www.ijiarec.com

ISSN:2348-2079

Volume-5 Issue-2

International Journal of Intellectual Advancements and Research in Engineering Computations

Experimental and Theoretical Analysis of Radiation in Industrial Radiography (IR-192) using Tenth and Half Value Layer Thickness in Concrete and Steel

M. Manikandan[1], V.Naveen Kumar[2]

[1]Assistant Professor, [2]UG Students,
Department of Mechanical Engineering, Nandha Engineering College, Erode-52,
Tamil Nadu, India.

[1]mmaniser@gmail.com, [2] thirunaveenme@gmail.com

Abstract - Radiography is used in wide range of application including medicine, engineering, forensic, security, etc. In NDT, radiography is one of the most wide used fields. Radiography Testing Method (RT) provides serious no. of advantages were used to find hidden flaws by the ability of short wavelength to penetrate materials. The Intensity of radiation is either captured by Film Radiography or in Real time Radiography. The radioactive sources Ir-192, Co-60 or in rare use of Cs-137. For Safety Shielding Concrete and Steel and Lead is used to reduce the intensity of radiation and Exposure to the Radiographer. The concept of Tenth and Half value layer thickness is widely used in shielding. In thisstudy, Experimental Reading is compared with Theoretical one using TVL and HVL thickness is calculated for steel and concrete. In which Radiation is used, were determined from measurements, using collimated beam of gamma rays from an Iridium-192.

Index words - Industrial Radiography, Newton's Inverse Square Law, Radiation Unit (RHM), Energy Value, Curie and Curie Strength, Decay Factor.

I. Introduction

Ionizing radiation has become a very important in our technological world, especially in industrial radiography. This radiation interacts with matter in two ways, by ionization and excitation. Absorbed radiation can cause biological damage in living tissues and DNA for radiographer. As per Standard followed in BARC one should receive 1mR/Per Hour. The principles of protection from gamma radiation sources are governed by four factors: time, distance, shielding and activity [1]. Shielding is the basic method for radiation protection. Intensity of gamma rays is attenuated exponentially. Therefore, theoretically it is not possible to attenuate the ionization radiation completely, although the dose rate can be reduced by any desired factor by an appropriate thickness of shielding. Thus, the half value layer, reduces dose rate to one-half of the initial dose, the tenth value layer, reduces dose rate to one-tenth of the initial dose rate [2]. The concrete used in shielding construction in enclosure, and also for test materials like steel various types of steel material. Concrete is very efficient both in absorbing gamma rays and in slowing down fast moving neutrons by the methods of elastic and inelastic scattering, because it consists of mixture of hydrogen and other light nuclei and the nuclei of fairly high atomic number [3]. Besides the physical and mechanical properties of concretes and steel, used in shielding construction, the radiation shielding properties should also be known. The thickness of any given material, at which .1*100% or .5*100% of the incident energy has been attenuated is known as the tenth- value layer (TVL) and half value layer thickness (HVL)respectively. The Tenth Value and Half Value layer thicknesses are expressed in units of distance (mm). These are photon energy dependent, and energy value, like the attenuation coefficient [4]. HVL and TVL values are the most frequently used quantitative raw factor for describing the penetrating ability of specific radiations through material like steel and concrete and lead and tungsten [5]. In this study, TVL and HVL thicknesses are calculated for concrete and steel used as shielding and work bench material. The thickness of concrete is 450 mm with density of 2500–3000 kg/m^3 and steel (SA 516 Gr 60/70) carbon steel with density factor of 7810 Kg/m^3. The experimental Verification are done using Camera Type (ROLEY-2) with the curie strength of 60.01 and collimated with radiation of Ir-192. The Experimental verification is done with a help of BRC level I Radiographer.

II. THEORETICAL VERIFICATION

The theoretical verification depends upon the factors type of radiation sources loaded in the camera. For a type of ROLEY-2 camera source of Ir-192 is loaded and the curie strength loaded in camera 60.01 Ci. The rate of photon charge is 0.55 or 55%. The unit used to measure is Rongenten per hour per meter distance (RHM). The half-life period of Ir-192 radiation is 74.5 days.

