Measurement of ^{133}I using Thyroid Monitoring System in Nuclear Emergency

Mee Jang[a], Gwang Min Sun[b], Hyun Ki Kim[a], Chang Woon Choi[a]
a National Radiation Emergency Medical Center, Korea Institute of Radiological and Medical Science, Seoul, Korea
b Korea Atomic Energy Research Institute, Daejeon, Korea

1. Introduction

Inhalation and the external exposure pathway dominate the exposure in the first few days after a severe accident in a nuclear power plant. Especially the dominant contribution to the effective inhalation dose comes from ^{131}I. Although ^{132}I, ^{133}I, ^{134}I and ^{135}I are actually produced in greater yields than ^{131}I from thermal neutron fission of ^{235}U, thyroid irradiation is ascribed almost entirely to ^{131}I because of its relatively long half-life. However, because the estimated thyroid dose by the short-lived radioiodine is higher at the closer zones to the reactor [1], we should consider ^{133}I as well as ^{131}I that have contributed to inhalation dose in Chernobyl accident [2]. But ^{132}I by precursor ^{132}Te is excluded in this study.

2. Methods and Results

We designed the thyroid monitoring system using NaI(TI) detector [3] and the manufacture of the system is in process. In the case of NaI(TI) detector, it is difficult to know the nuclide and activity if measured peaks are overlapped by poor energy resolution. In this section we presented the available technique to measure the ^{133}I in nuclear emergency.

2.1 Radionuclides

In the Chernobyl accident the radionuclides affected to inhalation dose are 20 species. Iodine (^{131}I, ^{133}I), cesium (^{134}Cs, ^{136}Cs, ^{137}Cs) and tellurium (^{129m}Te, ^{132}Te) have volatile form. Strontium (^{89}Sr, ^{90}Sr, ^{91}Sr), zirconium (^{95}Zr), niobium (^{95}Nb), molybdenum (^{99}Mo), ruthenium (^{103}Ru, ^{103}Ru), barium (^{140}Ba), cerium (^{141}Ce, ^{144}Ce), neptunium (^{239}Np) and plutonium (^{239}Pu) have non-volatile form [4]. However, krypton (^{85}Kr) and xenon (^{133}Xe) produced in great yields have less effect on inhalation dose. Here, we considered ^{85}Kr (513keV), ^{134}Cs(605keV), ^{137}Cs(662keV) and ^{140}Ba (537keV) because of similar gamma energy to ^{133}I (530keV).

2.2 Methods

The ratios of iodine, cesium and barium in the Chernobyl fallout were assumed to be ^{131}I:^{133}I:^{134}Cs:^{137}Cs:^{140}Ba = 9.54:15.264:0.55:1:1.375 [4]. We assumed that release rate of ^{85}Kr is similar to ^{137}Cs. Since no data on the daily deposition of each radionuclide in the 30-km zone are available, the radionuclide vector (radionuclide ratios to ^{137}Cs) developed by Muck [5] was deployed to derive the activity of each radionuclide.

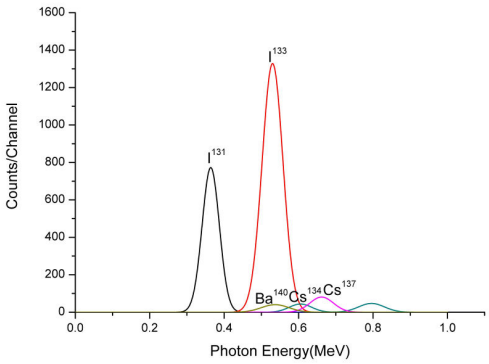

Figure 1. Peaks of radionuclides (^{85}Kr, ^{131}I, ^{133}I, ^{134}Cs, ^{137}Cs, ^{140}Ba) at the time of accident beginning

As shown in Figure 1, there is a possibility to overlap peaks of ^{133}I, ^{85}Kr, ^{134}Cs and ^{140}Ba, and only one peak is presented in the spectrum by NaI(TI) detector. The peak of ^{85}Kr was not almost noticeable by low release rate. We assumed that the FWHM (E_0) is 0.05 when E_0 is 0.3MeV. Because the release rate of ^{133}I is much larger than other radionuclides, the dominant contribution to the peak comes from ^{133}I. But the peak by ^{133}I decreases rapidly due to half-life of 20.8hour. After 3days from accident the peak is much smaller than the peak by ^{131}I as shown in Figure 2.

