Periodic Verification of the Scaling Factor for Radwastes in Korean NPPs – 13294

Yong Joon Park, Hong Joo Ahn, Byoung Chul Song, Kyuseok Song

Korea Atomic Energy Research Institute, P.O. Box 105, Yuseong, Daejeon, 305-330, Korea

jparky@kaeri.re.kr

ABSTRACT

According to the acceptance criteria for a low and intermediate level radioactive waste (LILW) listed in Notice No. 2012-53 of the Nuclear Safety and Security Commission (NSSC), specific concentrations of radionuclides inside a drum has to be identified and quantified. In 5 years of effort, scaling factors were derived through destructive radiochemical analysis, and the dry active waste, spent resin, concentration bottom, spent filter, and sludge drums generated during 2004 ~ 2008 were evaluated to identify radionuclide inventories. Eventually, only dry active waste among LILWs generated from Korean NPPs were first shipped to a permanent disposal facility on December 2010.

For the LILWs generated after 2009, the radionuclides are being radiochemically quantified because the Notice clarifies that the certifications of the scaling factors should be verified biennially. During the operation of NPP, the radionuclides designated in the Notice are formed by neutron activation of primary coolant, reactor structural materials, corrosion products, and fission products released into primary coolant through defects or failures in fuel cladding. Eventually, since the radionuclides released into primary coolant are transported into the numerous auxiliary and support systems connected to primary system, the LILWs can be contaminated, and the radionuclides can have various concentration distributions.

Thus, radioactive wastes, such as spent resin and dry active waste generated at various Korean NPP sites, were sampled at each site, and the activities of the regulated radionuclides present in the sample were determined using radiochemical methods. The scaling factors were driven on the basis of the activity ratios between α or β-emitting nuclides and γ-emitting nuclides. The resulting concentrations were directly compared with the established scaling factors' data using statistical methods. In conclusions, the established scaling factors were verified with a reliability of within 2σ, and the scaling factors will be applied for newly analyzed LILWs to evaluate the radionuclide inventories.

INTRODUCTION

Radioactive wastes in Korea have been largely divided into nuclear fuel cycle radwastes and non-nuclear fuel cycle radwastes. Nuclear fuel cycle radwastes are the waste generated in nuclear power plants (NPPs) and nuclear fuel fabrication facilities, and non-nuclear fuel cycle radwastes are generated in educational settings, medical institutes, and various industries. As increased in institutes and facilities utilizing radioactive materials in Korea, the generation of radwastes from nuclear facilities has tended to increase by approximately 10% each year. As the main generation source of radwastes, NPPs in Korea have been commercially operated at 4 sites since 1979. Korea has a total of 23 NPP units, which are comprised of 4 units of a pressurized heavy water type and 19 units of a pressurized light water type [1]. Low & intermediate level radwastes (LILWs) generated from these NPPs have reached approximately 90,000 drums as of March, 2012, and are still being stored at NPP sits [2].

The Korean scaling factor was finally developed in 2008 through hard work during 2004 ~ 2008, and approximately 1,500 drums have been shipped to a permanent disposal site in 2010 using the scaling factor [3,4]. LILWs generated after 2010 must be verified biannually based on Nuclear Safety and Security Commission (NSSC) Notice No. 2012-53, in which the acceptance criteria for LILWs is specified. For the performance of the periodic verification of the scaling factor, the regulated radionuclides in various classes of LILWs have to be assayed, and the results must be classified as corrosion products, fission products, and TRUs. Eventually, they must be checked to verify the established scaling factor.

In this study, radioactive wastes, such as spent resin and dry active waste generated at various Korean NPP sites, were sampled at each site, and the activities of the regulated radionuclides present in the sample were determined using radiochemical methods. The scaling factors were driven on the basis of the activity ratios between α or β-emitting nuclides and γ-emitting nuclides. Through a statistical t-test, the newly obtained analysis data compared with the scaling factor's data. Based on the comparison results, the LILWs generated during the new period will be applied by the scaling factor for shipping to the permanent disposal.

