KL-007

VIBRATION TEST WITH ACCELERATION FOR PORTAL RADIATION MONITOR BASED ON SNI IEC 62244:2016

D. Intaningrum, I.D. Junianto, R.L. Tyas, dan M. Amin

ABSTRAK

Portal monitor radiasi (RPM) karena proses sertifikasi harus diuji sesuai SNI IEC 62244:2016. Standar ini memerlukan beberapa pengujian untuk diterapkan, seperti uji mekanik yang dilakukan dengan uji getaran. Persyaratan yang harus dipenuhi adalah tidak ada alarm atau perubahan lain yang terjadi selama proses indikasi monitor yang bervariasi tidak lebih dari 15%, dan tidak ada kerusakan pada komponen monitor. RPM diuji dalam kondisi operasi dan terkena sumber radiasi. Sumber radioaktif diatur 50 cm dari titik referensi. Pada uji frekuensi, RPM diberi beban harmonik 0,5 g_n selama 10 menit dengan frekuensi yang dinaikkan secara bertahap dari 10 Hz menjadi 150 Hz, kemudian menurun dari 150 Hz menjadi 10 Hz pada masing-masing arah ortogonal (x,y, dan z). Ketahanan selama pengiriman diuji dengan memberikan beban harmonik sebesar 2 g_n selama 15 menit dalam tiga arah ortogonal (x,y, dan z). Frekuensi untuk setiap rentang adalah 10 Hz hingga 21 Hz, dan 22 Hz hingga 33 Hz. Hasil dari semua pengujian menunjukkan bahwa RPM memenuhi semua persyaratan.

Kata Kunci: Portal Monitor Radiasi; SNI IEC 62244:2016; Uji Getaran; Beban Harmonik; Arah Orthogonal.

ABSTRACT

Radiation portal monitor (RPM) due to the certification process should be tested according to SNI IEC 62244:2016. This standard required several tests to be applied such as mechanical shock that was conducted by vibration test. The requirement that should be complied with is no alarms or other changes happening during the process, the varying indications of the monitor are not more than 15%, and no damage to the monitor component. RPM was tested in operating conditions and was exposed to radiation sources. Radioactive sources are set 50 cm from the reference point. For frequency test, RPM was given harmonic load 0,5 g_n for 10 minutes with frequencies that increase gradually from 10 Hz to 150 Hz then decreases from 150 Hz to 10 Hz in each orthogonal direction (x,y, and z). The durability while shipping was tested by giving a harmonic load of 2 g_n for 15 minutes in three orthogonal directions (x,y, and z). The frequencies for each range are 10 Hz to 21 Hz, and 22 Hz to 33 Hz. The result of all tests indicated that RPM complies with all of the requirements.

Keywords: *Radiation Portal Monitor; SNI IEC 62244:2016; Vibration Test; Harmonic Load; Orthogonal Direction.*

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INTRODUCTION

The nuclear industry increased rapidly in a lot of aspects, such as medicine, computed tomography, non-destructive test, and x-ray imaging [1]. Proportional to these conditions, transport of nuclear material or nuclear sources become high securities issues. Transport around international borders has been performed cargo screening using Radiation Portal Monitors (RPMs) [2].

RPM is a detector designed to examine radioactive sources/materials carried out by people or vehicles passing through the detection areas. RPM is commonly installed at checkpoints of port, airport, industry, and health facilities to ensure the security entry and exit of goods related to nuclear material or sources [3].

In Indonesia, RPMs are still imported. If there are some troubles, we have to call an expert and costs a lot of money. Due to these concerns, the National Research and Innovation Agency of Indonesia (BRIN) developed prototypes of RPM. Indonesian RPM was made from NaI(Tl) Sodium Iodide crystal scintillators detectors [4].

Due to the certification process, RPM should be tested according to SNI IEC 62244:2016. This standard required several tests to be applied such as mechanical shock that was conducted by vibration test [5].

Previous researchers have been done for testing the performance of RPM [1], distribution of energy [6], and the effect of natural gamma background [7]. Mechanical test for RPM still has limited references even though this research is important.

The mechanical test proved that RPM can withstand without affecting its performance. While operating, the mechanical shock (half-sine) was given in any direction at an acceleration of 300 m/s^2. The time interval for the acceleration is 6 milliseconds. After the test, RPM should be checked if there are some loose and damaged components [5].

