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A Study of Occupational Doses and Radiation Safety for Industrial Radiography in Different Sites of Egypt

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Abstract: *As Industrial Radiography has grown up and may have a great contribution in radiation exposure for the workers in this field, this study was started to review occupational radiation exposure in industrial radiography expectedindifferent siteswith fixed facility in Egypt. In this paper, doses in some industrial radiographyhave been measured and then were analyzedto evaluate the operator procedures employed. The occupational workers were divided to three groups with four workers for each; the first groupused Ir-192 source with activity 70 Ci in fixed facility, the second groupused Ir-192 source with activity 70Ci in external work sites and the third groupIr-192 source with activity 70Ci in other external work sites. The first and the second groups were under direct supervision of Radiation Protection Officer(RPO) and researcher whoprovided them the radiation safety requirements continuously for each radiography operation to apply ALARAprinciple. While the third group was under user. Based on occupational workers monitoring results, 2015and2016, which were done by using thermoluminescent dosimetry (TLD). Theradiographerselaborate in routine operations received doses ranging from 3.5 to 10.2 mSv/year.Thisresultsshowed that the majority of industrial radiographers, approximately 65%, received less than 6 mSv/yand approximately35% received greater than 6 mSv/y.*

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I. Introduction

Industrial radiography is an important tool for non-destructive testing (NDT). Applications include weld inspection on oil and gas pipelines,weld inspection on separators, tanksand petrochemical production sites [1]. Where practical, radiography is expected to be undertaken in dedicated facilities in which effective engineering controls, safety and warning systems are installed. However, this is not always possible and radiography carried out in-situ is known as site radiography. Site radiography is one of the few occasions that large radiation sources are used in areas, which can be accessed by others and where effective engineering controls are not always practical and so where there is significant reliance on safe working practices to ensure protection of workers and the public [2]. Possibly for this reason, a significant number of industrial radiography incidents have been reported worldwide , in which persons affected were not only those directly connected with the activity but also members of the population involved by chance [3].

Industrial radiography work poses a negligible risk if it is performed in a safe manner. However, experience shows that incidents involving industrial radiography sources have sometimes resulted in high doses to workers, causing severe health consequences such as radiation burns and, in a few cases, death. Members of the public have also suffered radiation overexposures when radioactive sources used for industrial radiography were not properly controlled or regulated [4].

II. Material And Methods

All groups used the same type of the source (Ir-192), the same activity (70 Ci) and the same type of projector (camera) (Dilta 880). The sources were loaded in the beginning work on Jan., 2015 and reloaded on Jan., 2016 with the same radioactivities.

Occupational workers were divided to three groups, each consisting of four workers. The location of Group 1 was atfixed radiographic facility. This facility has been designed and built to ensure maximum safety and has proper locks, warning lights and signs. The location of group 2 was in different radiographic sites. The first and the second groups were operate under direct supervision of Radiation Protection Officer and researcher and have been provided them with personal protective equipment, permits to work, and the radiation safety requirements continuously according to Code of Practice for Industrial Radiography,*(IRCP91-2 October 2010)* [5]for each radiography operation to apply ALARAprinciplein particular,

- Before starting work, radiographers must ensure that the radiography devices are in proper condition with a functioning dose rate meter and personal dosimeters and radiation alarm devices as well as front and back cables.
- Before starting every work, RPO and researcher have been putted plan for the radiographic operation in terms of time exposure, safe distance, suitable shielding use and suitable equipment to implement the job and reduce the doses of workers.
- During the work, unauthorized persons must be prevented from handling the radiography device. When authorized personnel leave for their breaks, the radiography device must be locked in such a way that it cannot be used.
- A sufficient number of collimators shall be provided for radiography.
- Dose rate meters used in monitoring working conditions shall be calibrated in a measurement calibration laboratory
- After radiography, all radiography devices shall be kept in a safe storage that unauthorized persons cannot access.

The location of group 3 was in another different radiographic sites. This group was operated under direct supervision of Users. Thermoluminescentdosimetry TLD were distributed to all radiographers and collected every three months.TLD Measurements were performed by TLD Reader Model:(Harshaw 6600) in radiation protection laboratory of Egyptian Nuclear and Radiological Regulatory Authority (ENRRA).

III. Results And Discussions

The radiation levels in all radiography sites are high, the workers are exposed from external radiation sources.Personal radiation exposures have to evaluate by having occupational workers wearing thermoluminescent dosimeters TLD, which must be returned to be and analyzed by researcher.All radiographers useTLD dosimeters during work, and collected every three months, these dosimeters were measurements and analyzes in the radiation protection laboratory.

