NIPPON STEEL

www.nipponsteel.com

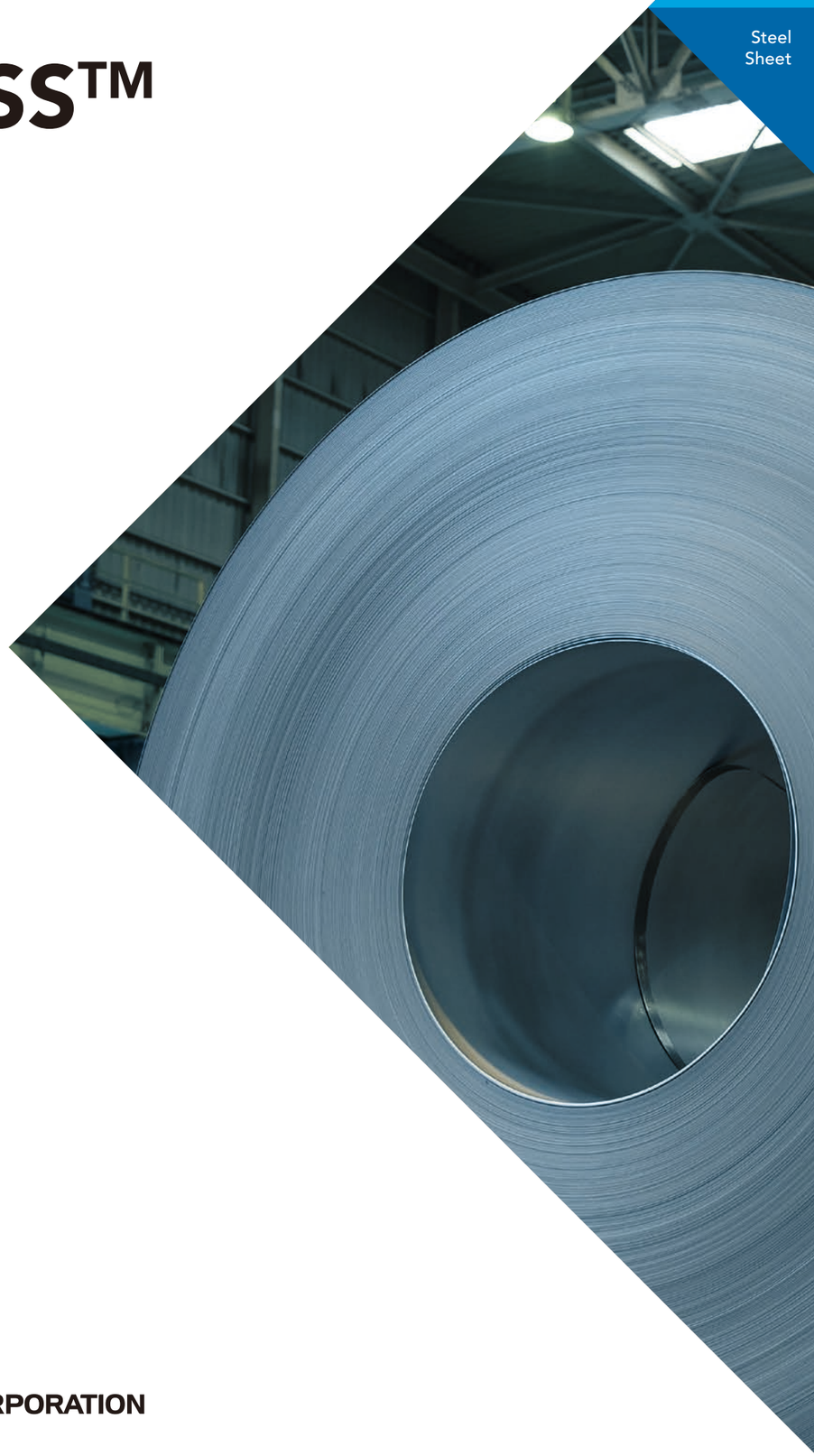
NIPPON STEEL CORPORATION
2-6-1 Marunouchi, Chiyoda-ku,Tokyo 100-8071 Japan
Tel: +81-3-6867-4111