The linear attenuation co-efficient describes the fraction of gamma rays that is absorbed or scattered per unit thickness of the absorber. Tables and graphs of the mass attenuation coefficient for elements and mixtures as a function of radiation energy which are available in literature. Since the linear attenuation co-efficient is depend upon the density of material, the mass attenuation coefficient is often reported for convenience.

Isotopes decay rate represents the half-life of the radioactivity. Half-lives of radioactive materials range from micro seconds to billion years. Ir-192 is 74.5 days. In order to find the remaining activity of a certain with a known half-life value after a certain period of time, the following formula may used

$$\text{Curie Strength}=\frac{loaded\ curie}{2^{\frac{passed\ days}{74.5}}}$$

The energy range of Iridium-192 will emit 0.31, 0.47 and 0.60 MeV gamma rays. In which shielding level of Ir-192 requires less. Interaction between penetrating radiation and matter is considered in radiography shielding. Since the probability encounters with the matter of distance travelled, the number of photons reaching a specific point within the matter decreases exponentially with the distance tarvelled as shown in the graph. If 1000 photon are aimed at ten 1 cm layers of material and there is 10% chance of a photon being attenuated in this layer.

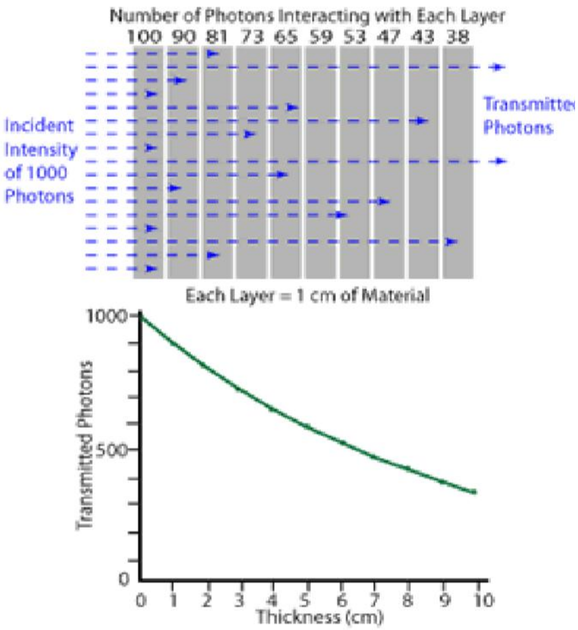

Fig.1

$$I = I_0 e^{-\mu x} (1)$$

Where,

I_0 : Initial intensity

μ : linear attenuation coefficient per unit distance

x : distance travelled through the matter

The thickness of any given material where 50% of the incident and 10% of the incident energy has been attenuated is known as the half-value layer and tenth value layer. It is a photon dependent.

The HVL and TVL are inversely proportional to the attenuation coefficient.

$$HVL=\frac{0.693}{\mu}$$

In order to calculate the ratio of intensity attenuation resulting from passing through a certain thickness of a material for which HVL is known,

$$r_1 = (0.5)^{(thickness/HVL)} (2)$$

$$r_2 = (0.1)^{(thickness/TVL)} (3)$$

The eqn (2) & (3) represent the halh value and tenth value layer formula of the described material on specific density and material property.

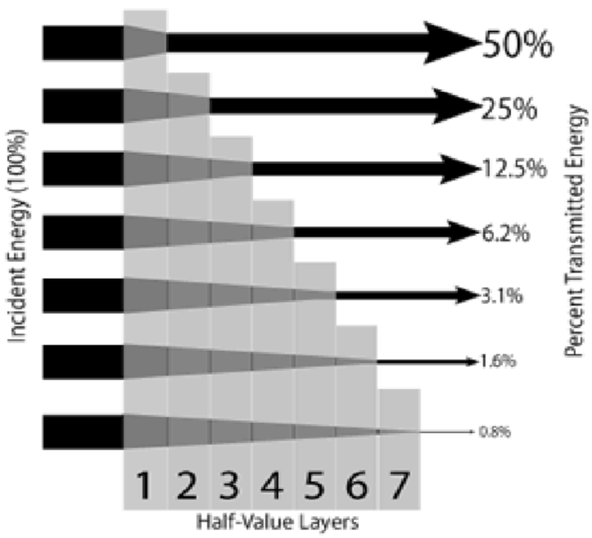

Fig.2

III. INTENSITY CALCULATION OF MATERIALS

i. Concrete:

