Noise is occurring more frequently in daily life. Accordingly, it seems that because of this, even our hearts produce heartless sounds. Putting much value on peaceful moments and quiet places — such feelings are becoming more apparent not only in industry but in our homes as well.

One powerful way to create quietude is to use VIBLESS, a vibration-damping steel sheet supplied by NIPPON STEEL. This product not only maintains advantages such as the high strength and excellent workability that are peculiar to steel sheets but also offers high vibration-damping capacity. VIBLESS is used widely as a material in automobile parts, electrical home appliances, and building construction where it helps to create quietness.

**Major Features of VIBLESS**

1. **Outstanding Vibration-damping Capacity**
2. **Excellent Press-formability**
3. **Available Spot Welding for Certain Types**
4. **High-temperature Baked Finish Available with Thermosetting Type**
5. **High Reliability Demonstrated by Proven Durability and Abundant Records of Usage in Such Fields as Automobile Oil Pans and Electrical Home Appliances**
6. **Nearly Identical Treatment for Both VIBLESS Scrap and General Steel Scrap**

**1. Noise and Noise Prevention, and Vibration-damping Capacity of VIBLESS**

Noise-prevention methods are broadly divisible into two categories:

Ⓐ The absorption or insulation of noise
Ⓑ The damping of vibrations that generate noise, thus minimizing noise

**Noise-prevention Methods**

- **Sound Insulation and Absorption**
  - Glass Wool, Wood, Wool, Cement Excelsior Board, Concrete, Thick-Gauge Steel Sheet
- **Vibration Damping and Absorption**
  - VIBLESS, Damping Sheet, Damping Alloy, Rubber, Wood, Plastics, etc.

Based on the provisions specified in Article 68-26, Item 1 of the Building Standard Law of Japan (including cases covered by Article 88, Item 1 of the Law), VIBLESS has been approved by the Minister of Land, Infrastructure and Transport as a material conforming to the provisions on incombustible materials specified in Article 2, No. 9 of the Law and in Article 108-2 of the Enforcement Order of the Law.
2. Structure and Vibration-damping Effect of VIBLESS

Structure

Structurally, VIBLESS consists of two steel sheets sandwiching an approximately 40 μm-thick layer of visco-elastic resin. The vibration-damping mechanism of this sheet is based on the shear deformation of the visco-elastic resin which transforms vibration energy into thermal energy.

Vibration-damping Effect and Characteristics

1. The vibration-damping capacity is usually given by the loss factor $\eta$. The higher this value, the greater the vibration-damping effect. VIBLESS is available for room-, intermediate- and high-temperature uses, so that its vibration-damping potential may be fully utilized according to service temperature. (Fig. 1)

2. Also available is VIBLESS for new intermediate-temperature use with an effective temperature range from room to high temperature, though it is slightly inferior in vibration-damping performance.

3. A comparison of the loss factor $\eta$ of VIBLESS with that of other materials is shown in Fig. 2; their respective vibration-damping wave patterns are given in Fig. 3. VIBLESS is superior in vibration-damping and has the high strength inherent in steel sheet.

4. Fig. 4 gives loss factors measured at respective temperatures when oil has been poured into an actual oil pan. It shows the excellent vibration-damping capacity of VIBLESS.

5. Sound-insulation Effect of VIBLESS

The sound transmission loss of VIBLESS follows the law of mass. When compared with that of ordinary steel sheet, it has the following characteristics.

1. No lowering of the sound transmission loss at resonance coincidence
2. Sometimes sound-insulating materials will themselves vibrate and generate sound due to the transmission of vibrations caused by large sound pressure or vibrations generated at the sound source. VIBLESS suppresses these vibrations, preventing the generation of sound.
3. Classification Symbols and Typical Types of VIBLESS

Classification Symbols for VIBLESS
Symbols in the specifications of VIBLESS mean:

Themes

Typical Characteristics of VIBLESS
The available types of VIBLESS vary with service temperature. Please select the most suitable type.

Coating Mass Symbol of VIBLESS
Please refer to the standards for such base steel sheets as electrogalvanized sheets and iron-zinc alloy-coated steel sheets.

Surface Treatment of VIBLESS
Because the available surface treatments differ according to the type of coating, please consult us.