VIBLESS™
U044en_01_201904f

NIPPON STEEL

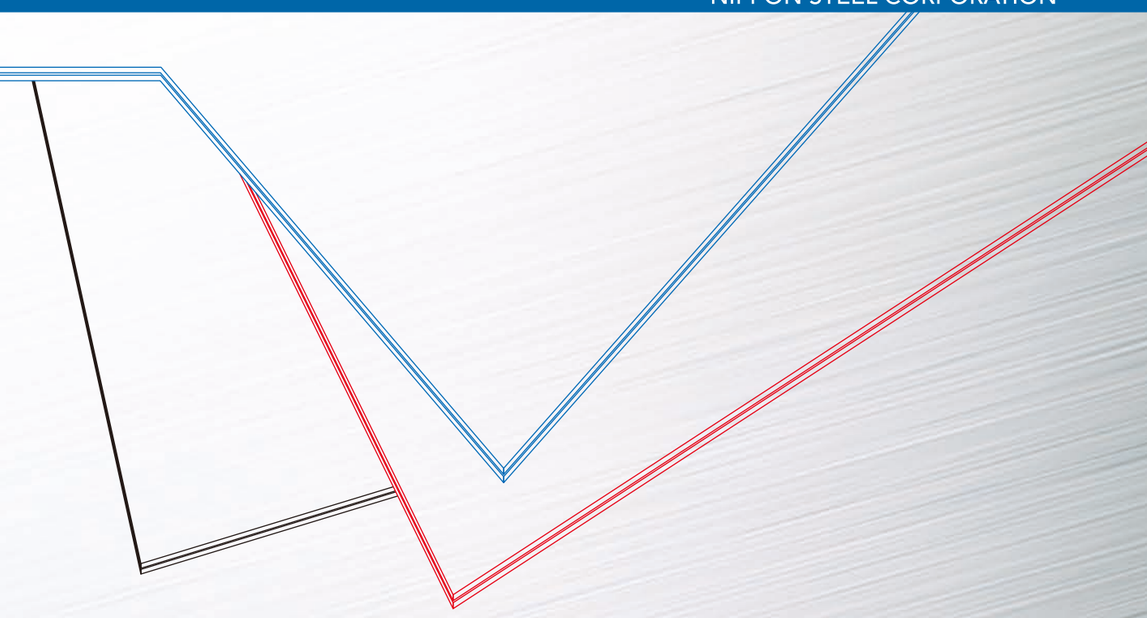
VIBLESS™

Steel Sheet



NIPPON STEEL CORPORATION

Preserving the Quiet VIBLESS™



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

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.

Contents

1. Noise and Noise Prevention, and Vibration-damping Capacity of VIBLESS……*1*
2. Structure and Vibration-damping Effect of VIBLESS……*2*
3. Classification Symbols and Typical Types of VIBLESS……*4*
4. Size Availability of VIBLESS……*5*
5. Properties of VIBLESS……*6*
6. Heat Resistance……*8*
7. Durability……*9*
8. Typical Applications……*10*
9. Packaging and Markings……*12*
10. Reference Information on Usage……*13*

References VIBLESS Production Line……*14*

Methods for Measuring Vibration-damping Capacity……*15*

Methods for Measuring Adhesive Strength……*15*

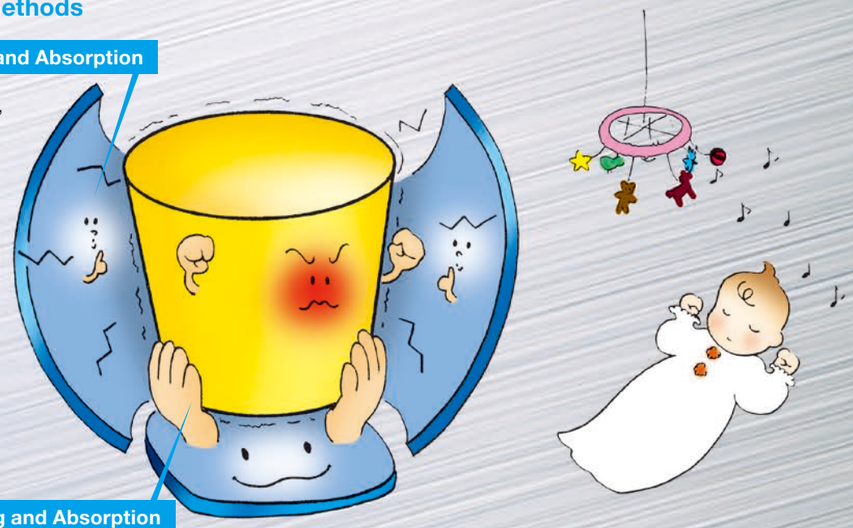
1. Noise and Noise Prevention, and Vibration-damping Capacity of VIBLESS