All groups performed a number of radiographic operations through the year, ranging from 100 to 112 operations according to work permits.

In site radiography table 1, the working conditions are such that some routine exposure is expected. Radiographers receive most of their exposure in the execution of the step by step procedure of industrial radiography in particular when they get close to the gamma-emitting radioactive source.

Table 1: Dose rate distribution in work site

Dose rate during projector handling	400μSv/h
Dose rate during transport by car	0.4μSv/h
Dose rate during collimator at 10 meter	65μSv/h

Tables 2, 3 and 4 are the results of radiographers doses through two years 2015 and 2016,

Table 2, for group 1 show the between two years 2015 and 2016 the estimated measurable whole body doses to radiography workers during implement the radiation safety requirements range from 3.5 to 5.1 mSv/year. Table 3 for group 2 shows that the equivalent doses of radiographers under supervision of RPO and safety requirements in different work sites range from 4.0 to 5.8 mSv/year. It can be noted that the highest annual exposure received as a result of routine operations is less than6 mSv. Table 4 shows the equivalent doses for occupational workers of group 3 range from 5.7 to 10.2 mSv/year. It can be noted that the highest annual exposure received as a result of routine operations is higher than6mSv. Analysis of the data shows that the majority of industrial radiographers, approximately 65%, receive less than 6 mSv/y, and approximately 35% received greater than 6 mSv/y.

Table 2: equivalent dose for group 1

No. of worker	2015 (mSv)				**Annual Dose**	2016 (mSv)				**Annual Dose**
	Q1	Q2	Q3	Q4		Q1	Q2	Q3	Q4	
1	1.2	0.9	0.8	0.6	**3.5**	0.8	1.3	0.9	0.8	**3.8**
2	0.9	1.3	0.85	0.85	**3.9**	1.2	1.1	0.9	0.9	**4.1**
3	1.3	1.27	1.1	0.93	**4.6**	1.1	1.3	1.3	1.4	**5.1**
4	1.1	0.9	1.3	0.8	**4.1**	0.9	1.0	0.8	1.2	**3.9**

Table 3: equivalent dose for group 2

No. of worker	2015 (mSv)				**Annual Dose**	2016 (mSv)				**Annual Dose**
	Q1	Q2	Q3	Q4		Q1	Q2	Q3	Q4	
1	1.1	0.9	1.2	0.8	**4.0**	1.2	1.3	0.9	0.9	**4.3**
2	1.3	1.1	1.2	0.9	**4.5**	1.4	1.3	1.3	0.9	**4.9**
3	1.1	1.2	1.2	0.8	**4.3**	1.2	1.2	1.3	1.0	**4.7**
4	1.2	1.4	1.3	1.2	**5.1**	1.5	1.6	1.4	1.3	**5.8**

Table 4: equivalent dose for group 3

No. of worker	2015 (mSv)				Annual Dose	2016 (mSv)				Annual Dose
	Q1	Q2	Q3	Q4		Q1	Q2	Q3	Q4	
1	2.0	1.9	1.9	1.5	**7.3**	2.1	2.2	1.9	1.9	**8.1**
2	1.8	1.7	1.5	0.9	**5.9**	2.2	2.4	2.0	1.8	**8.4**
3	2.2	2.4	1.8	1.5	**7.9**	1.5	1.6	1.8	0.8	**5.7**
4	2.1	2.3	2.1	2.0	**8.5**	2.6	2.7	2.5	2.4	**10.2**

A number of reasons for this high doses are commonly reported including:

- Failure to follow operational procedures (the most common of these where staff do not adhere to their radiation safety procedures),
- Inadequate training of the staff involved,
- Inadequate maintenance, equipment malfunction or defects resulting in equipment failure,
- Human error, often due to workload, inadequate time schedule
- Damage to equipment due to an accident.

IV. Conclusions And Recommendations

- This work supports earlier studies which show that on average industrial radiographers in Egypt receive higher occupational exposure than other workers in different activities.
- Before starting every work, RPO should be putted plan to implement the job and reduce the doses of workers.
- It is important that license conditions are periodically reviewed taking into accountExperience from inspections and reported incidents so as to ensure that they continue to protect exposed workers as well as members of the public adequately.
- Hiring and maintaining a well-trained workforce and encouraging good work practice should ensure the protection of exposed workers and members of the public from exposure to ionizing radiation above dose limits.
- Collimators should be used whenever possible, to reduce radiation levels and subsequentdoses.
- Personal dosimeters such as thermoluminescent dosimeters or film badges and direct reading dosimeters should be worn by radiographers at all times when they are performing site radiography work. Direct reading dosimeters should be periodically assessed by the radiographers to monitor the doses.

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