



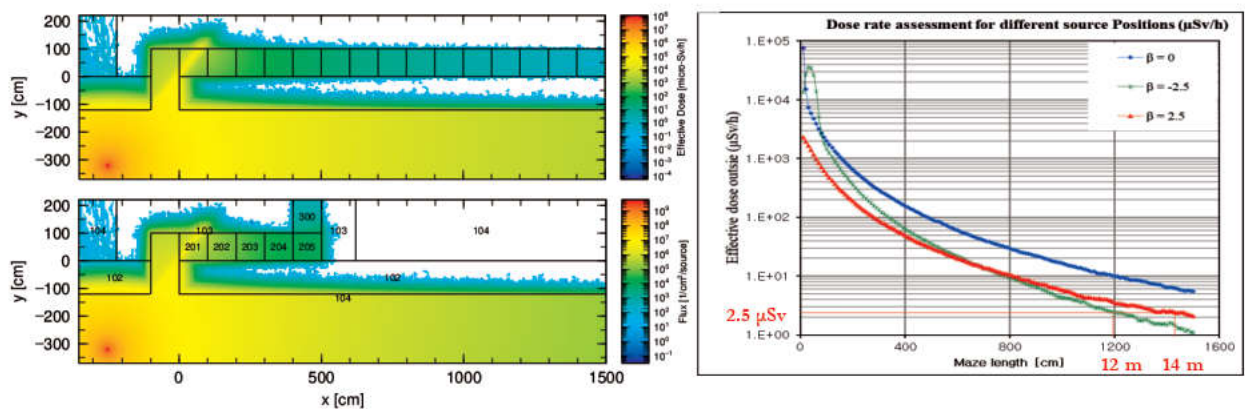
Korea Advanced Institute of Science and Technology



Korea Institute of Nuclear Safety

Technical Rules for Radioactive Source Storage for NDT Companies in Cameroon based on PHITS Monte Carlo Simulations.

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ABSTRACT

Industrial radiography has been spreading world widely and its use as non-destructive testing method for different equipment, goods, and object of all sort has been proved to be an essential indispensable technique for objects' control. Depending on the type of sources used, attention must be paid differently on the protective measures to be taken around a facility. In this regard, protection measures around an X-ray generator are different from those necessary to protect people and environment around a radioisotope, which spontaneously emits radiation, alpha, beta, gamma, or neutron, until it decays to a stable isotope or element. As the great issues of protection highlighted along with justified activities is the measure to limit the dose to an acceptable limit, the present study was projected to solve the problem of shielding design around industrial radiographic facilities using gamma and neutron sources. Gamma sources of Co-60 under 100 Ci and Ir-192 under 50 Ci and a neutron source of Cf-252 with an activity of 100 Ci were considered as typical sources used in fixed industrial radiography. The PHITS Monte Carlo code was used to compute the appropriate concrete wall necessary to shield gamma radiation and the most effective material appropriate to shield neutron source. For the gamma radiation source, the shielding design took into consideration the double and single corner maze, while the in the neutron radiography testing room, only a reinforced shielded door was necessary without maze design.

The result of the calculation showed that the minimum concrete wall thicknesses necessary to shield the radiation were 70 cm, 120 cm, and 250 cm for the Ir-192, Co-60, and Cf-252 sources, respectively. All the presented values were obtained with acceptable statistic except the case of Cf-252 where the calculation involving neutron interaction was time consuming and computing resources demanding. In addition, different materials were subjected to investigation to find out the most appropriate for neutron shielding as the Cf-252 spontaneous fission produce fast neutrons. These fast neutrons undergo moderation in hydrogenous or light material prior to their absorption in borate material where they produce gamma ray shield using concrete of dense material. It was found that tungsten was efficient in shielding energetic neutron, but is expensive to be used in shielding design. Paraffin, graphite, polyethylene, plastic, and iron could be used for neutron slowing down process and the combination of some of these material is more effective. Water (light and heavy), the most effective neutron moderator of lithium cannot be used in radiographic test rooms as they posed a structure problem (easy leakage, difficult to use in wall form). Also, while using hydrogenous material, attention should be paid on the safety and security of the design, construction and operation of the facility as the fire likelihood increase.

