Summary

We are continuously trying to reduce the low base dose emissions in the R.C.A. (Radiation Controlled Area) because we want to decrease the individual dose limits according to the adaption of ICRP 60 and the increase of the collective dose due to the plants continuous operation. We are also currently focused on trying to minimize the radioactive waste materials due to the increase of the disposal costs in Korea. We commenced with the manufacture of Lead blankets suitable for high radiation equipment and small sized pipes which are not easily shielded. We contain the radiation by the use of Lead plates from the Lead vests which we then manufactured into the Lead blankets at Hanbit nuclear power plant. We manufactured various types of Lead shielding materials according to the pipe size; also the Lead plates consist of grid pattern type in order to increase the shielding efficiency of Lead blankets. Consequently, shield efficiency has improved by re-using the Lead plates from the used vests. The effects contributed to a reduction of the exposure dose of radiation to workers due to the decrease of the dose rate in the high radiation area, and it could also lower the cost of the process by the reuse of the Lead plates.

1. Introduction

Occupational exposure to employees mostly occurs during the overhaul period. In addition, the major source is known as Gamma-ray emission from radioactive corrosive products.

Secondly, effective shielding of Gamma-rays in the RCA is directly associated with the reduction of exposure to radiation workers and the radiation safety department. We will continuously make efforts to reduce exposure to the aforementioned. However, the RCA is an enormous source in terms of the components which are impossible to shield, such as the reactor, steam generator etc. Although it is expected to be shielded, it is quite difficult to shield from radiation due to the size and location of pipes etc. Consequently, the radiation safety department in Hanbit PP#2 considered plans for effective shielding, especially concerning small sized pipes. When using the Lead blankets, it is laborious to shield the pipes. During the o/h, we are trying to minimize the low base dose emissions to reduce the exposure dose for employees.

2. Status and problems

There are numerous pipes located in each area of the containment building at Hanbit PP#2, some of them are small sized lines and they are installed in narrow spaces. Using the existing Lead blankets took longer than expected to shield these lines because of those different sizes. When the pipes were shielded with the previous Lead blankets, narrow work spaces made it inconvenient for employees to work and pass through the area. Some radiation shield materials didn't fit on the pipes because of different sizes so that radiation shield materials could have been dislodged from pipes. Also, the external appearances of the pipes were an eyesore. So, we tried to seek effective shielding methods. In addition, we also tried to reduce radioactive wastes by reusing existing shielding materials rather than incurring additional expenses. So, the Radiation Safety Department in Hanbit PP#2 believed that if Lead shielding materials with appropriate shapes were manufactured and could effectively isolate the high radiation and small sized pipes then the low base dose emissions could be reduced. The team also thought that the waste materials would be reduced by reusing the Lead plates from the Lead vest.

3. Process of manufacturing the Lead shields for small sized pipes

They are kept in storage for 3 different types at Hanbit PP#2

Table 1: Current Lead vests at Hanbit PP#2

Classification \ Type	Necklace type	Shoulder type	General type
Item			
Quantity	25sheet	41sheet	95sheet
Quantity for disposal	21sheet	15sheet	N/A

As seen in table 1, we mainly use the general type to reduce the exposure dose to employees in Hanbit PP#2 and sometimes use the shoulder type in case of insufficiency. Necklace types, were initially introduced, and are no longer used due to wear and tear and high contamination; they are only kept in storage for disposal. Thus we assumed that after disassembling the Lead vest it should be disposed of, it is to enable the manufacturing of Lead shielding for the appropriate shape because the existing Lead blankets are difficult for shielding the small sized pipes.

As seen in picture 1, we carried out extraction of the Lead plates in the Lead vests and then decontaminated them. We are committed to minimizing the amount of disposable material. There are approximately 45 Lead plates that can be used in the shoulder and necklace type vests.

Picture 1: Separated and decontaminated Lead plates

Picture 2: Extracted Lead plates

Disassembled plates shown on picture 2. The specifications are as follows; width 31cm, height 2.5cm, thickness 0.2cm and weight 0.12kg. There were1450 Lead plates extracted for further use, except for some plates that could not be reused.