This test also giving assured that RPM is safe while shipping. The vibration while shipping is affected by several factors such as the condition of the roads and vehicles that were used. The position of RPM while shipping is also affected by vibration and acceleration [8].

Aside from shipping, this test also assured that RPM is safe when comes to the earthquake. Indonesia is the meeting point of the Pacific, Eurasian and Indo-Australian plates. If these three plates experience several conditions such as shifting, braking, or sticking up, it will cause an earthquake. So, the aim of this paper is forgiving prove that Indonesian RPM meets the requirement of the vibration test according to SNI IEC 6224: 2016.

MATERIALS AND METHODS

Materials and Equipment

RPM was made from scintillator plastic NaI(Tl) Sodium Iodide crystal detectors and followed the requirement in IAEA-TECDOC-1312. The Nai(Tl) detector has a high ability to detect gamma-ray radiation and was integrated with a multichannel analyzer (MCA). The complete basic design and specification have been described in the previous research by other researchers [9].

This RPM was designed for vehicles with a maximum height of 220 cm and the detection zone is height 220 cm, length 62 cm, and wide 320 cm. The configuration of the RPM can be described in the picture below:

Figure 1. The Configuration of RPM [4]

The equipment used for the vibration test was a Vibrator combo system (LDS / Bruel & Kjaer) with V850-440 HBT900C models. For accelerating used Bruel & Kjaer Accelerometer, 4508 models. The temperature and humidity were constant.

Methods

This research accordance with SNI IEC 62244:2016 for vibration test. While operating, the mechanical shock (half-sine) was given to RPM from all of the directions (x, y, and z) at an acceleration of 300 m/s^2. The time interval for the acceleration is 6 milliseconds. This test was conducted 10 times while observing the function of the monitor. After these tests, RPM should be checked if there are some loose and damaged components [5].

The requirement for vibration tests based on standards are:

1. No alarms or others change happened during the process
2. The varying indications of the monitor not more than 15%
3. No damage to the monitor component [5].

For the purpose above, the research was conducted with the method as followed:

1. RPM should be in operating conditions.
   That is why RPM should be exposed to sufficient radiation sources to minimize the effect of statistical fluctuations. Radioactive sources are set 50 cm from the reference point. The count rate and average count rate should be recorded and determined.
2. Frequency Test
   RPM was given harmonic load 0,5 g_n with the frequency that increases gradually from 10 Hz to 150 Hz then decreases from 150 Hz to 10 Hz in each orthogonal direction (x,y, and z). For every cycle, the time recommendation is 10 minutes. The average result must be determined and recorded during the vibration.
3. Durability to vibration during shipping
   The endurance of RPM during shipment was tested by giving a harmonic load of 2 g_n for 15 minutes in three orthogonal directions (x,y, and z). The frequencies for each range are 10 Hz to 21 Hz, and 22 Hz to 33 Hz. However, if there is a mechanical resonance in point (a) the frequency was selected among the resonant frequencies. The average of the geometric exposure should be determined [5].

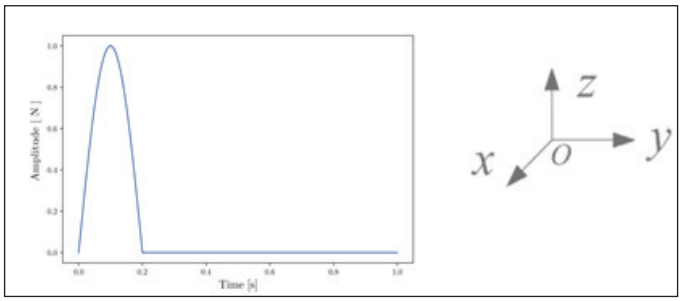

Figure 2. Normalize Half-Sine Impulse [10] and the Direction of the Test

Figure 3. Test Set Up – Vibration (X-axis) Left, and (Y-axis) Right

Figure 4. Test Set Up – Vibration (Z-axis)

RESULT AND DISCUSSION

Accelerated vibration at 300 m/s² with 0,5 g_n Harmonic Load

The test was conducted with half-sine mechanical shock for all the directions. From the result of the test in Fig 5a and 5c, we can conclude that in the x and y-axis RPM was vibrated throughout the testing process. In the x-axis, there were two high peaks with g_n ±2,9000 and ±2,5500 while in the y-axis there were 5 high peaks with g_n ±6,5000; 8,000,0 and 7,0000.