Notes
- VIBLESS using steel sheets other than those listed are available. Please consult us.
- The data shown are for a typical thermosetting resin and general type VIBLESS of commercial grade using cold-rolled steel sheets, 1.6 (0.8 + 0.8) mm thick.
- Measurement examples by means of the center-support stationary excitation method conforming to JIS G 0602
- Shear adhesive strength : Measurement examples conforming to JIS K 6850
- T-peel strength : Measurement examples conforming to JIS K 6854
- \( \eta_{\text{max}} = 9.80665 \times \text{kgf/cm}^2, N/25 \text{mm} = 9.80665 \times \text{kgf}/25 \text{mm} \)

Examples of Classification Symbols

<table>
<thead>
<tr>
<th>Type of Sheet</th>
<th>Commercial Grade</th>
<th>Drawing Grade</th>
<th>Deep-drawing Grade</th>
<th>Extradeep-drawing Grade</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold-rolled Steel Sheet</td>
<td>VCCC</td>
<td>VCCD</td>
<td>VCCE</td>
<td>VCCX</td>
<td></td>
</tr>
<tr>
<td>Electrogalvanized Steel</td>
<td>VEEC</td>
<td>VEEE</td>
<td>VEEX</td>
<td>ZINKOTE</td>
<td></td>
</tr>
<tr>
<td>Iron-Zinc Alloy-coated</td>
<td>VAA</td>
<td>VAAE</td>
<td>—</td>
<td>DURGRIP (Galvannealed)</td>
<td></td>
</tr>
</tbody>
</table>

Notes
- VIBLESS using steel sheets other than those listed are available. Please consult us.

4. Size Availability of VIBLESS

Cold-rolled Steel Sheets

Intermediate-temperature Use

High-temperature Use

Electrogalvanized Steel Sheets

Iron-Zinc Alloy-coated Steel Sheets
5. Properties of VIBLESS

1. Examples of Tensile Test Values (Test Piece: JIS No. 5)

<table>
<thead>
<tr>
<th>Type of Base Sheet</th>
<th>Yield Point (N/mm²)</th>
<th>Tensile Strength (N/mm²)</th>
<th>Elongation (%)</th>
<th>r Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold-rolled Steel Sheets (t = 0.8 mm)</td>
<td>150</td>
<td>290</td>
<td>50</td>
<td>2.00</td>
</tr>
<tr>
<td>VIBLESS (t = 0.8 + 0.8)</td>
<td>146</td>
<td>283</td>
<td>50</td>
<td>2.01</td>
</tr>
<tr>
<td>For Room-temperature Use</td>
<td>146</td>
<td>285</td>
<td>50</td>
<td>2.02</td>
</tr>
<tr>
<td>For Intermediate-temperature Use</td>
<td>145</td>
<td>285</td>
<td>51</td>
<td>2.02</td>
</tr>
<tr>
<td>For High-temperature Use</td>
<td>145</td>
<td>285</td>
<td>51</td>
<td>2.02</td>
</tr>
</tbody>
</table>

- The yield point and tensile strength of VIBLESS are slightly lower than those of the cold-rolled steel sheets used.
- The r value of VIBLESS is slightly higher than that of cold-rolled steel sheets used.

2. Formability of VIBLESS

Relation Between Various Kinds of Formability and Shear Adhesive Strength

![Diagram showing the relationship between formability and shear adhesive strength.]

Relation Between Cylindrical Deep-drawing limit and Blank Holding Force

- Levels of Ordinary Steel Sheet of the Same Thickness
- Deep Drawing Resistance
- Flange Wrinkling Resistance
- End Hardness (Flange up)

<table>
<thead>
<tr>
<th>Blank Diameter (mm)</th>
<th>Blank Holding Force (ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>120</td>
<td>180</td>
</tr>
<tr>
<td>160</td>
<td>200</td>
</tr>
<tr>
<td>180</td>
<td>220</td>
</tr>
<tr>
<td>210</td>
<td>250</td>
</tr>
<tr>
<td>230</td>
<td>300</td>
</tr>
<tr>
<td>250</td>
<td>350</td>
</tr>
<tr>
<td>270</td>
<td>400</td>
</tr>
<tr>
<td>290</td>
<td>450</td>
</tr>
</tbody>
</table>

- The fatigue property of VIBLESS is virtually equal to that of cold-rolled steel sheet, as shown in the figure.

