CHAPTER 3

INDUSTRIAL RADIOGRAPHY PRACTICE IN INDIA

CHAPTER OVERVIEW

Non-destructive testing using industrial radiography is an important part of quality control (QC) procedures adopted during manufacturing of industrial pressure vessels and other such equipment. This chapter describes the importance of industrial radiography in various industries. Historic growth and current status of the industrial radiography practice in India have been described here. The chapter describes the various models of radiography devices which are being used India. Some of the typical scenarios, which may lead to accidents have also been described in this chapter.

3.1 GENERAL

Industrial radiography is an important non-destructive testing (NDT) method for detection of presence of any flaw in the industrial vessels, which may be created either during the manufacturing process or during operational life due to aging. Industrial radiography is carried out during manufacturing and commissioning, as well as for periodic inspections during operational life to check the integrity of various industrial structures like pressure vessels, boilers, pipes etc. Therefore, radiography operations are carried out in manufacturing shops, and at commissioning and operational sites. Some of the vessels/equipment, especially which are operated at high pressures, require 100 percent radiography, combined with other NDT techniques like ultrasonic testing, eddy current testing, magnetic particle testing etc.. Industrial radiography technique has several advantages over the other NDT techniques, viz. it provides a permanent record of the testing, allows for detection of surface

as well as sub-surface flaws, preparation for the testing is very simple etc. However, at the same time, this technique has the disadvantage of associated radiation hazards to operating personnel and the technique is sensitive to flaw orientation. Due to its advantages, industrial radiography is a popular NDT technique worldwide and is used in various industries like those associated with petroleum, fertilizers, power plants, aerospace etc.

Industrial radiography is carried out using radioisotopes like Cobalt-60, Iridium-192, Selenium-75 etc., or by radiation generating equipment like X-ray machines and accelerators. Radiation generating equipment used for industrial radiography purpose are considered inherently safe since radiation can be totally stopped anytime by simply "switching off" the electric power to the equipment, whereas radioisotopes based industrial radiography devices keep on emitting radiation, even if the equipment is not in use. However, radioisotopes based devices have advantages of being handier or portable in size, as compared to X-ray based equipment. Due to ease of handling and operation, most of the radiography work on the sites is carried out by using radioisotopes based devices.

Table 3.1 Characteristics of gamma ray sources used in industrial radiography application

Source	Half Life	Exposure Rate (RHM)	Inspection Range in Steel (mm)	Energy Spectrum (KeV)
Co-60	5.25 Yrs	1.33	40-200	1170 & 1330
Ir-192	74.8 days	0.48	20-70	200-800
Se-75	120 days	0.215	4-30	9-400
Tm-170	128 days	0.003	2-12	50-90
Yb-169	32 days	0.125	2-10	60-300

Type of radioisotope to be used for radiography purpose is chosen based on the thickness of the material to be radiographed. For a higher thickness job, high energy X-ray or gamma ray source is used. Selection, of suitable source and source activity, is optimized based on the job thickness, exposure time, scattered radiation component, associated radiation hazards etc. Table 3.1 shows the characteristics of some of the typical gamma-ray radioactive sources used in the industrial radiography practice.

3.2 CURRENT STATUS AND TRENDS IN INDUSTRIAL RADIOGRAPHY PRACTICE IN INDIA

Industrial radiography practice is directly connected with the industrial growth of the country. As the industrial growth of India has a successful story, the number of radiography devices and institutions have also accordingly recorded substantial growth in the country. Industrial radiography is being practiced in India since 1960. In the earlier days, the design of Industrial Gamma Radiography Exposure Device (IGRED) was very simple, with limited safety features. Devices at that time were shutter operated, wherein the radiographer operated it standing near the source, and lifting the shutter to expose the source. The sources permitted in such devices were limited only to Iridium-192 with activity of 10 Curie or less. With time, the demand for the radiography devices has increased and the safety features provided in these devices have also enhanced, providing safe operation of the devices. Now a days, all the radiography devices in use are remotely operated with enhanced safety features to prevent any unintended operating failures.