The peak indicated the amplitude/ displacement of the wave. It means that RPM moving and displace caused by accelerated vibration. The trend in the x and y-axis was quite similar but with a different impact on RPM based on the amplitude.

The trend of the graph on the z-axis was different from the x and y-axis. It was because the vibration tends to up and down in the z-axis. From Fig 6c we could conclude that only one peak was indicated. The highest peak happened after 1 minute with g_n ±0,9750.

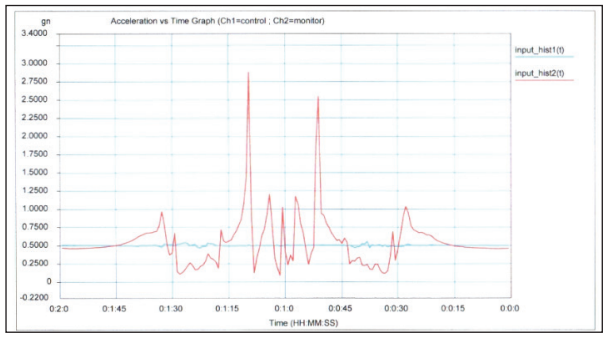

Figure 5a. Acceleration vs Time Graph (x-axis)

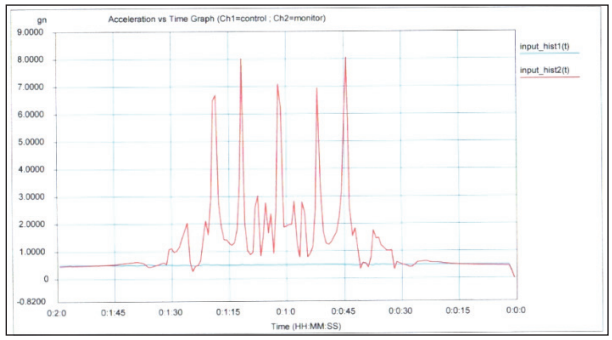

Figure 5b. Acceleration vs Time Graph (y-axis)

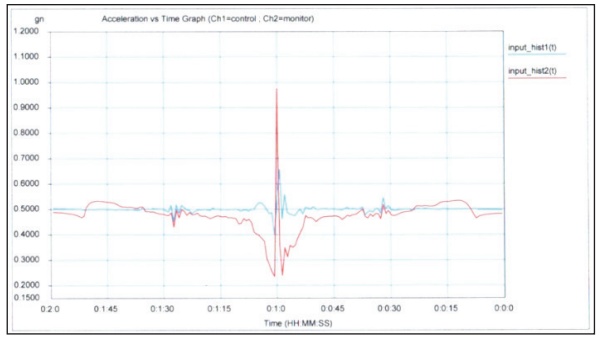

Figure 5c. Acceleration vs Time Graph (z-axis)

Frequency Scan

The frequency scan conducted by increases and decreases the frequency gradually as shown in Figure 6.

The transmissibility test was also conducted and documented in Figure 7a, 7b, and 7c. The harmonic load for the test was determined from the first peak shown in Fig. 5a, 5b, and 5c. The resonance frequency of the three directions were x-axis = 68 Hz, y-axis = 39 Hz, z-axis = 142 Hz.

Along this process, there were No alarms or other changes that happened. That is why we could conclude that for this test RPM meets the requirement.

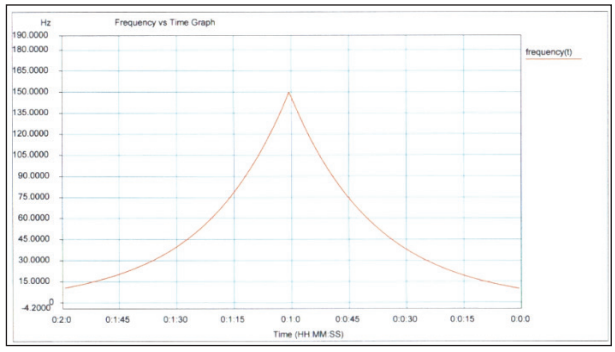

Figure 6. Frequency vs Time Graph (x, y, and z-axis)