Gamma ray shielding design showed that the most appropriate design to shield gamma from sources used in industrial radiography facilities in the double corner maze, compare to the single corner maze. The maze length necessary to shield gamma radiation up to 2.5 $\mu\text{Sv/h}$ in single corner maze design is almost the triple of the maze length needed in double corner maze design. This conclusion highlighted the importance of cost-benefit analysis in a plan stage prior its design, construction, commissioning, operation, and decommissioning. Three different positions of the source were evaluated and the outcome showed that the central position of the source in radiography testing facilities should never be allowed, unless there are special justifications as it is the case with highest exposure rate to the boundary areas enclosing the facility. The choice between the left and right position of the source in the facility merely depend on the length of the maze in the case the design is single corner maze. For example, in the case the source of cobalt-60 is used for neutron imaging, the left position of the source should be preferred when the maze length is less than 7 m and the right position if not. For iridium-192 source in industrial radiography facilities, the single maze design showed that at least 5 m maze length is needed to set the source position on the right side.

Neutron shielding is complex in industrial radiography using fast neutrons as those emitted by the spontaneous fission source of Cf-252 investigated in this research. Maze design is not appropriate for

neutron shielding and the shielded enclosure in this case should be made of reinforced door including material for neutron slowing down, its absorption and the gamma-ray shielding. From the computation based Monte Carlo methods, the following material should be used in combination with iron for slowing the energetic neutron, boron or borate material for neutron absorption and concrete or lead and the end of the chain for gamma attenuation. The combination of three to five material could be enough when well-chosen and the shielded enclosures should be design and constructed based on a long term plan evaluation. Attention should be paid on materials used to avoid the critical problem of activation as the neutron interaction with an alloy is likely to produce new radioisotope with high risk of contamination.

To keep the effective dose rate as low as reasonably achievable (ALARA) in the areas adjacent to the radiographic facilities, the International Atomic Energy Agency (IAEA) has developed regulatory guidelines, safety reports series, and various number of technical documents to help governments, institutions, and individuals involved from near or far in the use of radioactive sources in the practice of radiography. These guidelines have been using worldwide to develop a safety culture and network with less risk of radiological accident from the industrial side. As the National Radiation Protection Agency of Cameroon is the regulatory authority in Cameroon for the practice of industrial radiography, there is a particular need of clear and precise regulation on the use of radioactive sources for non-destructive test. The regulatory authority has the opportunity to consider the Korean regulation (or USNRC one) and the IAEA case to develop appropriate laws and rules for safe acquisition, possession, planning, designing, construction, commissioning, operation, and decommissioning of a radiography testing facility. The licensees, radiographers, and any individual involved in the use of gamma or neutron sources for activities related to industrial radiography could then have a law as foundation and regulation for their practice without ambiguity.

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CONTENTS

ABSTRACT	3
ACKNOWLEDGEMENT	v
CONTENTS	8
LIST OF FIGURES	11
LIST OF TABLES	14
CHAPTER 1. GENERAL INTRODUCTION AND BACKGROUND	1
1.1. Introduction.....	1
1.2. Background of the study	1
1.3. Objective of the research.....	2
1.4. Overview of the research and state of the art	3
1.5. Application of sealed radioactive sources in radiography	4
1.6. Safety and security of radioactive sources	5
1.7. Structure and environment of the work.....	6
1.8. Scope and structure of the study	6
CHAPTER 2. INDUSTRIAL RADIOGRAPHY	8
2.1. Introduction.....	8
2.3. Regulation in industrial radiography.....	10
2.3.1. The responsibility of the government (regulatory authority)	11
2.3.2. The operating organization	11
2.3.3. Industrial radiographers, manufacturers, and clients	12
2.4. Safety and security of radiation sources.....	12
2.5. Safety issues and regulatory framework	13
2.6. High intensity fixed radioactive sources (sources and containers).....	14
2.7. Radiation protection principle	16
Conclusions	17
CHAPTER 3. GAMMA RADIOGRAPHIC ROOM	18
3.1. Introduction.....	18
3.2. Gamma radiation sources	18
3.3. Source of Co-60 (High activity).....	19
3.4. Source of Ir-192 (High activity).....	21
3.5. PHITS Monte Carlo code.....	22
3.5.1. The principle of Monte Carlo Methods.....	22
3.5.2. PHITS Section format.....	25

