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# NEW HEAVY IMPACT SOURCE FOR THE MEASUREMENT OF FLOOR IMPACT SOUND INSULATION OF BUILDINGS

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## ABSTRACT
For the measurement and assessment of impact sound insulation of building floors, a standard heavy impact source is desirable to simulate such heavy and soft impacts as human walking and stepping, mainly by children. In Japan, therefore, the tire-dropping method is specified in the Japanese Industrial Standard (JIS A 1418) in addition to the method using the standard tapping machine specified in ISO 140 series. To adding this method, a development work has been performed and finally a separate heavy impact source (rubber ball) with a lower impact force and with small temperature dependence has been developed. In this paper, the specifications and characteristics of the new heavy impact source are shown and some examples of measurement results indicating the validity of the source are introduced.

## 1 - INTRODUCTION
Among noise generated in multi-family dwellings, floor impact sound can be pointed out as the noise source with the highest rate of complaints from residents. The rate is particularly high for floor impact sound generated by people walking, stepping and so forth. Since this type of floor impact sound has a peak in the low-frequency range, it is dominated by vibration characteristics of the floor structure and its control has been the target of vigorous research and development in Japan. In order to measure their properties, a standard heavy impact source was provided in the Japanese Industrial Standards (JIS A 1418) in 1978. These impact force properties assumed the impact force of a child jumping down from a chair. Recently, however, many have expressed the opinion that this is too large for a test-use impact force when the flooring material is of a light-weight wooden structure or when the building is built of wood, light weight steel frame or other structure and there are demands for stipulating an additional new impact source with reduced heavy impact force.
Accordingly, in February, 2000, at the time of the amendment of JIS A 1418 in order to make the JIS compatible with ISO, a new standard heavy impact source with a lower impact force was stipulated in addition to the conventional standard floor impact source. In this report, we introduce the specifications of the new standard heavy impact source and the characteristics of its impact force.

## 2 - CHARACTERISTICS OF NEW HEAVY IMPACT SOURCE
The basic approach of the new standard heavy impact source follows the approach of the existing standard heavy impact source. That is, the duration was not changed and set at 20±2ms while the peak impact force was reduced to about 1/3 that of the existing impact source. An outline of the new impact source

("impact source 2") is given in Table 1 in comparison to the existing impact source ("impact source 1"). In order to realize stability in the impact velocity at the time of floor impact, the same free fall method that was used in impact source 1 was also adopted in impact source 2 and it is a hollow spherical impact source capable of obtaining a peak impact force of about 1500N and a duration of about 20ms. Various materials for the impact source itself were examined in order to assure that it would be possible to obtain stability in the elastic coefficient and the loss factor in relation to changes in the ambient temperature and, as a result, it was decided to use silicon rubber for a spherical impact source by joining two hemispheres.

| Type / Item | Impact Source 1 | Impact Source 2 |
|---|---|---|
| Effective Mass | 7.3 kg | 2.5 kg |
| Air Pressure | 2.5 $10^5$ Pa | |
| Drop Height | 85 cm | 100 cm |
| Rebound Coefficient | 0.8 | 0.8 |
| Shape | | Sphere, diameter 80 mm |
| Impact Time | 20 ms | 20 ms |

**Table 1:** Outline of the standard heavy impact source.

After an impact source 2 prototype was placed in a thermo-hygrostat and cured for 8 hours or more at certain constant temperatures, we measured the impact force characteristics when impact source 2 was allowed to fall freely from heights of 1m and 0.5m using the impact force measuring device illustrated in Fig. 1.