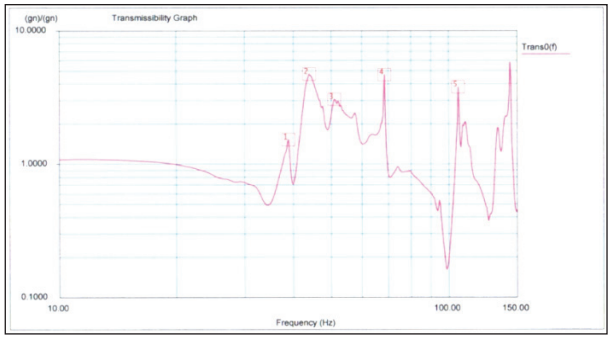

Figure 7a. Transmissibility Graph (x-axis)

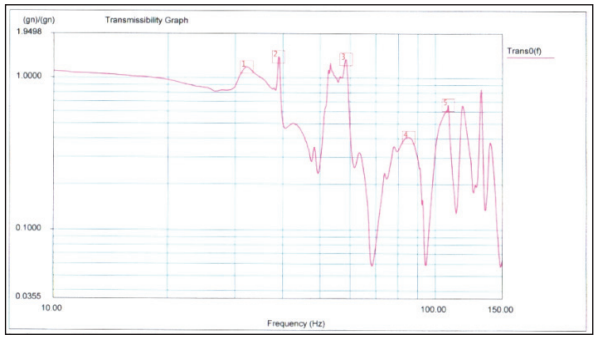

Figure 7b. Transmissibility Graph (y-axis)

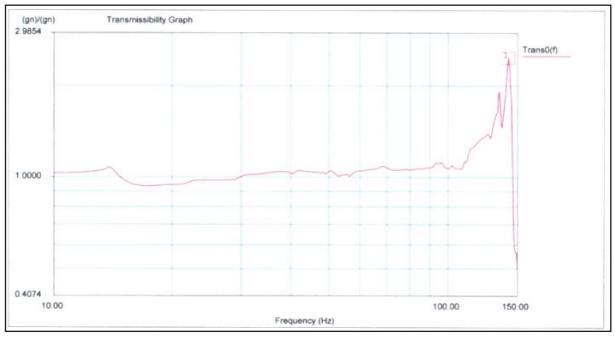

Figure 7c. Transmissibility graph (y-axis)

Durability to vibration during shipping

From the result of the test that was shown in Figure 8a, 8b, and 8c we could conclude that RPM was safe during the shipment. The RPM in the x, y, and z-axis vibration was not much affected.

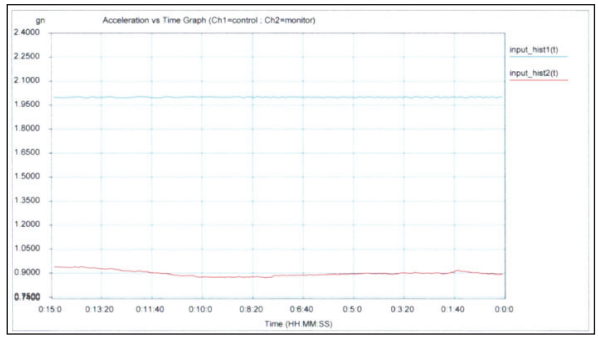

Figure 8a. Endurance Test – Acceleration vs Time Graph (x-axis)

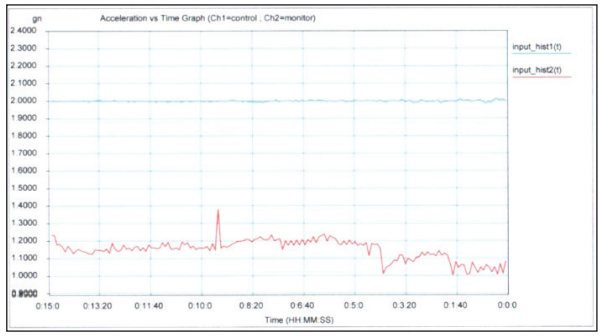

Figure 8b. Endurance Test – Acceleration vs Time Graph (y-axis)

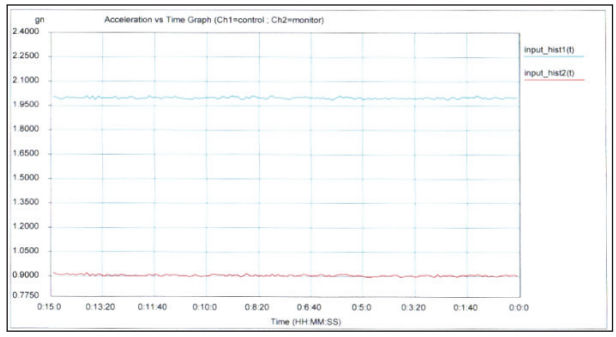

Figure 8c. Endurance Test – Acceleration vs Time Graph (z-axis)

For determining the deviation of the enumeration result of the RPMs was conducted by vibration test at the resonance frequency for 15 minutes. The deviation of the average enumeration in the RPM monitor's before and after vibrating was less than 15% that means RPM meet the requirement of the standards. The result can be seen in Table 1.