Table 2: Quantity of Lead plates available

Class / Type	collective(ea)	useable(ea)
Necklace type	945	853
Shoulder type	675	597
Total	1,620	1,450

4. Results of manufacturing the Lead shields for small sized pipes

The new manufactured Lead shielding material was designed not to sag/hang down regardless of size and length of the small pipes. They were also designed to be used for the long term. An outer cover for the Lead shielding material was designed using tarpaulin which is non-flammable and can be decontaminated without much effort. Moreover, the sheath for the Lead plates which were double stitched were arranged in a grid pattern to improve the shielding efficiency. The gap between the sheath and the Lead plate was within 2 mm. After fixing the Lead plate and inner part, they were sealed with an outer cover to minimize the sag of sheath. In addition, the edge of Lead plate was designed to be spherical to prevent accidents when the Lead shielding material is transported and installed.

Table 3: The result of designed Lead shielding material

Division	Existing Lead shielding	Improved Lead shielding
Comparison		
Detailed	Size(cm) : 110 × 40 Weight(kg) : 12.46	① Small Sizes(cm) : 40 × 35 Weight(kg) : 4.2 ② Medium Sizes(cm) : 60 × 35 Weight(kg) : 6.3 ③ Large Sizes(cm) : 80 × 35 Weight(kg) : 8.0

Table 3: The designed Lead shielding material was then improved. The Lead shielding material was designed with 3 types in mind, based on the size of pipes and how they could be used properly depending on the pipe size.

5. Application of Lead shielding materials onto small sized pipes

The newly manufactured shielding materials were applied onto the work place during the OH of Hanbit PP#2 unit 4. Pictures 3 - 7 show before/ after improvements.

Before improvements	After improvements
	

Picture 3: S/G C/L Line located at the inner wall in the RCB 86' to RDT small sized

Before improvements	After improvements
	

Picture 4: Shielding the lines around Cavity FAN located inner wall in the RCB 86'

Before improvements	After improvements
	

Picture 5: Shielding the high radiation line around S/G #2 Cold Leg Man-way located at the inner wall in the RCB 86'

Before improvements	After improvements
	

Picture 6: CV 10' RC LOOP 2A; High dose pipes around the PZR

Before improving	After improving
	

Picture 7: 441-201Q high dose pipes in SAB 10' Let-Down

As is seen in pictures 3 ~ 7, after shielding high dose small sized pipes with the Lead shielding materials those sizes and shapes have been improved for its shielding function, the integrity of pipes, and environmental conditions. Also to check the changes of dose rates around pipes, we measured the dose rate before/after the improvement at a distance of 30cm from the pipe.

Table 4: Changes of dose rates after shielding

Shielding area	Dose rate(mSv/hr)		reduction efficiency (%)
	before	after	
RCB 86' S/G C/L ?　RDT small sized pipe	0.62	0.51	17.7 ↓
High radiation area around the Cavity FAN	0.81	0.65	19.6 ↓
High radiation pipe around S/G 2 C/L M/W	0.58	0.56	3.5 ↓
RC LOOP 2A ?　High radiation pipe around PZR	0.72	0.18	75 ↓
High radiation area around Let-Down 441-201Q	3.10	2.80	9.7 ↓

After improving the shielding of the 'high dose rate and small sized pipes', the radiation dose rate around the pipes was considerably reduced after the improvement as it is seen on table 4. It is considered that it will contribute to the reduction of the employee’s exposure dose. As it was described before, thanks to the clearly arranged environment around pipes, the employees can maintain a stable mental health. And it seems like the intangible effects can be obtained, like the improvement of maintenance quality.

6. Conclusion

In Conclusion, the Lead plates in the Lead vest that should be disposed of can be reused for shielding of the 'high dose rate and small sized pipes', so that it effectively shields the pipes, reduces the low based dose around the pipes and also reduces the exposure dose to the employee’s. Also, reusing the Lead plates will help to reduce the radioactive waste materials that are currently issued hence, reduce disposal costs. Making up for the weaknesses of previous Lead shielding will bring intangible benefits to NPP operations, for example, the improvement of shielding performance, the integrity of the pipes, and the mental stability of employee’s. However, shielding of high dose rated pipes, facilities, and complex structures in the RCA still remain a serious challenge, so sustainable efforts and research are needed to solve these problems.