Analysis of Electromagnetic (EM) Radiation Shielding and Decay Chain for Nuclear Waste Treatment

Syed Bahauddin Alam¹*, Md. Didarul Alam , Palash Karmokar†, Asfa Khan†, Md. Nagib Mahafuzz†, Farha Sharmin†#, Hasan Imtiaz Chowdhury, Md. Abdul Matin

Department of EEE, *Bangladesh University of Engineering and Technology (BUET), Dhaka
†University of Asia Pacific (UAP), Dhaka
†#Development Research Network (D.Net)

¹baha ece@yahoo.com

Abstract

At present eons, equating cost factors, environmental issues, power generation with other substitute energy informants, atomic or nuclear power is turning into a popular alternative as an energy option. Though it is clean and safe alternative, nuclear waste is still a matter of great concern. In this paper, nuclear waste treatment for nuclear plant by radioactive and electromagnetic shielding via dose conversion factors, photons and neutrons response functions has been explained. Moreover, analyzing of Quality-Factor and Poisoning decay of Xenon and Samarium has been discussed.

Keywords: EM (Electromagnetic) shielding, dose, kerma, Quality-Factor, poisoning, Samarium, Xenon, digital watermarking.

1. Introduction

The promising conveyable of nuclear waste materials from nuclear reactors and defense amenities to a repository is the essence concern in the present eon. The aspiration of waste treatment is of grave importance now in order to handle nuclear waste transportation issues at the local, tribal, state, regional and national levels. For fossil fuel burning power plants, solid waste is primarily a trouble for coal based power generation. Approximately 10% of the substances of coal is ash which often includes metal oxides and alkali. Such residues necessitate disposition, generally burial, though some reprocessing is possible, in a manner that limits migration into the general environment. Volumes can be substantive. While burning in a power plant, oil also yields residues that are not entirely burned and thus conglomorate. These residuals must also be disposed as solid wastes. Once the fission operation in the reactor has decelerated, the fuel rods are supplanted. The spent fuel rods hold extremely radioactive fission products and must be stored safely. These used fuel rods are regarded as high level nuclear waste. Currently all high level nuclear waste is stored in large pools of water at the power plants where it was generated. Seven to ten feet of water is enough to stop all radioactivities. Since the late 1950’s, high level nuclear waste has been stored in this form, and there has never been any release of radioactivity. There is actually a relatively small amount of high level nuclear waste. For controlling and transmutation of radionuclides physical operation can be made at reactor for mitigating waste virility. In this paper, nuclear waste treatment by radioactive and Electro-Magnetic (EM) shielding via dose conversion factors, photons and neutrons response functions has
been explained. Moreover, Quality-Factor, dose rates and kerma is calculated, controlled and explained for that purpose. Finally Poisoning of Xenon and Samarium and Decay Chain has discussed.

2. Electromagnetic (Em) Radiation Shielding Technology (ERST)

In analysis, the source and shielding are identified and the task is to influence the resultant dose. The task is to regulate the existence of the shielding required to accomplish the destination. At commencement it must be said that screening contrives and shielding analysis are complementary activities. In convening, the source is identified and a target dose goal is specified. Whether one is engaged in a hand computation or in a most elaborate Monte Carlo model, one is confronted with the chores of (1) qualifying the source, (2) characterizing the nature and rarefying dimensions of the shielding materials, (3) valuating at a target location the radioactivity strength and possibly its angular and energy dispersions, and (4) commuting the saturation to a dose or reaction substantive in terms of action therapy cores. Monte Carlo codes are amenable to these more complex shielding problems and have become more and more popular as high-speed ciphering has become uncommitted to so many people. Generally, nevertheless, they do require considerably more expertise and aiming to use and are often much denser in accomplishing a root than are the deterministic methods.

