PRE-CONCEPTUAL STUDY ON THE REVIEW FRAMEWORK FOR THE RADIATION SHIELDING SAFETY OF THE PWR SPENT FUEL CASK INTERIM STORAGE IN KOREA

BYEONG-SOO KIM, JAE-HAK JEONG, CHAN-WOO JEONG
Korea Institute of Nuclear Safety
19 Kusong-Dong, Yusong-Ku, Daejeon, 305-338, Republic of Korea

ABSTRACT

In Korea, 20 nuclear power plants are in operation and lots of spent fuels are on the onsite storage. The onsite storage capacity in Korea is supposed to be full around at the year of 2016 and interim storage facilities could be considered to be constructed before 2016. A review framework to evaluate the radiation shielding safety of the interim storage facilities is developed in this study. It includes acceptance criteria, review procedures and activities of independent analyses. A case study is performed to apply the review framework. Modeling the review reference storage, evaluating the source terms and calculating the photon fluxes are performed. It is shown that the application of the review framework could satisfy the regulatory demand that would arise in the near future in the review area of the radiation shielding safety of the interim storage in Korea.

1. Plan for Interim Storage for Spent Fuel

Spent fuels generated from nuclear power plants in Korea are on the onsite storage in each unit. The onsite storage capacity in Korea is supposed to be full around at the year of 2016. Some plants had already encountered the excess of their initial storage capacity. For those plants of PWR type, the storage capacity has been expanded by adopting and implementing high-density wet storage racks. For PHWR reactors, an on-site dry storage facility has been constructed so as to expand their storage capacity.

The latest national policy for spent fuel management in Korea was made in 2004. It is that spent fuels should be stored within each nuclear power plant until 2016 by the additional expansion of the onsite storage capacity and the spent fuel management strategy including the construction of the interim storage facility shall be decided in a timely manner through national consensus by public consultation among stakeholders[1].

The detailed schedule for the interim storage for spent fuel is not yet decided. But, it can be seen that the interim storage facility might be in preparation by 2016 and the related researches should be ongoing. Also, it is supposed that a regulatory demand on the safety evaluation would arise before the year of 2016. In this study, a review frame for the radiation shielding safety of interim storage for PWR spent fuels is pre-conceptually developed to prepare for the regulatory demand. A case study is performed to apply the review framework.

2. Review Framework for the Radiation Shielding Safety

The main purpose of the study is to set up a review framework to evaluate the radiation shielding safety of the interim storage facilities. The review framework developed in this study is pre-conceptual, for the details of the interim storage facilities are not determined and the framework can be changed.

The review framework includes acceptance criteria, review procedures and activities of independent analyses. The acceptance criteria are input to review procedures and the compliance with the criteria is

output from the review procedures. Review procedures demand independent analyses such as source terms evaluation and shielding calculation. The simple diagram of the review framework is in Fig 1.

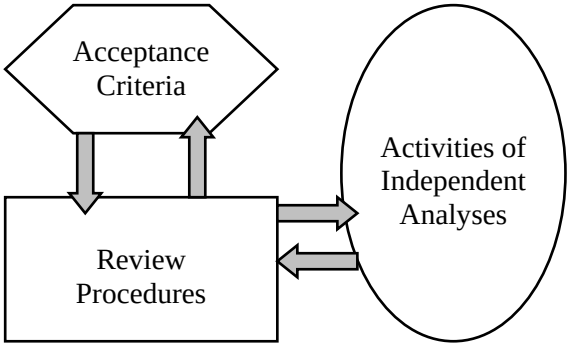

Fig 1. A simple diagram of the review framework

2.1 Acceptance Criteria

The acceptance criterion is assumed pre-conceptually to be the dose limit of 0.25mSv/hr at the boundary of the controlled area under the normal condition. It is from the U.S. Federal law of 10CFR72.106. It might be changed at the final review framework when the setup of the criteria of the interim storage in Korea is completed.

2.2 Review Procedures

Review procedures are consisted of several successive steps. A series of reviews for various areas is performed. This is the main review stage and the review conclusion will be produced.