3.5.3. PHITS preliminary results	27
3.6. Radiographic Room design	28
3.7. Result of dose simulation and discussion.....	30
3.7.1. Co-60 results	30
i. Wall thickness calculation	30
ii. Single maze calculation results.	31
iii. Double corner maze calculation.....	33
3.7.2. Result for Ir-192	36
i. Wall thickness calculation	36
ii. Single maze calculation results.	37
iii. Double corner maze calculation.....	38
8. Conclusions	41
CHAPTER 4. GAMMA RADIOGRAPHIC ROOM	43
4.1. Introduction.....	43
4.1. Neutron radiation sources	43
4.2. Neutron shielding specificity	45
4.2. Neutron moderation	47
4.3. PHITS for neutron calculation	48
i. Neutron source:	48
ii. Material.....	48
iii. Cells	48
4.4. Radiographic Room design for neutron source	50
4.5. Result of dose simulation and discussion.....	52
4.6. Conclusions.....	54
CHAPTER 5. TECHNICAL RULES FOR RADIOLOGICAL PROTECTION.....	56
1. Introduction	56
2. Radiological protection in industrial radiography	56
2.1. Administrative controls.....	56
2.2. Engineering controls.....	57
i. Radiation exposure controls including distance and shielding.....	57
ii. Structural considerations	58
iii. Accessibility.....	58
iv. Security measures	58

3.	IAEA regulation of industrial radiography	58
i.	Enclosure design and use	60
ii.	Shielding design for shielded enclosures	60
iii.	The control of exposure in shielded area.....	61
4.	Korea Regulation of radiographic room design.....	62
5.	Projection for Cameroon (Central Africa) and Recommendations for regulatory body –NRPA Cameroon 63	
6.	Conclusion and perspectives	64
CHAPTER 6. CONCLUSIONS AND OUTLOOK		66
6.1.	General conclusions	66
6.2.	Specific conclusions.....	67
i.	Thickness of the shielded enclosures	67
ii.	Appropriated design and source position for gamma shielding	68
iii.	Neutron shielding design.....	68
iv.	Regulation view	69
6.3.	Future work.....	69
Appendixes		71
Appendix A: Categorization of sources used in industrial radiography.....		71
Appendix B: Korean Laws Related to the practice of Industrial Radiography.....		73
Sub-section 2: Sealed Sources		73
Appendix C: Dose calculation for gamma and neutron radiations		76
i.	Gamma radiation Kerma	76
ii.	Neutron	78
Appendix D: Shielding design dose and flux distribution for gamma radiography.....		83
Effective dose graphical result for Co-60 source.....		83
-	Single corner maze results	83
-	Double corner maze results	83
Effective dose graphical result for Ir-192 source.....		84
-	Single corner maze results	84
References		85