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

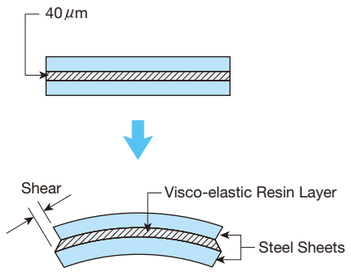
VIBLESS, Damping Sheet, Damping Alloy, Rubber, Wood, Plastics, etc.

VIBLESS is effective in the case of Ⓑ above. It demonstrates particularly high performance when used in direct contact with a source of vibration or when incorporated in such a source.

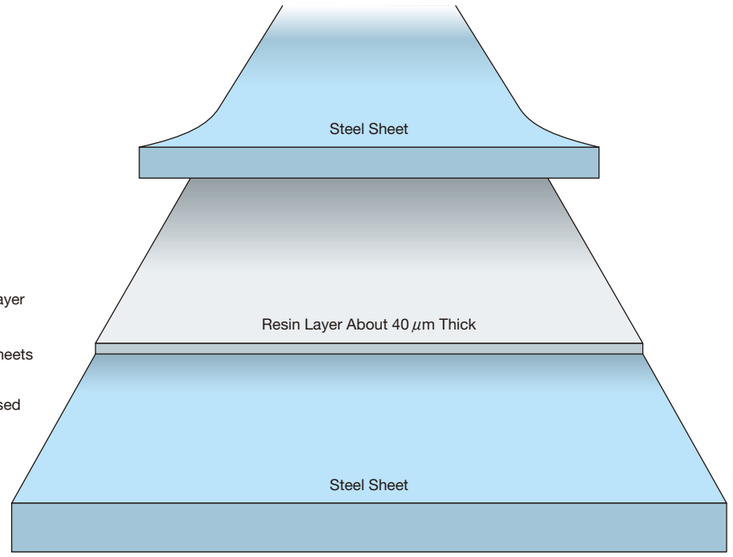
2. Structure and Vibration-damping Effect of VIBLESS

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.



Shear deformation of the visco-elastic resin layer caused by vibration has the effect of damping vibration.

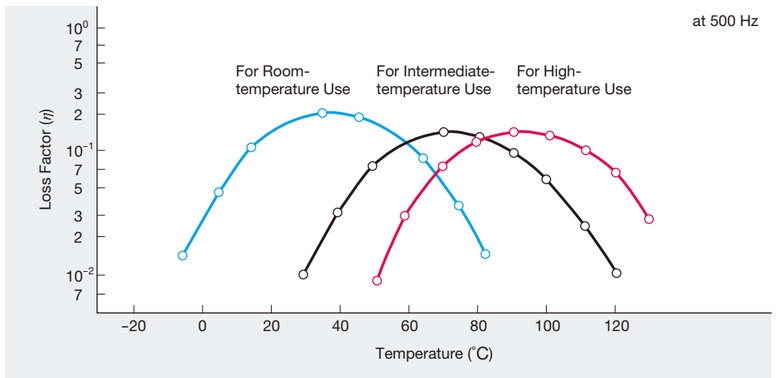


Vibration-damping Effect and Characteristics

(1) The vibration-damping capacity is usually given by the loss factor " η ". 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.

Fig. 1 Relation Between the Loss Factor of VIBLESS and Temperature



(3) A comparison of the loss factor " η " 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.