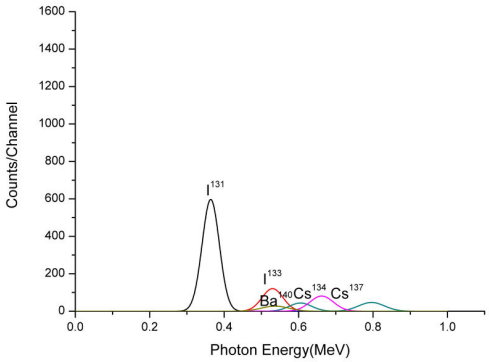

Figure 2. Peaks of radionuclides (^{85}Kr, ^{131}I, ^{133}I, ^{134}Cs, ^{137}Cs, ^{140}Ba) after 3day from accident

We checked the change of peak area due to difference of release rate and half–life. The result is presented in Figure3.

2.3 Results

The peak was dominantly made by ^{133}I and the change rate of peak area is high due to short half-life. After 48hr from accident the peak area of ^{85}Kr, ^{134}Cs and ^{137}Cs is almost constant due to long half-life. Also it may be neglected the contribution by ^{140}Ba due to relatively long half-life. The area of peak including ^{133}I decreases about 76% at t=48hr compared with t=0hr. Using this result, we can calculate the activity of ^{133}I indirectly.

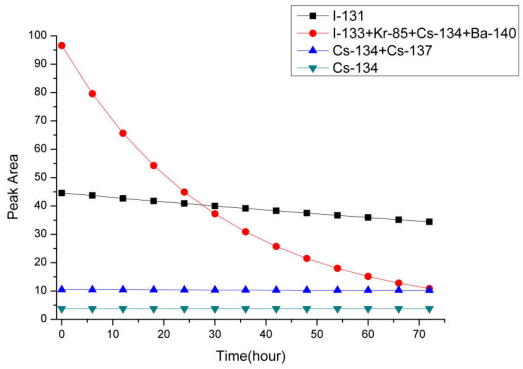

Figure 3. Area of four peaks appeared in the spectrum

3. Conclusion

In the case of severe accident in a nuclear power plant it is necessary to consider ^{133}I as well as ^{131}I at closer zones to the reactor. ^{133}I is important to evaluate the dose due to higher radiobiological effectiveness. However, measurement of ^{133}I is difficult because of short half-life and interruption of another radionuclides.

To solve this problem we suggested the method to measure ^{133}I using change of the peak area. We should have first measurement as possible as fast and measure the thyroid several times at regular intervals to utilize this method.

The air concentration of ^{133}I depends on the release rate of power plant, wind strength and wind direction. Therefore the available measurement time of ^{133}I is variable according to the accident situation or it may be impossible to detect ^{133}I under specified condition. However, it is necessary to have the protocol to measure the activity of ^{133}I if it exists.

If thyroid monitoring conducted after ^{133}I is almost decayed, we consider to measure ^{133}Xe ($T_{1/2}$=2.190day) and ^{133M}Xe ($T_{1/2}$=5.243day) produced by decay of ^{133}I. This method can offer a tool to evaluate the effect by ^{133}I in a long-term point of view.

REFERENCES

[1] Yuri Gavrilin, Valeri Khrouch, Sergey Shinkarev, Vladimir Drozdovitch, Victor Mineko, Elena Sheminakina, Alexander Ulavoskey, Andre Boubille, Lynn Anspaugh, Paul Voilleque and Nickolas Luckyanov, Individual Thyroid Dose Estimation for a Case-control Study of Chernobyl-Related Thyroid Cancer among Children of Belarus-Part I: ^{131}I, Short –lived Radioiodines (^{132}I, ^{133}I, ^{135}I), and Short-lived Radiotelluriums (^{133M}te and ^{132}Te), Health Physics, Vol.86, No.6, p.565-585, 2004.

[2] M. Balonov, G. Kaidanovsky, I. Zvonova, A. Kovtun, A. Bouville, N. Luckyanov and P. Voilleque, Contribution of Short-lived Radioiodines to Thyroid Doses Received by Evacuees from the Chernobyl Area Estimated using Early In-vivo Activity Measurements, Radiation Protection Dosimetry, Vol.105, No.1-4, p.593-599, 2003.

[3] Mee Jang, Hyun Ki Kim and Chang Woon Choi, Development of Portable Thyroid Monitoring System for ^{131}I and ^{133}I in Nuclear Emergency, Proceedings of the Fourth International Symposium on Radiation Safety and Detection Technology (ISORD-4), July 18-20, 2007, Seoul, Korea

[4] Korand Muck, Gerhard Prohl, Ilya Likhtarev, Lina Kovgan, Vladislav Golikov and Johann Zegar, Reconstruction of the Inhalation Dose in the 30-km Zone after the Chernobyl Accident, Health Physics, Vol.82, No.2, p.157-172, 2002.

[5] Korand Muck, Gerhard Prohl, Ilya Likhtarev, Lina Kovgan and Vladislav Golikov, A Consistent Radionuclide Vector after the Chernobyl Accident, Health Physics, Vol.82, No.2, p.141-156, 2002.