. of Workers in 2002			
	Group 0	Group 1	Group 2	Group 3
Not Applied	5,544	1,677	1,387	2,396
0.07 mSv per measure period	6,152(▲608)	1,118(▼559)	1,356(▼31)	2,378(▼18)
0.1 mSv per measure period	6,456(▲912)	875(▼802)	1,319(▼68)	2,354(▼42)

Table 3. Effects on individual and collective doses by applying an RL.

Items	RL	Group 0	Group 1	Group 2	Group 3	Total
No. of workers whose individual dose changed by applying an RL	0.07 mSv	608 (10 %)	268 (24 %)	407 (30 %)	846 (36 %)	2129 (19 %)
	0.1 mSv	912 (14 %)	277 (32 %)	467 (35 %)	974 (41 %)	1901 (17 %)
Average %CV and max. dose difference (mSv/y) for changed persons	0.07 mSv	- (0.19)	45.6 % (0.38)	10.7 % (0.43)	2.0 % (0.30)	19.4 % (0.43)
	0.1 mSv	- (0.39)	64.5 % (0.77)	19.1 % (0.58)	4.1% (0.53)	29.2 % (0.77)
Change of average annual dose by applying an RL for changed worker and for all workers (mSv/y)	0.07 mSv	0.05 (0.05)	0.06 (0.01)	0.06 (0.02)	0.05 (0.02)	-
	0.1 mSv	0.07 (0.07)	0.11 (0.03)	0.10 (0.04)	0.09 (0.04)	-
Collective dose and changed amount (man-mSv)	0.07 mSv	0(▼30)	182(▼16)	803(▼23)	7699(▼39)	8683 (▼109)
	0.1 mSv	0(▼65)	189 (▼29)	781 (▼47)	7624 (▼86)	8593(▼228)