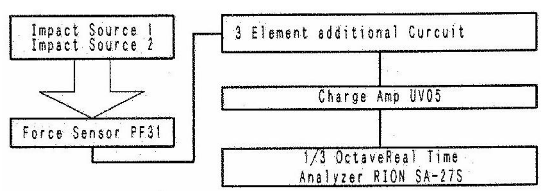


**Figure 1:** Measuring device for impact force and duration.

Fig. 2 shows examples of the measurement of the properties of impact force with the temperature set at -30°C, 0°C and +40°C and with a drop height of 1m. In addition, Fig. 3 likewise shows the measurement of impact force properties when the drop height is 0.5m. Fig. 2 shows constant values for both impact force peak and duration even under the severe conditions of curing temperatures of -30°C and +40°C and it could probably be said that it is suitable as a standard impact source. In the case of impact sources having the same elasticity, the impact force is proportional to the square root of the drop height, as indicated in the equation below.

$$F_{max} = M\sqrt{2gh}\,(1+\mu)\,\frac{\pi}{2\Delta t} \quad (1)$$

Where $F_{max}$: Impact force peak (N), $M$: Impact source mass (kg), $h$: Drop height (m), $\mu$: Rebound coefficient, $\Delta t$: Duration of impact force (sec), $g$: Gravity acceleration (m/s$^2$).
Thereupon, when we attempted a verification with the temperature set at -30°C (Figs. 2 & 3), since the peak impact force is 1,500N when the drop height is 1m, the peak impact force when the drop height is 0.5m is calculated to be $F$ = 1,500N/ $\sqrt{2}$ = 1,061N, which essentially corresponds to the actual measurement value of 1,062N of Fig. 3. This correspondence was the same at other curing temperatures and it could be said that the impact source has similar elasticity within the range of both drop heights.
Impact force frequency characteristics are expressed as the impact exposure level per 1 sec. The impact force frequency characteristics at each temperature setting with a drop height of 1m are shown in Fig. 4. These indicate that, since the resistance of the impact source cannot be ignored, the initial portion of the impact of the impact time waveform is somewhat steep and, therefore, in particular, some rise in level can be observed in the vicinity of the 250Hz band due to that influence. However, when comparing at each temperature setting, it indicates stable frequency characteristics with virtually no change overall and it could also be considered a stable impact source from the standpoint of frequency characteristics.

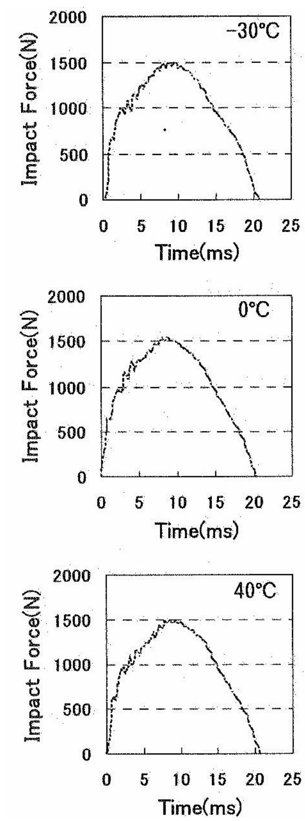


**Figure 2:** Impact force properties due to changes in the temperature setting ($h$=1m).

The results of measurement of the rebound coefficient of impact source 2 at each temperature setting are given in Table 2. It is clearly evident from this that it remains constant at about 0.88 over the temperature range of -30°C to +40°C.

| | | | | |
|---|---|---|---|---|
| Temperature setting (°C) | −30 | −20 | −10 | 0 |
| Rebound coefficient | 0.87 | 0.87 | 0.88 | 0.87 |
| Temperature setting (°C) | 10 | 20 | 30 | 40 |
| Rebound coefficient | 0.89 | 0.89 | 0.89 | 0.89 |