3. Fatigue Property

Plane-bending Fatigue Test

- In general, formability improves with increased adhesive strength.
- In drawing VIBLESS, apply a higher blank holding force than when working with ordinary steel sheets.
- Since the properties of VIBLESS vary with the type of the intermediate visco-elastic resin layer, please consult us before using.

4. Resistance Weldability

- VIBLESS (Commercial Grade)
  Welding of VIBLESS requires a supporting electrode system, because of the intermediate layer of nonconductive, elastic high polymer. The use of the supporting electrode system developed by NIPPON STEEL enables both spot and projection welding to be performed in a manner similar to that for cold-rolled steel sheet.

Example of Current Application By By-pass Circuit

- By-pass Jig System
  - Hand Vice
  - Weld Spot System
  - Supporting Electrode System

- Weldable VIBLESS
  Conductive metal particles are added to the intermediate resin layer. This permits resistance welding without the need for the aforementioned by-pass circuit.

- Proper Welding Region
  Proper Welding Conditions for Spot Welding are as follows:

  - Test Pieces to be Welded
  - Welding Current (KA)
  - Welding Time (s)
5. Properties of VIBLESS

1. Arc Welding

In arc-welding of VIBLESS to ordinary steel sheet, arrange the ordinary steel sheet in the lower position. (Photo①)

When arc-welding VIBLESS to VIBLESS, heat penetration into the resin layer of the lower VIBLESS would cause the resin to gasify and erupt out of the joint, resulting in arc instability. It is recommended, therefore, that arc-welding be performed under low heat-input conditions to avoid such heat penetration. (Photo②)

2. Control of Aged Lowering of Screw Torque Loss Due to Addition of Metallic Fillers

1. Test Method
   - Size of test piece: 1.6 mm (0.8 + 0.8) × 30 × 300 mm
   - Drilling: Drilling in a diameter of 6.5 mm and at a pitch of 50 mm → A set of M6 bolt, VIBLESS, washer and nut
   - Initial fastening force: Set at 100 kgf
   - Measurement of initial torque in the case of incremental fastening at room temperature after retaining in the prescribed time at 80 °C

2. Results
   - Because of the addition of metallic fillers, maximum torque loss is about 20% even at 80 °C.
   - Further, torque loss occurs within several hours after the initial addition of filler but remains nearly constant afterwards.

6. Heat Resistance

Change in Adhesive Strength Due to Heating
(In the case of fixing the temperature level and then changing the lapse of time)

Change in Adhesive Strength Due to High-temperature Heating
(In the case of fixing the lapse of time and then changing the temperature level)

7. Durability

Shown below are the results of a study concerning VIBLESS quality changes in various conceivable service environments. They show that VIBLESS undergoes hardly any deterioration in performance, providing excellent quality assurance in application.

(Resin : thermo-setting type for high-temperature application)
8. Typical Applications

<table>
<thead>
<tr>
<th>Classification</th>
<th>Application Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automobiles</td>
<td>Engine oil pan (Diesel, Gasoline), Mission oil pan, Engine cover, Wheelhouse, Dash panel, Door panel, Room partition, Seat-back center, Floor panel, Roofing, Brake part, Horn parts, Belt cover, Cross members</td>
</tr>
<tr>
<td>Electrical Machines</td>
<td>Washing machine body, Dryer drum, Fan-heater housing, Speaker frame, Cover and other components of acoustic equipment (Video cassette recorder, Compact disc player, etc.), Printer components, Housing for hot-water supply pot, Air-conditioner components, Components of antenna for BS broadcasting, Copy machine components, Motor cover, Motor fan cover, Motor frame, Switchbox</td>
</tr>
<tr>
<td>Building Materials and Others</td>
<td>Roofing, Floor, Staircase, Shutter, Curtain rail, Shooit, Hopper and cover for industrial machinery, Various types of noise-prevention walls, Steel furniture, Air conditioner duct, Dispensing chutes of vending machines, Ship wall</td>
</tr>
</tbody>
</table>

- Chain housing
- Dash panel
- Oil pan (Gasoline)
- Oil pan (Diesel)
- Wheelhouse
- Seat-back center
- Engine belt cover
- Roofing, Floor, Staircase
- Noise-prevention wall
- Ship wall
- Curtain rail
- HDD cover
- Dryer drum
- Motor base of fan heater
- Washing machine body
9. Packaging and Markings

Example of Packaging
(The form of packaging differs according to the distance and method of transport.)