Two more foundation stones need to be in place to support a mature radiation shielding technology. Working with buildup factors computed using the P ALLAS code, Harima developed a data fit in the following form, called the geometric progression formula. This appears to be a very exotic, even eccentric, fitting formula. Both the results of PALLAS calculations and the constants for the patterned advance buildup factors are tabularized in pattern criteria. One is a comprehensive set of samples, or interaction coefficients, explicating not only reactions but also dosimeters colligated coefficients such as those for energy dethronement. Another is a set of efuence-to-dose factors relevant to a comprehensive alignment of dosimetry stipulates. By controlling these parameters, PALLAS code and hyperbolic functions, dose conversion factors can be controlled. The phantom dose, in fact, is a point function and serves as a standardized reference dose for instrument calibration and radiation protection purposes. A local irradiation dose within a simple geometrical phantom or some sort of intermediate dose within an anthropomorphic phantom by phantom-related dose is considered. Dose conversion factors are also usable for three profundities of incursion into the geometric phantom: (1) a 10-mm depth, the dosage being called the ambient dose, a foster to the earlier whole body dose and the dose suitable for instrument standardization; (2) a 3-mm depth, suited for exemplifying the dose to the lens of the eye; and (3) a 0.07-mm depth, desirable for constituting the dot to the skin. At energies over about 0.1 MeV, the assorted photon response mappings are very closely equal. Personnel dosimeters are usually calibrated to contribute responses proportional to the ambient dose. This is a fortunate position for radiation mensuration and surveillance determinations. Both the ambient dose and the tissue Kerma closely estimate the efficacious dose equivalent. The unshielded dose rate at the dose point is given by. For Shielded primary photon dose rate, primary photon dose rate is attenuated exponentially, and the dose rate from primary photons, taking account of the shield. An intimately concerned deterministic quantity, used only in association with circuitously ionizing (uncharged) radioactivity, is the Kerma, an acronym for ‘Kinetic Energy of Radiation Absorbed Per Unit Mass’. The absorbed dose is, in principle, a measurable quantity; but in many contexts it is unmanageable to compute the immersed dose from radiation of ence and material properties. The calculation of the kerma (rate) is closely related to the reaction (rate) density. In a
neutron dissipate, the scattering nucleus recoils through the medium producing ionization and innervations of the ambient atoms. The primary mechanism for transferring the neutrons kinetic energy to the medium is from neutron scattering interactions, when fast neutrons pass through a medium. The average neutron energy loss (and hence average energy of the recoil nucleus) for isotropic elastic scattering in the center-of-mass system of a neutron with initial energy E. The Quality-Factor and the Absorbed Dose are both point functions that is deterministic measures that may be assessed at points in infinite. Their product is identified as the dose equivalent H and is distinguished as a reserve assess of radiotherapy jeopardy when enforced in the context of establishing radiation protection guideposts and dose determines for population radicals.

