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A Development of the Equipments for the Tests of a Sealed Source

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1. Introduction

Radioisotopes have been employed in various industrial, medical, environmental, and advanced scientific fields. Commercial applications are extended continuously with the developments of the industries. Radioactive isotopes are currently used in more than 2,000 organizations in Korea, and the domestic demand is expected to grow steadily. The sealed source once manufactured should be tested and classified in accordance with ISO-2919 and a domestic regulation.[1,2] In this paper, the equipments for the tests of a sealed source such as a temperature test, a pressure test, an impact test and a puncture test were developed by excluding a vibration test to classify the sealed source. A case study for a selenium-75 gamma radiography sealed source is presented.

2. Test Method

The classification of each sealed source type should be determined by an actual testing of two sealed sources of that type for each test in Table 1. Sealed source classification requirements for a typical usage are given in ISO-2919. The classification of the sealed source type shall be designated by the ISO/, followed by two digits to indicate the year of approval of the standard used to determine the classification, followed by '/', followed by a letter to show the activity level of the sealed source, followed by five digits which shall be the class numbers describing the performances for the temperature, the external pressure, the impact, the vibration and the puncture respectively. If required, a number is inserted between the parentheses describing the type of bending test the source has passed. An example is 'ISO/98/C43515'.

Sealed sources shall be cooled to the test temperature, -45℃ in less 45 min and heated to the test temperature within the maximum time limit specified in ISO-2919. The specimen is retained at the specified temperature for at least 1 hour and then for classes 2 and 3 cooled slowly to an ambient temperature and for classes 4~6 subjected to a thermal shock by transferring them to water within 15 s. The water is at a flow rate of at least ten times the sealed source volume per minute or if the water is stationary, it shall have a volume of at least twenty times the sealed source volume.

Sealed sources shall be placed in the chamber and exposed to the test pressure specified in the ISO-2919 and returned to atmospheric pressure for two periods of 5 min each. The low-pressure test is conducted in air. Using water as the medium in contact with the sealed source the high-pressure test is conducted.

An impact test is performed by dropping a hammer whose upper part is equipped with a means of an attachment, ant the lower part should have an external diameter of (25±1) mm and a flat striking surface with its outer edge rounded to a radius of (3.0±0.3) mm, onto the sealed source on the steel anvil with a 1 m height.

A vibration test is performed to fix the source securely to the platform of the vibrating machine and to conduct the test with the frequencies specified in ISO-2919. A vibration test is conducted for each axis of the source.

A puncture test is performed by dropping a hammer whose lower part bears a rigidly fixed pin onto the sealed source with a 1 m height. The characteristics of a fixed pin should have an hardness from 50 to 60 Rockwell C, a (6.0±0.2) mm a external height, a (3.0±0.1) mm diameter and hemispherical striking surface. The centerline of the pin shall be in alignment with the center of gravity and with the point of attachment of the hammer. The mass of the hammer and pin depends on the test class.

Different specimens may be used for each of the tests. After each test, the source should be examined visually for a loss of integrity and it should also pass an appropriate leakage test in accordance with ISO 9978.[3]

3. Equipments of the Test

The cooling test is conducted in the chamber. The chamber whose dimensions are 318.5(D) X 606(H) mm

Table 1. Classification of sealed source performance

Test	Class					
	2	3	4	5	6	X
Temperature	-40℃~80℃	-40℃~180℃	-40℃~400℃	-40℃~600℃	-40℃~800℃	Special test
External Pressure	25kPa	25kPa~2MPa	25kPa~2MPa	25kPa~2MPa	25kPa~2MPa	
Impact	50g from 1m	200g from 1m	2k from 1m	5kg from 1m	20kg from 1m	
Vibration	25~500 Hz	25~500 Hz, 50~90Hz, 90~500Hz	25~80 Hz, 80~2,000 Hz	Not used	Not used	
Puncture	1g from 1m	10g from 1m	50g from 1m	300g from 1m	1kg from 1m	

is made from STS304 plate (3 mm) and the use of a poly-urethane with 25.55 mm thickness as an insulator. The media to cool the sealed source can be a dry ice or liquid nitrogen. The heating test is conducted in a furnace which can be heated up to 1200℃.

