Compliance Test for Portable Industrial Gamma Radiography Devices Based On National Standard of Indonesia

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Abstract. *IAEA Safety Report No.7 mentioned that radiography activities cause the highest radiation accident in industry. Portable gamma radiography devices are widely used in industrial radiography field. In accordance with BAPETEN Chairman Decree No. 8 Year 2014, Article 46 Paragraph (4), the devices have to met 7 parameters to get the certificate of eligibility. Compliance test for portable industrial gamma radiography refers to BAPETEN Chairman Decree No. 8 Year 2014. Meanwhile, methods of the test refer to Indonesian National Standard (SNI) namely SNI ISO 3999:2008 and SNI 18-6650.2-2002. The methods include radioactive leak test method, radiation leak test method, and also visual/function test and endurance test of projection method. On 22 December 2014, PTKMR (CTRSM) had been appointed by Regulatory Body (BAPETEN) as Testing Laboratory of Industrial Gamma Radiography Device (IGRD). Since appointed as testing laboratory, PTKMR has tested 30 pieces of portable gamma radiography device.*

Introduction

In accordance with IAEA Safety Report No.7, radiography activities can cause the highest radiation accident in industry (IAEA, 2003). Device mal function is one of the causes of the accident. Portable gamma radiography consist of some moving parts, they might be wear and tear. Institutions that use this device some times replace the origin components with spurious parts. Poor care of maintenance aggravates the devices become worse which encourages the radiation accident and excess radiation exposure (IAEA,1996). Quality assurance test of devices plays role to ensure that devices perform their intended fuctions and prevent the excess radiation exposure to operators (Kannan et.al., 2003).

Portable gamma radiography devices are widely used in industrial radiography. Many of them are in poor condition (BAPETEN, 2014). In 2014, Indonesian Regulatory Body (Nuclear Energy Regulatory Agency or BAPETEN) issues BAPETEN Chairman Decree No. 8 Year 2014. According to Article 46B, Paragraph (4) of the decree, there are 7 parameters that have to be met in order for the devices to get the certificate of eligibility (BAPETEN, 2014). The certificate is a requirement for the issuance of licence for use of devices.

Similar to the provisions in Indonesia, India has implemented Quality Assurance Procedures for Functional Performance of Industrial Gamma Radiography Devices as mandatory requirement. Each device has to be tested for its performance. Only after meeting the requirements of safety features, radioactive source is allowed to be loaded into the radiography device (Kannan R., et.al., 2003). Meanwhile, evaluated 11 kinds of ^{192}Ir portable gamma radiography devices used in Brazil based on conformance to the main safety requirements of ISO 3999 standard issued in 1997 and 2000 (Aquino J., et.al., 2003).

The present work will outline a method of compliance test for portable industrial gamma radiography based on indonesian national standards adopted from ISO standards.

Methodology

Nature of The Test

Compliance test for portable industrial gamma radiography is a non-destructive test. The test covers radioactive leak test, radiation leak test, visual/ function test, and also endurance test of projection. The last both of tests check the functional dan performance ot the devices. In this test, gamma radiography device is seen as exposure device not as radioactive package. Parts of industrial gamma radiography device that are tested essentially consist of gamma container/gamma camera, drive unit, and also guide tube.

Reference Standards

The compliance test for portable industrial gamma radiography covers 7 parameters as stated in BAPETEN Chairman Decree No. 8 Year 2014 . However, methods of the test refer to Indonesian National Standard (SNI) adopted from ISO Standard, namely SNI ISO 3999:2008 (BSN, 2008) and SNI 18-6650.2-2002 (BSN, 2002).

Figure 1. Three types of portable gamma radiography camera are utilized in Indonesia.

Table 1. Parameters and references of test method for portable industrial gamma radiography

No.	Test Parameter	Indonesian National Standard	Reference of Test Method
1	Radioactive leak test	SNI 18-6650.2-2002	a. Clause 5.3; 5.3.1; 5.3.2; 5.3.2. b. Appendix A item A.3
2	a. Visual/defective inspection b. Endurance test of projection	SNI ISO 3999:2008	a. Clause 5.4.1.1 b. Clause 5.6.3 c. Clause 5.7.1; 5.7.2 d. Clause 6.3.3
3	Gamma container locking mechanism inspection	SNI ISO 3999:2008	a. Clause 5.4.1.2 b. Clause 5.4.2
4	Coupling inspection of camera container with drive unit and guide tube	SNI ISO 3999:2008	Clause 6.3.3
5	Inspection for condition of drive unit and guide tube	SNI ISO 3999:2008	Clause 5.7.1; 5.7.2
6	Radiation leak test	SNI ISO 3999:2008	a. Clause 5.3 b. Clause 6.4.1.1;6.4.1.2
7	Inspection of device labeling	SNI ISO 3999:2008	Clause 7.1.1;7.1.2;7.1.3;7.1.5.