**Table 2:** Measured values of rebound coefficient (impact source 2).

## 3 - EXAMPLES OF MEASUREMENT OF FLOOR IMPACT SOUND IN STEEL FRAME RESIDENTIAL BUILDINGS

We measured the floor impact sound in the steel-frame residential building as to two rooms. The floor structure of both rooms was a light-weight steel framework structure and autoclaved light-weight concrete panel was used for the floor. The floor finishing material of Room 1 was carpet or direct wood flooring. As the impact source, adding to the impact source 2, an ISO standard tapping machine and the impact source 1 stipulated in JIS A 1418 (light automobile tire with a mass of 7.2kg, free fall from a height of 90cm, peak impact force: 3900N, impact time: 20ms), an adult jumping up and down and jumping down from a chair were also used for comparison purposes. For the measurements of floor impact sound, we excited the upper layer of the floor finishing materials with each impact source and measured the equivalent sound pressure level for 15 sec in each octave band in the case of the tapping machine and the peak level due to time weighting characteristic F for each octave band in 31.5Hz − 1000Hz in the case of the other impact sources.

The results of the measurements for each room are shown in Fig. 5. In the case of room 1, the results of the measurement using impact sources 1 and 2 indicated essentially constant frequency characteristics with hardly any influence due to changes in the floor finishing materials. That is due to the fact that the floor finishing materials are compressed at the time of impact and become harder because the impact source is heavy and soft and the impact force is large. Directly-applied floor finishing materials were little

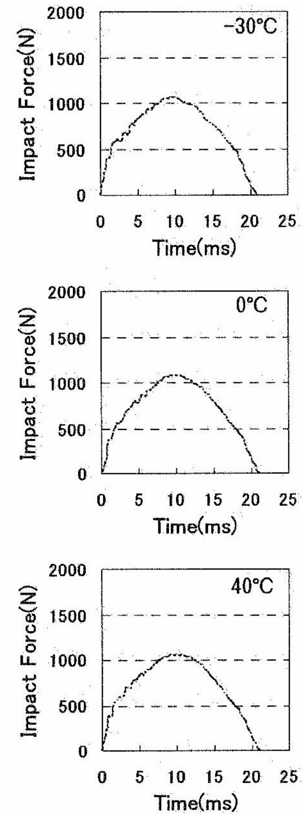


**Figure 3:** Impact force properties due to changes in the temperature setting ($h$=0.5m).

influenced by changes in performance and results were expressed that one would expect of the original purpose of use of the heavy impact source of determining performance due to the vibration properties of the floor structure. In addition, the results of the measurement of the adult jumping up and down indicated relatively good correspondence to the impact source 2, especially in the low frequency range, and it is thought possible to assess the performance of floor impact sound insulation due to people jumping and down and so forth using the measurements of impact source 2.
The results of measurements using the tapping machine clearly show the effect of floor impact sound reduction depending on the hardness of the surface due to changes in the floor finishing materials and it could be said that it is possible to determine the performance of light-weight, hard impact sources with good precision; however, it is difficult to accurately determine the effect of people walking and other heavy impact sources.

## 4 - CONCLUSION

Based on the test results of floor impact sound using actual residential floor structures, it can be said that the heavy impact source proposed in this study is effective for use in testing the performance of floor impact sound insulation for people walking, jumping up and down and so forth. In addition, due to the large impact force of impact source 1 of 3,900N, it could be said that, from the standpoint of the measurement condition, S/N ratio, it is suitable for testing concrete and other heavy structures while impact source 2 is suitable for testing wooden structures, light-weight steel frame structures and other structures due to its relatively small impact force of 1,500N.

## REFERENCES

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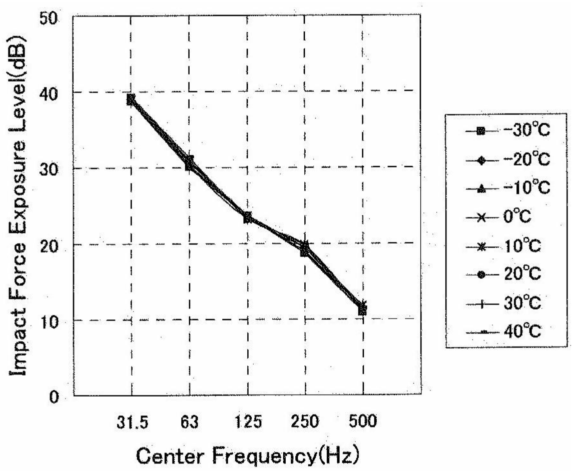