Example of Marking on Packaging Label

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Name</th>
<th>Markings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VIBLESS</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specifications</th>
<th>VEEX : J S DD MN</th>
</tr>
</thead>
<tbody>
<tr>
<td>① Symbol of Oiling</td>
<td>H : Heavy Oiling</td>
</tr>
<tr>
<td>② Symbol of Surface Treatment</td>
<td>M : Non-treatment</td>
</tr>
<tr>
<td>③ Symbol of Temperature Grade</td>
<td>K : Normal Oiling</td>
</tr>
</tbody>
</table>

Item: No Steel Cover on Coil Inside and Outside
Example of V.C.I. Paper or Film Packaging
(Coil)

10. Reference Information on Usage

VIBLESS — a composite material composed of steel sheet and visco-elastic resin — offers characteristics different from those of ordinary steel sheets. Special care should be given to the following points:

Shearing/Cutting
(1) Shearing and blanking: Adjust the clearance to half that for ordinary steel sheet.
(2) For fusion-cutting, select the methods characterized by a small beam diameter, such as laser beam cutting.

Forming
(1) Because VIBLESS is more likely to wrinkle during drawing than ordinary steel sheets, higher blanking force should be adopted (refer to paragraph 5-(2) Formability of VIBLESS). In particular, in drawing parts for which forming is difficult, the plastic flow performance of the visco-elastic resin constitutes an important factor that makes preliminary testing essential.
(2) In bending of VIBLESS, flange bending may occur due to a difference in residual stress between the upper and lower steel sheets (refer to paragraph 5-(3) Bendability). Countermeasures against this include:
   - Design: To adopt a larger bending radius.
   - Fabrication: To extend the die width (ten times or more the sheet thickness is desirable). V-cutting (refer to paragraph 5-(2) Bending) and other methods can be applied.

Joining
(1) Resistance welding: The provision of a bypass circuit is required for the commercial grade (refer to paragraph 5-(2) Resistance Weldability).
(2) Arc welding: Because the resin is likely to burn and voids are likely to occur, care should be taken to adopt low heat input (refer to paragraph 5-(2) Arc Welding). There is also a method by which arc welding is performed after the visco-elastic resin has been removed by burning.

Screw-fastening
(1) Screws compatible with the upper and lower steel sheets should be used.

Painting
(1) For a high-temperature baking finish (180˚C or higher), the thermosetting resin type is essential, so please consult us prior to the application.

Galvanizing at Fabricators’ Shop
(1) Electro-galvanizing: As for the commercial grade, the electric current should be passed through both surfaces.
(2) Hot-dip galvanizing: It is recommended not to apply hot-dip galvanizing, because it changes the quality of the visco-elastic resin.

Treatment at Fabricators’ Shops
(1) Because VIBLESS is manufactured by bonding two steel sheets together, its rigidity is lower than that of an ordinary steel sheet having the same thickness. Accordingly, care should be exercised when VIBLESS is used for members requiring structural strength.
(2) Because the adhesive strength of visco-elastic resin is less than 1/10 that of ordinary steel sheets, applications where force is applied in the direction that would cause delamination of steel sheets should be avoided.

(3) The properties of VIBLESS depend on the resin applied, so please consult us prior to the application planning.
Methods for Measuring Vibration-damping Capacity

Methods for Measuring Vibration-damping Capacity, Loss Factor \( \eta \)

**Principle of Measurement**

The loss factor is obtainable from the half power band width (3 dB) of the frequency-response curve of the vibration acceleration divided by the excitation force.

\[
\eta = \frac{f_2 - f_1}{f_0} \text{ (3 dB)}
\]

**Center-support Stationary Excitation Method**

(Refer to the Figure Below)

- **Test Piece** Width: 30 mm, Length: 300 mm
- **Impedance Head**
- **Test Piece**
- **Exciter**
- **Amplifier**
- **FFT Analyzer**
- **Computers**

**Frequency Response Curve**

**Methods for Measuring Adhesive Strength**

1. **Shear Adhesive Strength**

   - Test Piece Width: 25 mm
   - Weld Zone Length: 10 mm
   - Room temperature
   - Shear adhesive strength is obtained by calculating strength per 1 cm² of area.

2. **T-peel Strength**

   - Test Piece Width: 25 mm
   - T-peel Load (kgf) 0, 20, 40
   - T-peel Strength 0, 20, 40
   - T-peel Speed: 5–50 (mm/min)

   Room Temperature