SNI ISO 3999:2008 was adopted from ISO 3999:1999 on the Radiation protection-Apparatus for industrial gamma radiography-sepsifications for performance, design and tests (Aquino, et.al., 2003). The standard contains a description of methodsfor radiation leak test, visual/function test, and endurance test of projection. Meanwhile, SNI 18-6650.2-2002 adopted from ISO 9978:1992 contains a description of a radioactive leak testing method (BSN, 2008).

Method of The Test

Radioactive Leak Test

Radioactive leak test on the portable industrial gamma radiography uses smear test. This method adopted the SNI 18-6650.2-2002 (BSN, 2002). First, it is ascertained that gamma container, drive unit, and also guide tube in a state not connected and plug nut in a released position. The tip of cotton bud sprayed radiacwash is rubbed on the deepest part (near the source) of connection hole of gamma container. The same step was carried out using a dry cotton bud.The wipe was also carried out on the hole guide tube and the control cable along the guide tube was used. Swab samples wereput in a plastic bag and labeled. Samples were analyzed using a gamma spectrometer. Value of a radioactive leak was calculated using the equation (1). Sealed source is considered leak if the activity result detected is 0.2 kBq (185 Bq)/(~ 5 nCi) or more (BAPETEN, 2009).

$$K_{rad} = \frac{R_s - R_b}{\eta_\varepsilon \cdot \rho_\gamma \cdot F} \quad \text{................ (1)}$$

with:

K_{rad} : radioactive leak test (Bq)
R_s : result count (cps)
R_b : background count (cps)
η_ε : measurement effiency (%)
ρ_γ : gamma abundance (%)
F : wipe factor (%).

Radiation Leak Test

Radiation leak test method refers to the SNI ISO 3999: 2008 clause 6.4.1. and 5.3. The test was done to ensure that the radiation doses are within the limits specified in the national standard (clause 5.3 of SNI ISO 3999: 2008)

Remove drive unit and guide tube from gamma container. The test is carried out with gamma container alone in locked position and plug caps in place. Ensuring that there is no radioactive contamination at the surface of gamma container before measuring dose rate equivalent at the surface and 50 mm from the surface.

The ambient dose rate measurement is carried out in conditions of gamma container does not contain radionuclides. The location of measurements are at the forefront, right side, left side, rear and top position on the surface, at a distance of 50 mm, and at a distance of 1 meter from the surface. The ambient dose rate measurements were also performed on the same location, but the container has been filled gamma radionuclides with known activity. Then, the difference value of ambient dose rate on gamma container without radionuclide and contains radionuclide was calculated. The maximum ambient dose rate of portable gamma container on the surface, at a distance of 50 mm, and at a distance of 1 meter may not exceed the limit value as shown in Table 2. The maximum value of the activity of radionuclides allowed in the gamma container is calculated using equation (2).

$$A_{max} = A_{msa} X \left(\frac{x_{max}}{x_{msa}}\right) \quad .... (2)$$

$$x_{msa} = x_{msa.WS} - x_{msa.NS} \quad .... (3)$$

with:

A_{max} = the maximum activity of radionuclide

A_{msa} = radionuclide activity at the time of measurement

x_{max} = maximum ambient dose rate (Table 1)

x_{msa} = measurement ambient dose rate

$x_{msa.WS}$ = measurement ambient dose rate with radionulide in the gamma container

$x_{msa.NS}$ = measurement ambient dose rate without radionulide in the gamma container

Visual/Function Test and Endurance Test of Projection

Before tested, it is ensured that drive unit and guide tube are not contaminated. It is used non radioactive dummy as pigtail substitute.

Visual test of gamma cameras was done by checking the availability and condition of the lid gamma camera (plug nut and lock cover); safety key system; automatic locking system (posylock); the symbol of radioactive, type and serial number as well as the maximum capacity of a gamma camera and the type of radioactive source; condition of drive unit, guide tube and also movement guidance of the cable to the drive unit.

Test of the connection is conducted between the drive unit with a gamma camera and the guide tube with a gamma camera. Then it is proceed with the endurance test of projection with the configuration as the Figure 3. Movement "expose" (removing the source) and "retract" (insert source) are conducted each as much as ten times. This movement is observed the smoothness and inspected the condition of the connection between the control cable and pigtail (dummy).