3. Nuclear Waste Treatment by Poisoning: Decay Chain (NWTPDC)

In a reactor core the fission products that accumulate are of concern for two explanations. First, they play long-term ignite origins through their disintegrations. Second, they act as epenthetic neutron absorbent or toxicants that, over time, decrease the thermal utilization factor and, thus, bring in electronegative reactivity into a core. For fission products acquired from the fission of \(^{235}\)U, it is often presumed that each fission produces 1 atom of static poisonous substance with an concentration cross section of 50 barns. While this simplistic rule-of-thumb exploits for long-term reckonings of burn up effectuates, the two particular poisons \(^{135}\)Xe and \(^{149}\)Sm have such prominent absorption cross sections that they must be tempered on an individual basis. To determine the reactivity transient caused by a particular fission product poison, \(N_p t / \sum f\) buildup equations for the poison decay chain and a quantity that is found from the decay. The reactivity \(\rho\) introduced by a fission product poison is directly proportional to its average concentration \(N_p\) in the core. where \(k_{\text{eff}}\) indicates the core with the poison included and \(k'_{\text{eff}}\) refers to the same core without the poison. Since the poison changes only the thermal utilization factor, the two multiplication factors are related to each other by \(k_{\text{eff}} = k'_{\text{eff}} = f\). A very small nuclear denseness of Xenon nuclide can have a right smart reactivity consequence. Of all isotopes it has the largest thermal neutron absorption cross section. For Counterbalancing Xenon Poisoning, a reactor operating at a constant flux density \(\phi_0\), the equilibrium concentrations of \(^{135}\)I and \(^{135}\)Xe are found from decay per buildup equations by setting the time derivative to zero. The result is Equilibrium Xe(135)and I(135) concentrations as a function of the steady-state flux density. From equations it is understood that, while the \(^{135}\)Xe concentration is independent of \(\phi_0\) at high flux density levels, the \(^{135}\)I concentration continues to increase linearly with \(\phi_0\). Xe(135) transients shutdowns from equilibrium at constant flux densities, \(^{135}\)I would decay away, and the \(^{135}\)Xe concentration would finally begin to decrease as it decays. \(^{135}\)Xe transient for the buildup to equilibrium is shown in Fig. 10 following the shutdown from various flux levels. If during the shutdown transient, reducing the \(^{135}\)Xe reactivity temporarily to below its equilibrium values, the reactor were started up again, the large absorption cross section for \(^{135}\)Xe would cause this nuclide to be burned up very rapidly. Examples of these restart transients. In many power or propulsion reactors, the time to poison is usually only a few tens of minutes, and the operator may go through substantial force to acquire the reactor resumed before it poisons.
out so as to avoid a protracted period of lost production. Once the reactor has poisoned out, it is requisite to postponement until the negative $^{135}$Xe reactivity has peaked and descended back to a level that can be offset by all controllable positive reactivities. The time from the closure until the reactor poisons out is called the time-to-poison. The interval throughout which the reactor cannot be resumed is called the poison shutdown time and is typically of 15-25 hours continuance. It is unimaginable to restart the reactor, and the reactor is stated to have poisoned out. $^{135}$Xe equilibrium flux density before shutdown. The second fission product poison which must be accounted for explicitly in power reactors is $^{149}$Sm. This stable nuclide is a daughter of the fission products $^{135}$Sm and $^{135}$Pm. The generation rate of $^{149}$Sm is the decay rate of $^{149}$Pm. There is negligible production of $^{149}$Sm as a direct fission product. Since $^{149}$Sm is stable, the only way it can vanish is for it to absorb a neutron which it does at a volumetric rate of $\sigma_a^s \phi (t) S(t)$ where $S(t)$ is the average $^{149}$Sm concentration. Thus at equilibrium, all reactors have the same amount of $^{149}$Sm poisoning.

5. Conclusion
Radioactive waste comes from many places in the nuclear fuel cycle, but fission products generated in reactors dominate both the high-level and low-level problems. Nuclear waste management technologies via PUREX process, ISR and Laser Isotope Separation (LIS) technology, RSICC software, DIMS system development and modernized radioactive waste treatment processes are adopted at earlier and it is apprehend that, nuclear waste treatment technology is more efficacious than the conventional one. In this paper, nuclear waste treatment by radioactive and electromagnetic shielding via dose conversion factors, photons and neutrons response functions has been explained. Moreover, analyzing of Quality-Factor and Poisoning decay of Xenon and Samarium has discussed. Through proper management and treatment technologies of nuclear wastes discussed in this paper, world can have nuclear energy as a safe and clean future energy reservoir.

References


Fig. 1. Buildup factors computed by geometric progression method the PALLAS code
Fig. 2. Photon Response Functions

Fig. 3. Neutron Response Functions
Fig. 4. Equilibrium Xe(135) and I(135) concentrations as a function of the steady-state flux density.

Fig. 5. Xe(135) transients shutdowns from equilibrium at constant flux densities.

Fig. 6. Xe(135) transient for the buildup to equilibrium.
Fig. 7. Xe(135) Equilibrium flux density before shutdown

Fig. 8. The buildup of Sm(149) to equilibrium
This academic article was published by The International Institute for Science, Technology and Education (IISTE). The IISTE is a pioneer in the Open Access Publishing service based in the U.S. and Europe. The aim of the institute is Accelerating Global Knowledge Sharing.

More information about the publisher can be found in the IISTE’s homepage: http://www.iiste.org

The IISTE is currently hosting more than 30 peer-reviewed academic journals and collaborating with academic institutions around the world. Prospective authors of IISTE journals can find the submission instruction on the following page: http://www.iiste.org/Journals/

The IISTE editorial team promises to the review and publish all the qualified submissions in a fast manner. All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Printed version of the journals is also available upon request of readers and authors.

IISTE Knowledge Sharing Partners

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digital Library, NewJour, Google Scholar