For a pressure test a chamber which was made from STS304 stainless steel with 52 mm thickness was used. A rotary pump for a low-pressure test and a hydraulic jack for a high-pressure test were used at the same port as shown in Fig. 1. The size of the chamber is 318.5(D) X 560(H) mm. The maximum pressure of the chamber is 30 kg/mm^2. So a pressure test can be conducted for the class 2 and the class 3 of an external pressure test.

The hammers for an impact test and a puncture test were made. The hammer is cramped and released by an air-type release equipment.

Figure 1. The pressure test apparatus.

4. An Example of Test

An example of the tests is performed to classify the sealed source. Gamma radiography by using Selenium-75 is now generally acknowledged throughout the world to provide performance benefits relative to Iridium-192 in the working range of 5~30 mm steel. Selenum-75 has a softer gamma ray spectrum than Iridium-192 and it has a significantly longer half-life. For these reasons selenium-75 provides real performance benefits and working life advantages. A selenium-75 gamma radiography sealed source as shown in Fig. 2 was used. A sealed source classification requirement for an industrial radiography is classified as '43515'. A vibration test is not needed.

The two sealed sources for each test are prepared. The specimens were cooled to -60~-159 ℃ within 30 seconds by using liquid nitrogen and retained for 21 minutes. To perform a heating test the temperature of the furnace was raised from -1 ℃ to 403 ℃ within 5 minute and retained for 61 minute. And then the sealed sources were transferred to water whose volume and temperature were 100 cc and 21.1℃, respectively.

Two sealed sources were placed in the chamber and exposed to 25 kPa for 6 minutes and 2.2 MPa for 6.25 and 5.2 minutes and returned to an atmospheric pressure twice.

The hammer for an impact test with a 5 kg mass was dropped onto the two sealed sources on the anvil with a 1 m height. The deformation of a sealed source was large as shown in Fig. 3. The average change of the diameter and length were 2.185 mm and 0.445 mm, respectively.

The hammer for a puncture test with a 300.19 g mass was dropped onto the sealed sources with a 1 m height. The local deformation at the impact point appears as shown in Fig. 4.

The vacuum bubble test for a leakage test is conducted before and after the tests.[3] There are no leakages for any of the specimens before and after the tests. So the safety of the selenium-75 gamma radiography source is verified in accordance with classification ISO/05/C43515.

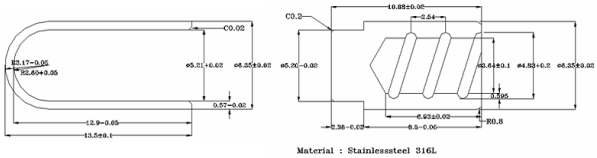

Figure 2. The selenium-75 gamma radiography source.

Figure 3. Deformation due to an impact test and a puncture test.

5. Conclusion

The equipments for the tests of a sealed source such as a temperature test, a pressure test, an impact test and a puncture test were developed by excluding a vibration test to classify the sealed source. A pressure test can be conducted for a class 2 and 3 of external pressure test. A case study for a selenium-75 gamma radiography sealed source is presented. The safety of the selenium-75 gamma radiography source is verified in accordance with classification ISO/05/C43515.

REFERENCES

[1] KOREA MOST Act. 2004-20, "Regulations for the Manufacturing the Radioisotope", 2004.
[2] ISO 2919:1999(E), "Radiation protection - Sealed radioactive sources - General requirements and classification," (1999).
[3] ISO 9978:1992(E), "Radiation protection - Sealed radioactive sources - Leakage Test Methods," 1992.