Currently, about 2700 such devices are being operated in India by 554 radiography agencies. Most of these agencies are service providers to industries. Figures 3.1 and 3.2 show the growth trends of the industrial radiography practice in India, in terms of the numbers of radiography devices and radiography institutions respectively.

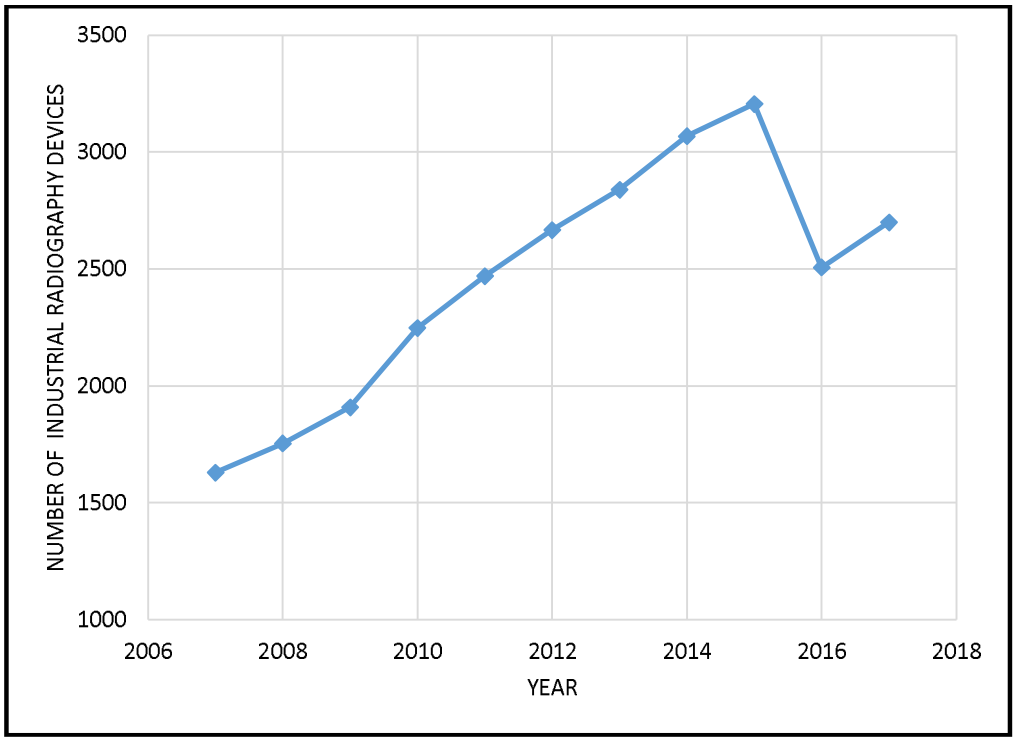

Figure 3.1. Illustration of growth of industrial radiography devices in operation