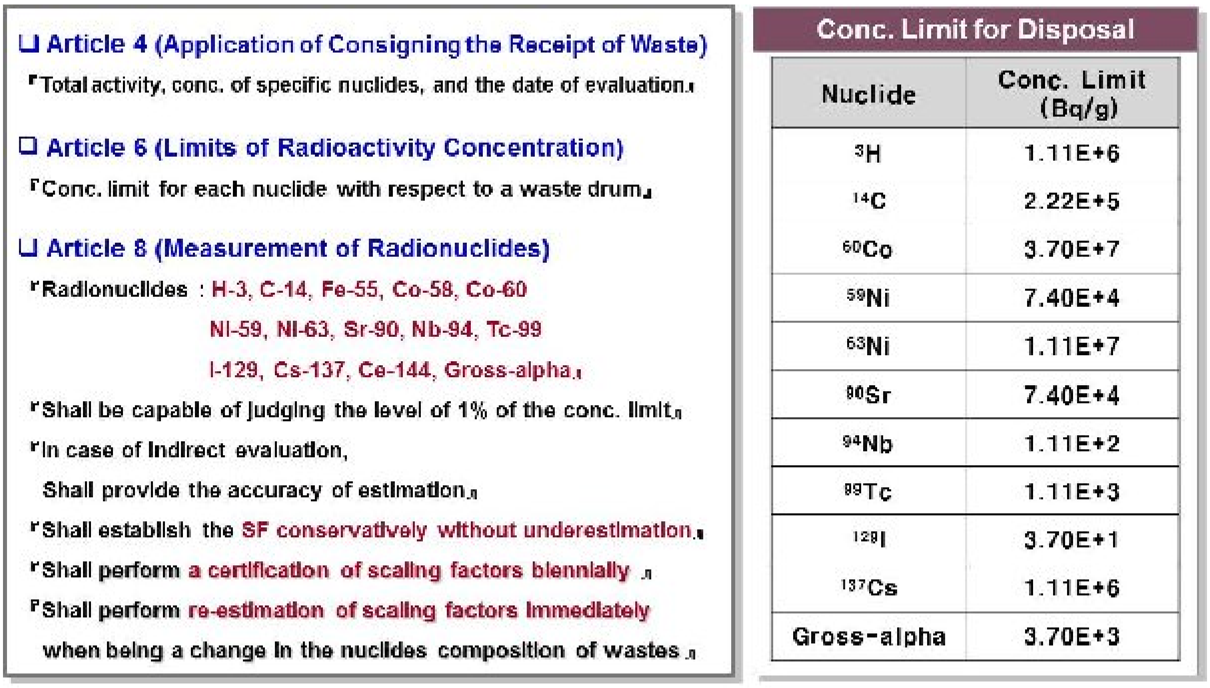

Figure 1. Summary of the acceptance criteria for LILWs (Nuclear Safety and Security Commission (NSSC) Notice No. 2012-53)

METHODS AND RESULTS

Analysis methods of the radionuclides

The sample was weighed and put in a 125 mℓ digestion vessel to be dissolved completely by using a HNO_3/HCl/HF mixed solvent, and subsequently, placed in a microwave oven (Ethos PLUS Milestone Microwave Digestion). Microwave with a maximum energy of 400W was irradiated for 20 ~ 50 minutes to dissolve the samples in the mixed solvent. A proper sampling is very important to avoid errors from the inhomogeneous distributions of the nuclides. Therefore, a single portion of the digested sample was sequentially used throughout the procedures before the γ-spectroscopic measurement [5]. Samples were classified into volatile DTM nuclides such as H-3, C-14, Tc-99, and I-129 and non-volatile compounds. C-14 and H-3 in radwastes were extracted into gaseous $^{14}CO_2$ and liquefied HTO by a wet oxidation and distillation method, simultaneously [6,7]. I-129 was separated and purified with an ion exchange resin and counted by a low energy gamma [8]. All the other wastes were completely dissolved by means of a microwave digestion system at a condition of 250 ~ 400 watt. Tc-99, Fe-55, Ni-59, Ni-63, Sr-90 and Nb-94 were individually separated by an ion exchange resin and an extraction chromatography [9]. Plutonium in the dissolved solution by the microwave digestion method was separated by using an ion exchange resin and the isotopic composition was measured by TI-MS. Am-241 and Cm-244 in the residual solution were purified using a HDEHP extraction and then measured by α- spectrometry after an electrodeposition [10].