LIST OF FIGURES

Figure 1-1. Real situation encountered in an industrial radiography installation: Proximity of radiographic rooms with other heavy metal factory workers, office workers, and people without adequate knowledge on radiological risk exposure.....	2
Figure 2-1. typical classification of radiography according to the radiation type. The radiation in red color are those under investigation in the present study.....	9
Figure 2-2. Principle of gamma / neutron radiography. For clear understanding, the first case is the one without scattering and the second case is the real where scattered photons influence the image resolution on the film or detector.....	9
Figure 2-3. Basic fixed radiographic room design. (a) gamma radiography using single maze (with Co-60 or Ir-192 sources) and (b) neutron radiographic room without the need of maze (Cf-252 source).....	10
Figure 2-4. lifetime of radioactive sources used in industrial radiography (the source could be either Co-60, Ir-192, or Cf-252, or any other appropriate source that is not discussed in the present thesis).	13
Figure 2-5. Category one exposure devices used for mobile industrial radiography. The shielding enclosure adjoining the source are made of lead, tungsten, depleted uranium, steel (alloy), or combination of two or more of those high atomic number (Z) material [1].....	15
Figure 2-6. Category one/two exposure devices used for fixed industrial radiography. The shielding enclosure adjoining the source are made of concrete for gamma source, and both concrete, boron, and graphite for neutron shielding [1].	15
Figure 2-7. common room design for fixed industrial radiography using gamma sources and neutron source of Californium – 252 when doors are appropriately designed.	16
Figure 3-1. Radiation types and their penetration range in the medium. In red color, gamma radiations are likely to be shield by thick layer of concrete or high Z (Atomic number) material.....	19
Figure 3-2. The simplified decay scheme of Co-60 including the dual high gamma ray energies (1.1732 and 1.3325 MeV) [50].	20
Figure 3-3. Spectrum of cobalt-60 source measure with an HPGe detector. The two gamma peaks are observed at corresponding energy.....	20
Figure 3-4. Spectrum of iridium-192 source measure with an HPGe detector. Multiple gamma-ray peaks are observed at corresponding energy.....	21
Figure 3-5. The simplified decay scheme of Ir-192 including the multiple high gamma ray energies [50].	22
Figure 3-6. Different applications (fundamental technologies and applications fields) of PHITS code including useful data library for computation [54, 56, 57]	22
Figure 3-7. Distribution of gamma-rays from isotropic Co-60 source (100 Ci) for appropriate wall thickness setting in the entire radiographic room. Scattered photon consideration from the four walls, the roof, and the floor.	28
Figure 3-8. Geometry simplification for the calculation from the long computational time consideration. The red axe designates the simplification axe and only the upper part of the geometry is considered and the bottom part is neglected or at least considered as air-filled medium.	29

Figure 3-9. simplified geometry for computational time efficiency. The parameter β describe the source position in the geometry. The source occupied three different positions: central ($\beta=0$), left ($\beta = -2.5$ m) and right ($= +2.5$ m). the parameter α described the length of the maze and its minimum value was set to 0 and the maximum to 5 m as this length achieved the ALARA requirement..... 29

Figure 3-10. Geometry design for appropriate shielding thickness and distribution of gamma-rays from isotropic Co-60 source around the wall (simplified geometry). 30

Figure 3-11. XY projection of the gamma effective dose rate ($\mu\text{Sv/h}$) in the maze around the radiographic installation; ingle corner maze case. (a) The source position is the left side describe in the simplified geometry by the parameter $\beta = -2.5$ m; (b) $\beta = 0$; and (c) $\beta = +2.5$ m. 32

Figure 3-12. Effective dose rates in the single corner maze tally around the designed radiographic installation for different source positions. The source position is described by the parameter β . The ALARA principle applicable for Korea is achieved for 12 m and 14 m maze length in the cases of left and right position, respectively. 33

Figure 3-13. Tally for effective dose rate calculation in the case of double corner maze design. The Y position in the upper part of the geometry is considered as the tally region for calculation and is referred to the following graphs as “concrete wall thickness”. The corresponding distance is 120 cm as referred in the graphs. 34

Figure 3-14. Effective dose rates in the double corners maze tally around the radiographic installation for $\beta = 0$ source position (central). The source position is described by the parameter $\alpha = (0 - 5)$ m. 34

Figure 3-15. Effective dose rates in the double corners maze tally around the radiographic installation for $\beta = -2.5$ m source position (left side of the entrance). The source position is described by the parameter $\alpha = (0 - 4)$ m. 35

Figure 3-16. Effective dose rates in the double corners maze tally around the radiographic installation for $\beta = +2.5$ m source position (right side of the entrance). The source position is described by the parameter $\alpha = (0 - 5)$ m. 36

Figure 3-17. Geometry design for appropriate shielding thickness and distribution of gamma-rays from isotropic Ir-192 source around the wall (simplified geometry). 37

Figure 3-18. Single maze design with gamma flux from Ir-192 source of 50 Ci. The wall thickness of 70 cm was set for calculation and the cells 201 to 2015 are tallies for effective dose rate calculation. 38

Figure 3-19. Effective dose rates in the single corner maze tally around the designed radiographic installation for different source positions. 38

Figure 3-20. Geometry for double corner maze in the case of Ir-192 source. Simple design without any source position (left, central, or right). Air occupation is colored in green while the other color is thick concrete walls. 39