Due to the mechanical resonance was found in the test, the geometric exposure was conducted by endurance test for each frequency at each orthogonal direction. The result can be seen in Fig. 9a, 9b, and 9c.

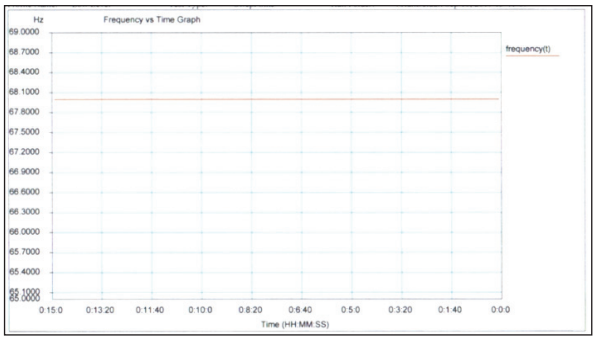

Figure 9a. Endurance Test – Frequency vs Time Graph (x-axis)

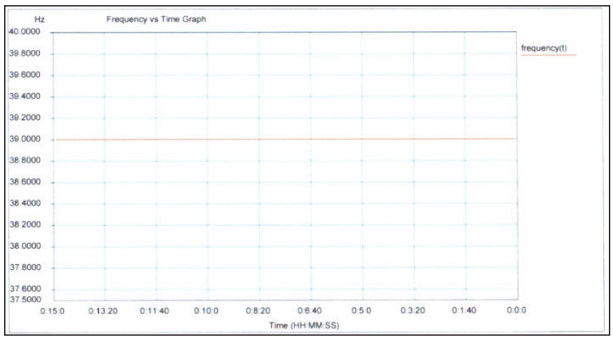

Figure 9b. Endurance Test – Frequency vs Time Graph (y-axis)

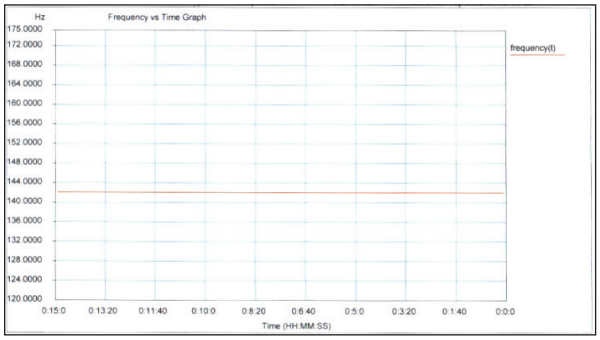

Figure 9c. Endurance Test – Frequency vs Time Graph (z-axis)

Table 1. Vibration Measurement Result

Frequency	Average Initial Value	Average Final Value	Deviation (%)
68	1749	1986	13,5
39	1886	1879	0,4
142	1487	1497	0,6

For all the tests that have been conducted, RPM meets all of the requirements of the mechanical shock SNI IEC 62244:2016. The summary of the test can be seen in Table 2.

Table 2. Result of the Vibration Test

No.	Requirement - Test	Result
1.	Frequency scan	
	No alarm or other changes in operation while vibration exposure	No alarm and other changes
	Resonance frequency	
	X-axis	68 Hz
	Y-axis	39 Hz
	Z-axis	142 Hz
2.	Durability to vibration during shipping	
	The result should not vary by more than 15% of the reference value	< 15%
	The physical of a monitor is not affected by vibration	The monitor was not affected

CONCLUSION

In this research, RPM was tested for mechanical shock based on SNI IEC 62244:2016 and shown that it's meet all the requirements. There were no alarms or other changes during the vibration, the durability of RPM during shipping also was not affected. The resonance frequencies were found in this research for each orthogonal direction (x = 68, y = 39, and z = 142).

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