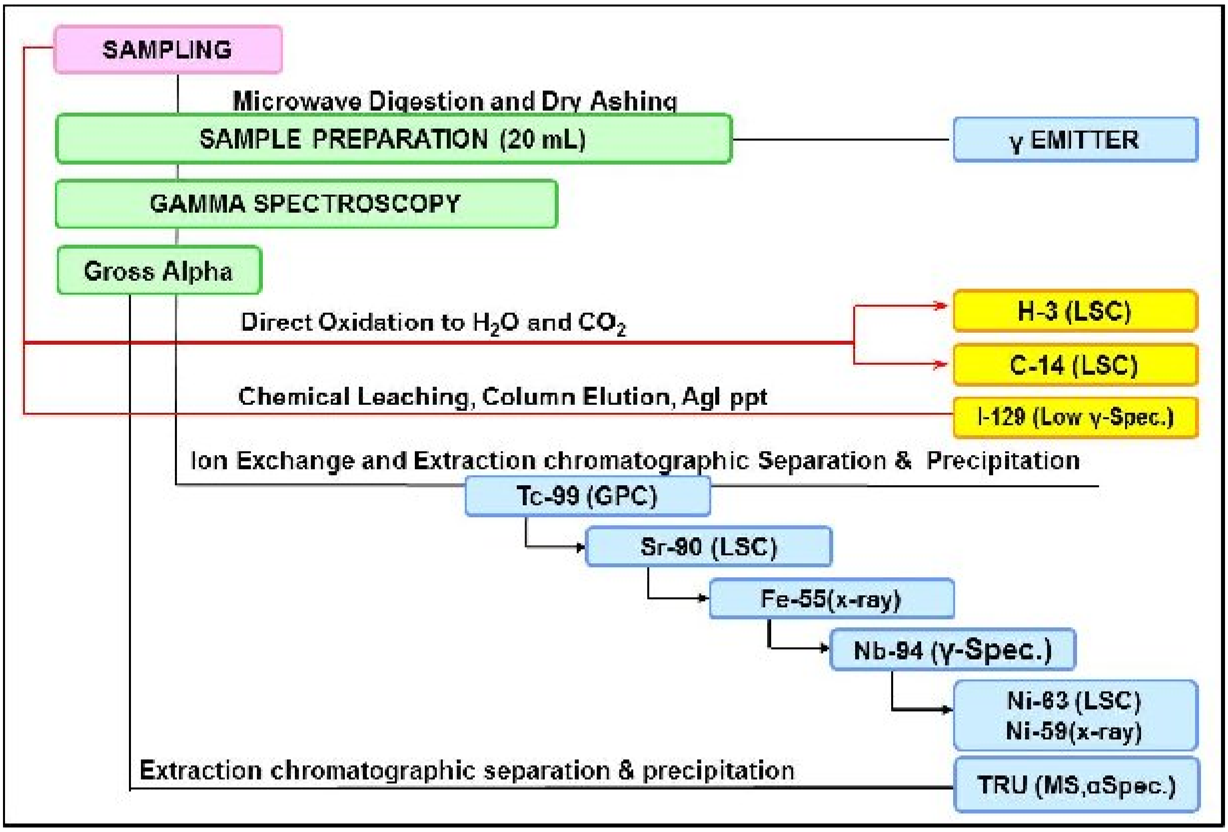

Figure 2. Systematic analysis methods of radionuclides

Results of Periodic verifications

A way in which the newly analyzed results from the LILWs may be tested is by comparing them with those used in determination steps of scaling factors. In this case means averages and standard deviations of two groups were used. In order to test H0 : μ1 = μ2 when it cannot be assumed that the two groups come from populations with similar standard deviations, the statistic t is calculated where

$$t = \frac{(\bar{x}_1 - \bar{x}_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \quad (1)$$

Where, s_1 and s_2 are standard deviations of group 1 and group 2, and n_1 and n_2 are the number of analyzed data.

Using equation (1), the newly obtained analyzed data was evaluated, and the example of C-14 was shown in Figure 3. In Figure 3, 1st data, which was analytical results from the radwastes generated during 2004 ~ 2008, was used to determine the scaling factors, and 2nd data was analytical results from the radwastes generated during 2009 ~ 2010.