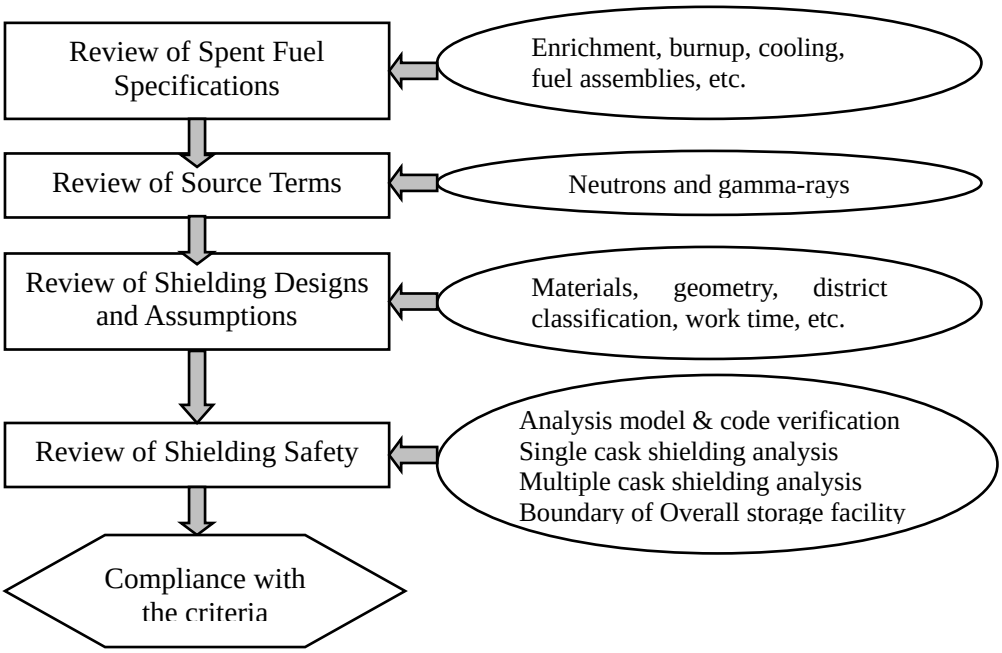

Fig 2. A simple diagram of review procedures

2.3 Activities of Independent Analyses

In the review procedures, independent analyses for source terms and shielding are required. To perform these analyses, proper tools could be chosen such as ORIGEN2.1, ORIGEN-ARP, MCNP, QAD, DORT, SCALE, etc. It is recommended that the different approach to modeling and codes from those of the utilities be applied in the independent analyses.

3. Case Study

For case study, some parts of the review framework are pre-conceptually applied to the PWR spent fuel cask interim dry storage. A review reference storage model is established and preliminary analyses for source terms and shielding performance are performed.

3.1 Review Reference Storage Model

A review reference is modeled for interim dry storage of the PWR spent fuels whose characteristics are 5 w/o U-235 enrichment, 50,000MWD/MTU burnup, 7 years of cooling and a storage capacity of 24 fuel assemblies.

3.2 Source Terms

The energy spectrums and the intensities for neutrons and gamma-rays are calculated and applied as the radiation source terms for the shielding analyses. ORIGEN-ARP (SCALE 5.0)[2] code and the embedded libraries are utilized to evaluate the source terms of the spent fuels.

3.3 Shielding Model and Analysis

To perform the shielding analysis, SAS4 (SCALE 5.0)[2] and QAD-CGGP-A[3] codes are used. Homogenization of the spent fuels, three-dimensional geometry modeling and the dose conversion factor of ANSI/ANS-6.1.1-1977[4] are applied. For a case of the single cask storage, dose rates are calculated by SAS4 and QAD-CGGP-A. For multiple casks such an array of 2x5, QAD-CGGP-A code is utilized due to its array function. Simplified geometry modeling of the cask storage is in Fig 3.

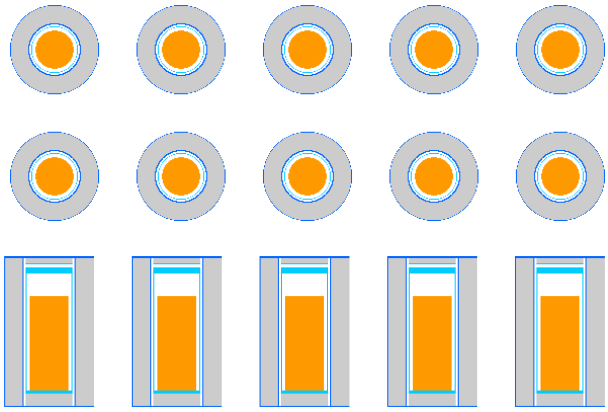

Fig 3. Simplified Cask Geometry Modeling of 2 x 5 array

3.4 Results

Dose rate are calculated to the 400 meters away from the cask storages. When the direct radiation is only considered and the effects of radioactive effluents not included, then, the distance in compliance with the dose limit of acceptance criteria is shown to be around 200 meters away for the one cask storage. The curves of dose rates for one cask storage are in Fig 4.