Curie strength: 28 ci (90.52days)

Intensity = 28×.55

=15.4 RHM or 15400 mRHM

Thickness of concrete is 450 mm. from equation (2) sub. The value of intensity coming out of the concrete is r_{1} =13.52 mRHM

ii. Steel:

Curie strength: 28 ci (90.52days)

Intensity = 28×.55

=15.4 RHM or 15400 mRHM

Thickness of steel placed as shielding is 64mm. from equation (2) sub. The value of intensity coming out of the steel is r_{1} =468.29mRHM

IV. EXPERIMENTAL RESULT

In experimental setup, the process is carried in an industry. The dimension of shielded enclosure is 10000*6200*5000 mm.

They type of camera and radioactive source is ROLEY 2 and Ir-192 source.as per the decay chart and using the half-life period the curie level is calculated and intensity of radiation is determined.

The exposure of radiation in concrete is lead for 10 sec and the intensity of radiation is absorbed using the collimeter and checked in survey meter how much the intensity of radiation is absorbed per unit area and for 450 mm thickness material the intensity is 13.79mRHM.

The same process is repeated for the steel and the density of steel material and grade of steel is standardized in ASME Procedure. SA 516 grade60/70 material of medium carbon steel is specified with density of 7810 kg/m^3.

V. CONCLUSION

The Experimental and theoretical analysis shows the variation and the shielding material preferences. The density of material in which used as an shielding in which the incident photon study analysis and calculated using the half value and tenth value layer thickness. The study shows the intensity of radiation attenuated through the given material and absorbent rate of photon based on the density of materials.

REFERENCES

[1] S. Vallabhajosula, Molecular Imaging: Radiophar- maceuticals for PET and SPECT, Springer Science & Business Media, 2009, p. 392.

[2] NCRP Radiation Protection in Educational Institutions, National Council on Radiation Protection and Measurement, Report No. 157 (2007).

[3] F.A. Ikraiam, A. Abd El-Latif, A. Abd El-Azziz, J.M. Ali, Arab J. Nucl. Sci. Appl. 42, 287 (2009).

[4] I. Akkurt, C. Basyigit, A. Akkaş, S. Kılınçarslan, B. Mavi, K. Günoglu, Acta Phys. Pol. A 121, 138 (2012).

[5] P. Sprawls, The Physical Principles of Medical Imag- ing, 2nd ed., Aspen Publication, NY, USA, 1993.

[6] I. Akkurt, K. Günoglu, C. Basyigit, A. Akkaş, Acta Phys. Pol. A 123, 374 (2013).

[7] A. Akkaş, Suleyman Demirel University Technology, Faculty Civil Engineering, 32260 Isparta, Turkey.

[8] H.Durmuz, A.Beri Tugral and B.Buyuk, Istanbul Technical University, Energy Institute Nuclear Researches Division, Turkey.

[9] Manual on Shielded Enclosure, International Atomic Energy Agency.

[10] NDT Resource Centre https://www.nde-ed.org/EducationResources/CommunityCollege/RadiationSafety/safe_use/shielding.htm

[11] Sh. Sharifi, R. Bagheri, S.P. Shirmardi, Ann. Nucl. Energy 53, 529 (2013).

[12] P. Papagiannis, D. Baltas, D. Granero, J. Pérez- Calatayud, J. Gimeno, F. Ballester, J.L.M. Venselaar, Med. Phys.35,4898(2008).