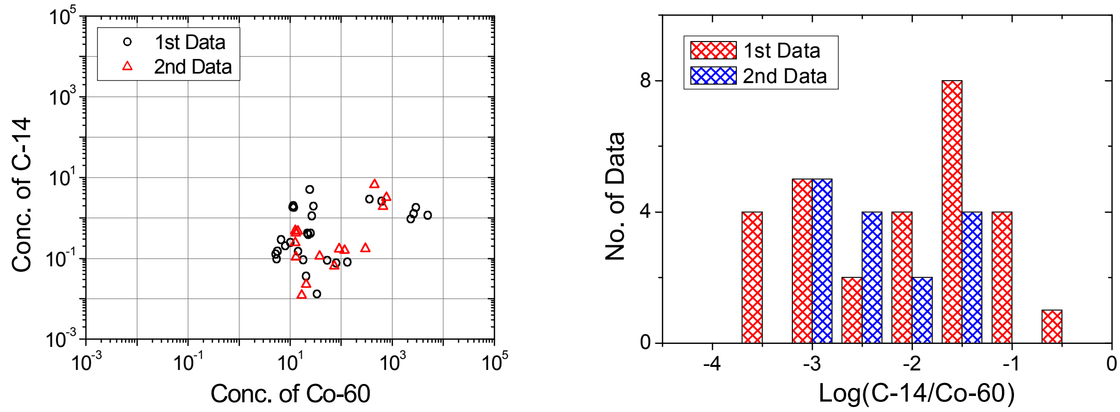

Figure 3. Evaluations of radionuclide distributions of C-14 for the application of the scaling factor

From Figure 3, 2nd data is included in the category of 1st data, and it was confirmed that the scaling factor can apply to 2nd data without re-estimation. As a t-test result, t was calculated to be 0.25. Since the observed value of t is less than the critical value so the null hypothesis is retained. The result is not significant at the 5% level.

CONCLUSIONS

The Korean scaling factor was determined with radwastes generated during 2004 ~ 2008 using radiochemical methods. The periodic verification for radwastes generated since 2008 was carried out based on the Notice of NSSC. Radwastes generated during 2009 ~ 2010 were radiochemically analyzed, and the results were compared to the scaling factor's data. As a verification result, it was reviewed that the radwastes generated at the new period was possible to be applied to the scaling factor without re-estimation.

REFERENCE

1. http://www.khnp.co.kr
2. 2012 Nuclear energy yearbook published in Korea Atomic Industrial Forum (2012)
3. K. W. Jee and H. J. Ahn, "Estimation of hard-to-measurement radionuclides in low & medium level radwastes from Korea NPP", ICEM'05 conference (2005)
4. K. W. Jee and H. J. Ahn, "Methodology for the determination of a scaling factor in Korean nuclear power plants", RADWAP 2008 conference (2008)
5. H. Y. Pyo, "Sample preparation of DRY radioactive wastes discharged from nuclear power plantS using a closed-vessel microwave acid digestion system", ICEM'05 conference (2005)
6. H. J. Ahn, H. N. Lee, and S. H. Han, "Simultaneous assay of ^{14}C and ^{3}H in evaporator bottom by chemical oxidation method", J. Kor. Rad. Waste Soc., 3, 193(2005)
7. S. D. Park, "Simultaneous determination of ^{14}C and ^{3}H for low and intermediate level radioactive wastes(LILWs) by wet oxidation-acid stripping process", ICEM'05 conference (2005)
8. K. C. Choi, "Determination of ^{129}I in radioactive wastes from Korean NPPs", ICEM'05 conference (2005)
9. C. H. Lee, M. Y. Suh, K. S. Choi, K. Y. Jee, and W. H. Kim, "Sequential separation of ^{99}Tc, ^{94}Nb, ^{55}Fe, ^{90}Sr and $^{59/63}Ni$", J. Radioanal. Nucl. Chem., 272, 187-194(2007)
10. K. S. Joe, T. H. Kim, Y. S. jeon, K. Y. Jee, and W. H. Kim, "Determination of ^{241}Am and ^{244}Cm in radwaste samples", J. Kor. Rad. Waste Soc., 3, 1(2004)