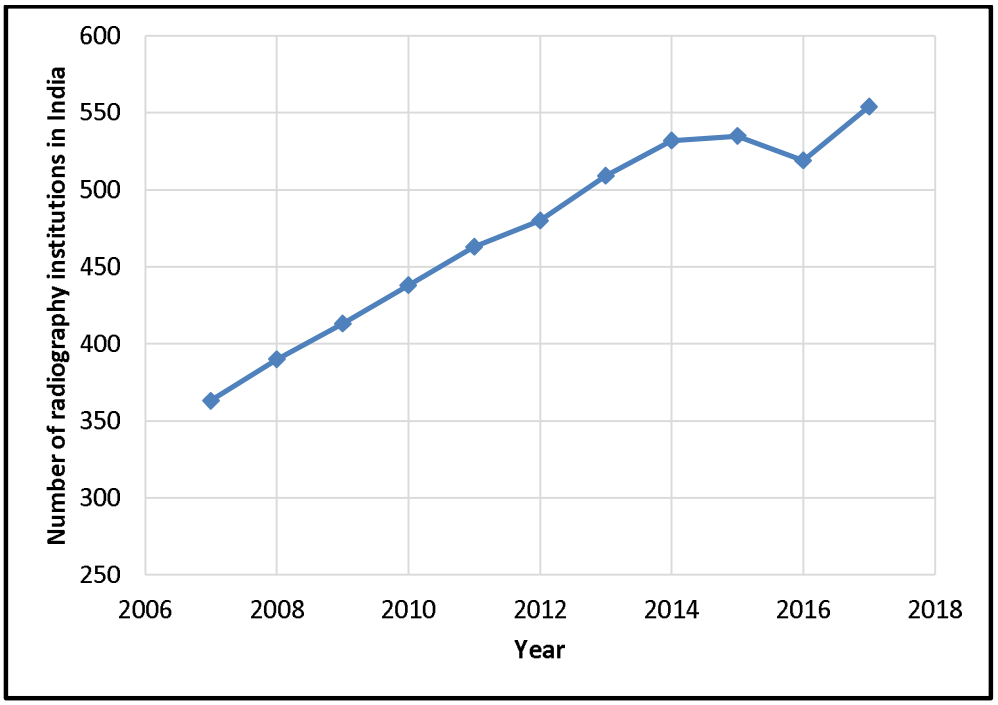

Figure 3.2. Illustration of growth of industrial radiography institutions in India

Both the figures clearly show a general trend of rise in radiography practice in India with time. There is a steady increase in the numbers of the radiography devices and the institutions using them, except for a year. As seen in figure 3.1, a sharp decline in the number of radiography devices is noticed for the year 2015-16. It is understood that during that period, few old models of industrial gamma radiography exposure devices were phased-out by the regulatory body due to non-adherence of safety requirements, which were augmented in the new design. Due to the same reason the of phasing out the old devices, few institutions closed down their operations which were solely operating those old devices, resulting in the slight declined in the number of institutions during the year 2015-16 as shown in the figure 3.2

Various models of industrial radiography exposure devices are available in the country all of which adhere to the basic safety design requirements as per the current national and international standards [44]. These different models of IGREDs, however, do have minor variations in their designs. Some of the models have additional safety features and different design of source assembly. In India, Board of Radiation and Isotope Technology (BRIT) is the only manufacturer of the industrial gamma radiography exposure devices, manufacturing ROLI series of radiography devices. Indigenous models of radiography devices use lead and heavy alloys as shielding material, whereas imported radiography devices use depleted uranium as the shielding material. Some of the Se-75 radiography devices, which require lesser shielding material, uses tungsten as shielding material. Table 3.2 shows various models of the industrial radiography exposure device, which are in use by the radiography agencies in India.

Table 3.2 Details of approved IGRED models in use in India

Sr. No.	Model	Manufacturer	Source capacity	Shielding material weight	Shielding material	Country of origin
1	ROLI-1(SS)	Board of Radiation and Isotope Technology, India	1.30 TBq, Ir-192	37.00	Lead	India
2	ROLI-2	Board of Radiation and Isotope Technology, India	2.40 TBq. Ir-192	38.00	Lead and Heavy Alloy	India
3	ROLI-3		0.74 TBq, Ir-192	25.00	Lead and Heavy alloy	India
4	DELTA 880	QSA Global Inc, USA	5.55 TBq, Ir-192	15.40	DU	USA
5	SENTRY 110		4.07 TBq, Co-60	133.00	DU	USA
6	SENTRY 330		12.21 TBq, Co-60	218.00	DU	USA
7	1075 SCARPRO		3.00 TBq, Se-75	7.50	Tungsten	USA
8	SPEC 150	Source Production and Equipment Co. Inc., USA	3.70 TBq, Ir-192	17.00	DU	USA
9	SPEC-300		11.10 TBq, Co-60	227.00	DU	USA
10	IR-100	Industrial Nuclear Co. Inc., USA	4.44 TBq Ir-192	17.20	DU	USA
11	Gamma Mat TSI 5/1	NTP Radioisotope Europe SA, Belgium	5.0 TBq, Ir-192	13.00	DU	Belgium
12	Saferad SE-3SC	Saferad Limited, England	2.96 TBq, Se-75	2.30	DU	England