Figure 3-21. Effective dose rates in the double corners maze tally around the radiographic installation using Ir-192 source, for $\beta = 0$ source position (central). The source position is described by the parameter $\alpha = (0 - 5)$ m. 40

Figure 3-22. Effective dose rates in the double corners maze tally around the radiographic installation using Ir-192 source, for $\beta = -2.5$ m source position (left position). The source position is described by the parameter $\alpha = (0 - 4)$ m. 40

Figure 3-23. Effective dose rates in the double corners maze tally around the radiographic installation using

Ir-192 source, for $\beta = 2.5$ m source position (right position). The source position is described by the parameter $\alpha = (0 - 4)$ m..... 41

Figure 4-1. Californium neutron source spectrum from the PHITS code implementation and data from the IAEA-NDS- 98 44

Figure 4-2. Representation of typical neutron radiography arrangement using radioisotope (neutron emitter) ... 45

Figure 4-3. Possible neutron shield options available for industrial applications. The hydrogenous material in blue mostly consisted of water is the best option, but not useful for structure shield as the case in NDT testing installations (walls). 46

Figure 4-4. Fast neutron attenuation setup based on Schaeffer equation. 47

Figure 4-5. Effective dose rate for single maze corner in the case gamma radiographic room is adapted for neutron radiography. The smallest value of the effective dose rate was found to be $791.01 \pm 0.23 \mu\text{Sv/h}$ (for 15m maze length) and $151.9 \pm 0.25 \mu\text{Sv/h}$ (for 25m length maze), which is extremely high and the gamma design cannot be applied for neutron imaging. Results for left, central, and right position of the neutron source are presented in the three other curves. 49

Figure 4-6. Design for industrial neutron radiography installation on the left side (display of the modification from radiographic test rooms presented on the right side with maze design). As describe in Figure 4-5, maze design is not appropriate for neutron shielding. 51

Figure 4-7. Simplify geometry for neutron shielding design with various material implementation. Different geometries include as first material layer to break down the neutron lead, iron, graphite, aluminum, tungsten, zirconium, and polyethylene. 52

Figure 4-8. Preliminary dose calculation in the geometry along the tally normal position for different material as 1st layer of the shielding enclosure. 53

Figure 4-9. Zoom in the region a, b, and c of the preliminary dose calculation result as displayed in the previous figure for the same material and same geometry for better view and discussion. 54

Figure 0-1. Difference between energy imparted and energy transferred from interaction of direct and indirect ionizing radiation with a medium. 78

LIST OF TABLES

Table 1-1: reported radiation overexposure accidents by type of overexposure worldwide in industrial radiography application from 1980 to 2013 (during only 33 years of intense operation) [34].	5
Table 1-2: Typical radionuclides for industrial radiography. Five gamma sources and common neutron sources used [1]	7
Table 2-1: Advantages and disadvantages of gamma radiography	8
Table 2-2: classification of source containers according to their mobility	14
Table 3-1: Summary of the effective dose rate calculation, related to concrete wall thickness in the closest public area (XYZ = 10cm X 50cm X 50cm). 120 cm or more is the appropriate thickness found from this calculation and this is in accordance with the experimental data in industrial radiography. The standard deviation is less than 10 % in all calculation.	31
Table 3-2: Summary of the effective dose rate calculation, related to concrete wall thickness in the closest public area (XYZ = 10 cm x 50 cm x 50 cm) in the case of Ir-192 source. 70 cm or more is the appropriate thickness found from this calculation and this is in accordance with the experimental data in industrial radiography. The standard deviation is 3.6 % in the relevant calculation result selected.	37
Table 4-1: Neutron classification according to their energy range, velocity of wavelength.	45
It is usually important to multiply the previous equation by a factor B depending on the neutron energy called the buildup factor. Values of removal cross section for several materials are presented in the following table (Table 4-2). When the industrial radiography operations use fast neutron without moderation, the shielding enclosure design around the source is a challenging task.	47
Table 4-3: Removal cross-section for some materials used for neutron shielding.	47
Table 4-4. non-effective result from concrete wall shielding around 100 Ci of Cf-252 source in a neutron industrial radiographic room using fast neutron.	50
Table 5-1: Color code controls as recognized by the IAEA safety reports series No. 13	61