Unit(dB)

| | 31.5Hz | 63Hz | 125Hz | 250Hz | 500Hz |
|---|---|---|---|---|---|
| -30℃ | 38.7 | 30.1 | 23.4 | 18.7 | 11.0 |
| -20℃ | 39.2 | 30.7 | 23.7 | 18.9 | 11.4 |
| -10℃ | 39.1 | 30.4 | 23.3 | 19.0 | 11.0 |
| 0℃ | 38.9 | 30.2 | 23.1 | 19.7 | 10.9 |
| 10℃ | 39.3 | 30.8 | 23.6 | 19.4 | 11.7 |
| 20℃ | 39.3 | 30.9 | 23.1 | 19.4 | 11.2 |
| 30℃ | 39.3 | 31.0 | 23.3 | 19.7 | 11.4 |

**Figure 4:** Frequency characteristics of the impact force exposure level at each temperature setting.

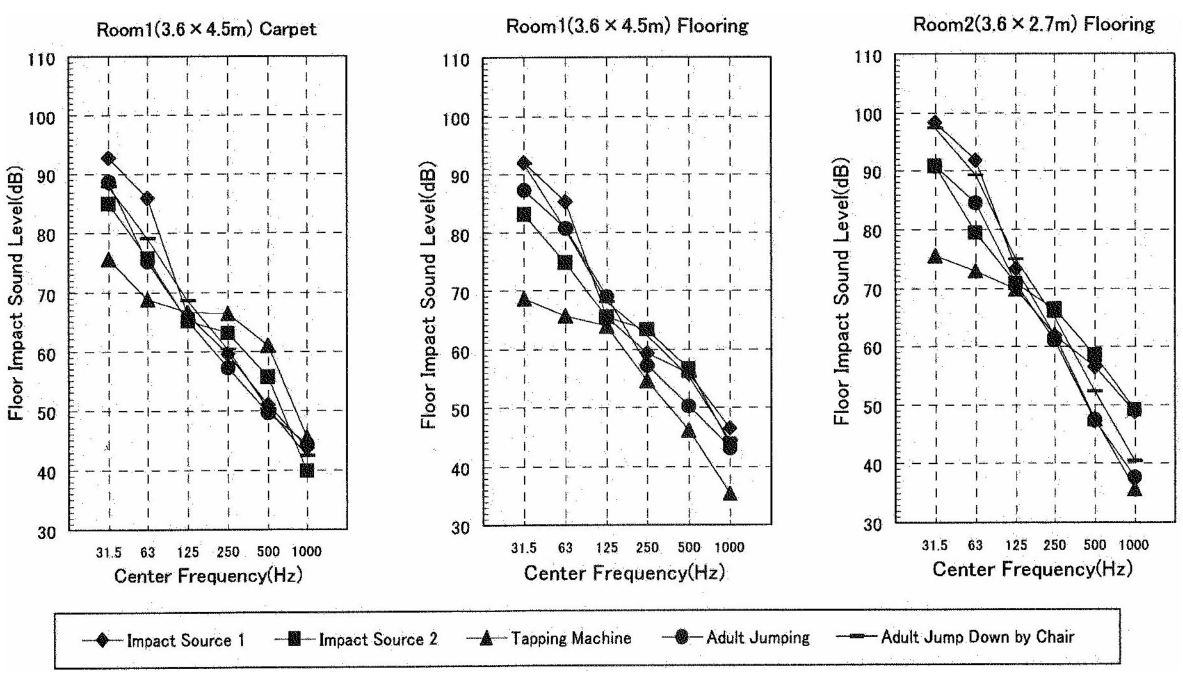


**Figure 5:** Measurement results of floor impact sound using various impact sources.