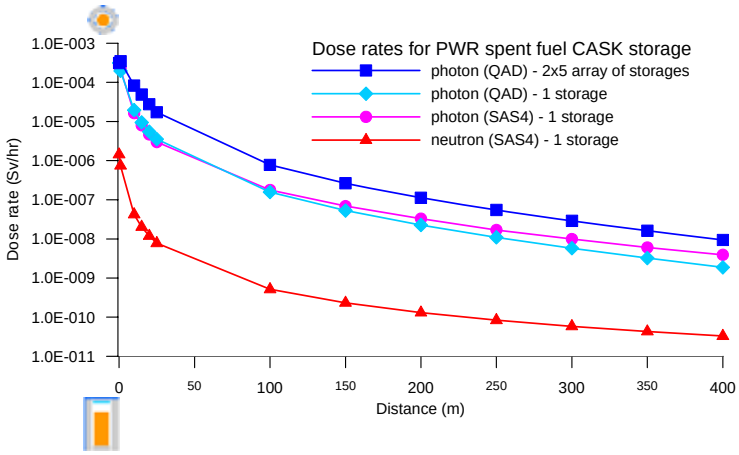

Fig 4. Dose rate for the one cask storage

For the array of 2x5 cask storages, the dose limit is satisfied as the distance of 300 meters. The photon dose rates within the cask storage and with the distances are shown in Fig 5 and Fig 6, respectively. At the final review stage, all the contributions to the dose including radioactive effluents would be summed up to evaluate the boundary.

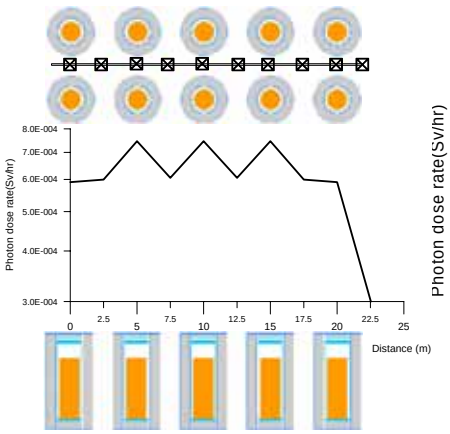

Fig 5. Photon dose rates within the array

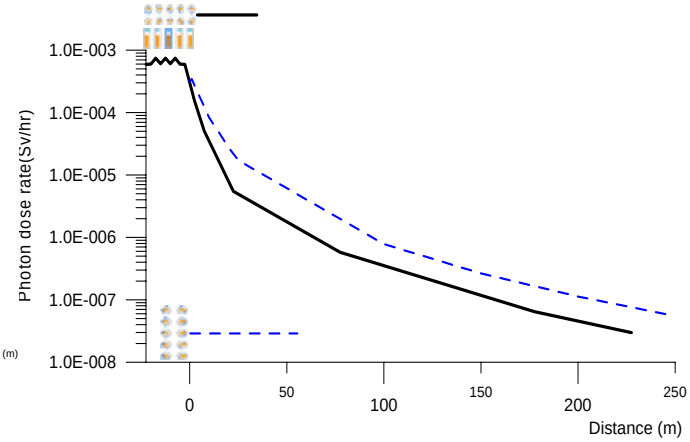

Fig 6. Photon dose rates for the array

4. Conclusion

In this study, a pre-conceptual structure of the review framework for the shielding safety evaluation is developed and preliminary activities of independent analyses including modeling the review reference storage, evaluating the source terms and calculating the photon fluxes are performed. Now the review framework is being developed and not completed yet. Currently activities of analyzing the effects of neutron streaming, Co-60 gammas and radioactive effluents are missed. The further study will be continued to set up the review framework completely to cover the missed issues. After the review framework is completed later, it is expected that the application of this review framework will satisfy the regulatory demand that will arise in the near future in the review area of the radiation shielding safety of the interim storage in Korea.

References

[1] J. H. Cheong, et al., Development of Regulatory Technology of Radioactive Waste, KINS/GR-297, 2005

[2] SCALE: A Modular Code System for Performing Standardized Computer Analyses for Licensing

Evaluations," ORNL/TM-2005/39, Version 5, Vols. I–III, April 2005

[3] K.A. Litwin, I.C. Gauld, G.R. Penner, "Improvements to the Point Kernel Code QAD- CGGP: A Code Validation and User's Manual," RC-1214, COG-94-65, AECL Research, August 1994

[4] ANSI/ANS-6.1.1-1977, American National Standard Neutron and Gamma-Ray Flux-to-Dose-Rate Factors, American Nuclear Society, March 1977