13	EXERTUS CIRCA 80	Jsc Energomontage International, Russia	2.96 TBq, Se-75	5.00	Tungsten encased in SS housing	Russia
14	EXERTUS DUAL 120		7.40 TBq, Ir-192	14.00	DU	Russia

DU= Depleted Uranium

There is no difference in the operating mechanism and operational procedures of these radiography devices, except that some devices require actuation of safety mechanism for operations. Shielding from the source provided in these radiography devices are such that the maximum radiation leakage limits from them are below the internationally recommended permissible limits [44].

3.3 OCCUPATIONAL WORKERS IN INDUSTRIAL RADIOGRAPHY

The operation of industrial radiography devices involves the risk of radiation exposure to the operators; therefore these devices should be operated only by qualified and trained personnel. Thus, training courses are designed and conducted, nationally and internationally, for training the industrial radiography operators (radiographers) for radiation safety and radiography techniques. Prior to operating the device, radiographers have to undergo these trainings.

In addition to trained radiographers, Radiological Safety Officers (RSO) are appointed in each of the radiography agency, who are responsible for ensuring radiation safety in the institution. Any incidental situation is handled by the RSO. Radiation safety related issues in the institution are to be analysed by the RSO, to avoid accidents. Also, there are some auxiliary staff in the radiography institutions like helpers, dark room technician etc.

3.4 ACCIDENTS INITIATORS IN INDUSTRIAL RADIOGRAPHY

In spite of the radiography devices possessing various safety features, unusual incidents and accidents in industrial radiography practice may occur. Several cases have been reported in India and worldwide for accidents in industrial radiography practice [1]. This practice is prone to accidents due to several reasons, primarily due to the portable nature of the exposure devices, which allows for their frequent transportation from one site to another site through the public domain. Another reason for industrial radiography practice to be accident prone is the need for sources to move out of the safe shielded position for exposure during each operation. During frequent source transitions in and out of the device, there is a probability that the source may get stuck in the transit location. Following are the typical scenarios that may lead to accidents in industrial radiography practice.

I. Source getting stuck in the projection sheath or collimator.
II. Source assembly decoupling from the remote control unit during operation.
III. Physical damage to the device, which affects the shielding.
IV. Loss of radiography device during transport.
V. Loss/theft of radiography device during storage.
VI. Attempt to repair the device by unauthorized person, leading to radiation exposure.
VII. Excessive exposure to radiography personnel due to lapses in safe operation.
VIII. Fire, which may damage the device shielding.
IX. Unauthorized person present in the controlled area during an exposure.

3.5 CHAPTER SUMMARY

Industrial radiography is an important non-destructive technique for detection of presence of any manufacturing or ageing related flaw or defect in the job

without altering its physical or chemical properties. Industrial radiography utilizes a radiation source like Cobalt-60, Iridium-192, X-rays etc. for its operation. There are various advantages of industrial radiography over other NDT techniques, which makes it a favourable choice for the industries. Due to its advantage, industrial radiography is carried out in various important industries like those related to petroleum, fertilizer, power plants, aerospace etc.. India has seen appreciable industrial growth, and correspondingly a growth in the industrial radiography practice. Radiography devices and industrial radiography institutions are growing in India, as shown in the figures 3.1& 3.2 respectively. Various models of industrial radiography devices are available and operated in India, which comply with the international design requirements. BRIT is the designer and manufacturer of radiography devices in India. Nevertheless, there are several models, other than those from BRIT, used in India, which are imported from other countries. Although, the basic design of these radiography devices is the same, there are some differences in their additional safety features. In spite of these safety features, provided in the devices, several accidents in their use are reported nationally as well as internationally. Primarily, the portable nature of these devices and the frequent source movements outside the safe shielded position, make these devices accident prone. Typical scenarios have been outlined in the chapter, which may lead to unusual incidents/accidents in this practice.