Result of visual inspection and projection endurance is then evaluated to determine the appropriateness of gamma radiography device operated for the non-destructive testing activities in the field.

Table 2. Ambient equivalent dose-rate limit

1	2	3	4
Class	Maximum ambient equivalen dose-rate mSv/h (μSv/h)		
	On external surface of container	At 50 mm from external surface of container	At 1 m from external surface of container
P (portable)	2 (2000)	0,5 (500)	0,02 (20)

Reference: SNI ISO 3999: 2008.

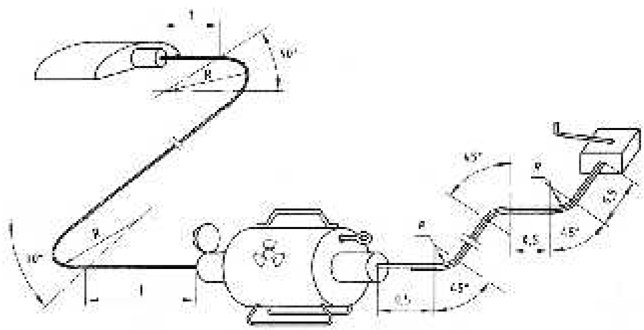

Figure 2. Configuration of endurance test of projection

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Table 3. The result of testing portable gamma radiography devices at CTRSM

No.	Type of Radiography Devices	Amount of Devices	Result of Testing
1	Tech Ops 660	9	All passed the test at 100 Ci
2	Tech Ops 660 A	6	All passed the test at 120 Ci
3	Tech Ops 660 B	13	All passed the tes at 71,99 Ci (1), 100,67 Ci (1), 129 Ci (1), 90,81 Ci (1), and 140 Ci (9)
4	Delta 880	2	All passed the test at 150 Curie

Source : Subdivision of Work Safety and Protection Radiation-CTRSM (per 2 October 2015)

Result and Discussion

Compliance Test of Portable Industrial Gamma Radiography Devices at CTRSM-NNEA

Centre for Technology of Radiation Safety and Metrology (CTRSM) is a centre for research and services of testing and calibration in the National Nuclear Energy Agency (BATAN). Compliance test for portable industrial gamma radiography devices is one of the testing services in this centre. CTRSM (PTKMR) Laboratory has adequate equipment and testing procedures which refer to the SNI ISO 3999: 2008 and SNI 18-6650.2-2002.

On December 22, 2014, the Regulatory Body (BAPETEN) appointed CTRSM (PTKMR) as Testing Laboratory of Industrial Gamma Radiography Devices through the Decree of the BAPETEN Chairman Number 1406/K/XII/2014.

Data of The Test

Since appointed as a testing laboratory, CTRSM has tested 30 portable radiography devices with details as in Table 3.

After appointed, the CTRSM has conducted radiation leak test on portable radiography devices with a maximum capacity of 100 Ci (9 devices), 120 Ci (6 devices), 140 Ci (13 devices), and 150 Ci (2 devices). But the 4 devices passed the test with a capacity below the maximum capacity specified by the manufacturer. This indicates a radiation leak at the devices. Meanwhile, radioactive leakage test performed did not indicate a leak of radioactive equal or exceed 185 Bq.

In the visual/function test and endurance test of projection, initial examination conducted before the devices are tested. The initial examination needs to be done to ensure that radiography devices are feasible to be tested. If the devices are not feasible tested, then they should be fixed in advance or done reconditioning. In the period after being appointed as a testing laboratory, of 30 gamma radiography devices were tested its performance, and all of them have been qualified.

Conclusion

As the implementation of BAPETEN Chairman Decree No. 8 Year 2014, CTRSM has prepared adequate equipment and testing procedures referring to the Indonesian National Standard namely SNI ISO 3999: 2008 and SNI 18-6650.2-2002. After conducting the technical dan management assessment, BAPETEN appointed CTRSM as a testing laboratory of industrial gamma radiography devices on December 22, 2014.

Compliance test forportable industrial gamma radiography devices includes the radioactive leak test, the radiation leak test, and also the visual/ function and endurance test of projection. Since being appointed as a testing laboratory, CTRSM has tested 30 pieces of portable gamma radiography devices. They are Tech Ops 660 series and Delta 880 series. All of the devices being tested passed, although some of them should be reconditioning/ repaired before tested.

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