Fig. 2 Relation Between the Vibration-damping Capacity and Strength of Individual Materials at Room Temperature

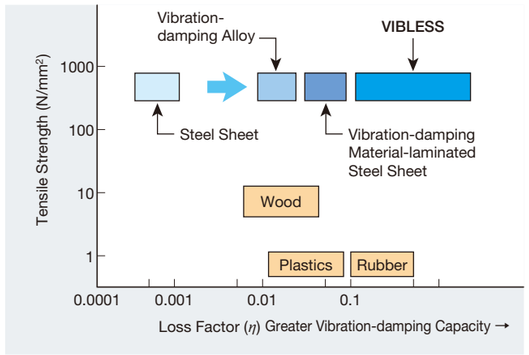
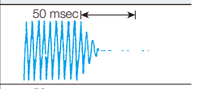
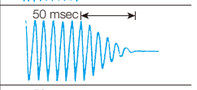
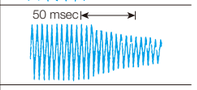
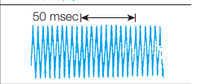
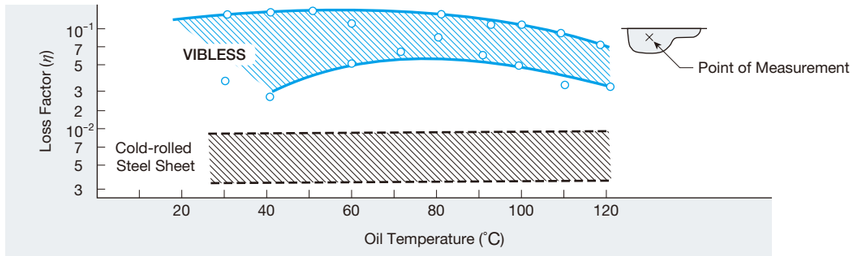


Fig. 3 Loss Factor and Corresponding Vibration-damping Wave Pattern

Material (Thickness)	Loss Factor (η)	Vibration-damping Wave Pattern
VIBLESS (0.8 + 0.8 mm)	0.3 (Resonant Frequency 182 Hz)	
Vibration-damping Material (2.0 mm)-laminated Steel Sheet (0.8 mm)	0.1 (Resonant Frequency 121 Hz)	
Vibration-damping Alloy (YUS 430D) (1.6 mm)	0.02 (Resonant Frequency 209.3 Hz)	
Cold-rolled Steel Sheet (1.6 mm)	0.0005 (Resonant Frequency 219.2 Hz)	

(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.

Fig. 4 Relation Between Loss Factor and Oil Temperature When VIBLESS is Used in Oil Pans

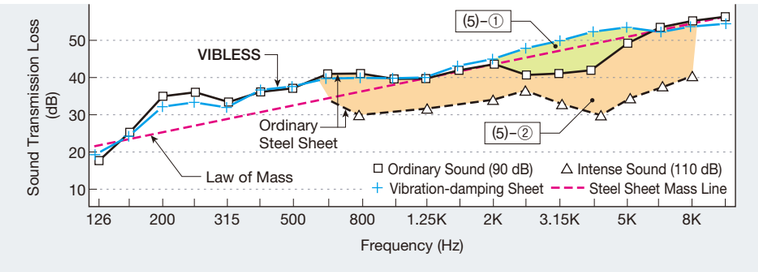


(5) Sound-insulation Effect of VIBLESS

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

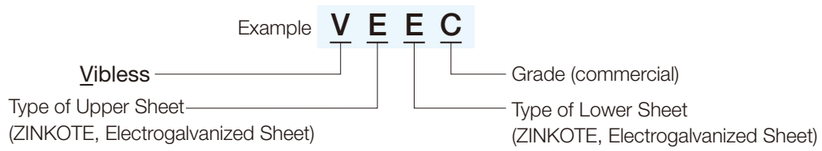
② Sometimes sound-insulating materials will themselves vibrate and generate sound due to the transmission of vibrations caused by large sound pressure or vibrations generated at the sound source. VIBLESS suppresses these vibrations, preventing the generation of sound.



3. Classification Symbols and Typical Types of VIBLESS

❶ Classification Symbols for VIBLESS

Symbols in the specifications of VIBLESS mean :



Examples of Classification Symbols

Type of Sheet	Commercial Grade	Drawing Grade	Deep-drawing Grade	Extradeep-drawing Grade	Remarks
Cold-rolled Steel Sheet	VCCC	VCCD	VCCE	VCCX	
Electrogalvanized Steel Sheet	VEEC	VEED	VEEE	VEEX	ZINKOTE
Iron-Zinc Alloy-coated Steel Sheet	VAAC	VAAD	VAAE	—	DURGRIP (Galvannealed)

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

❷ Typical Characteristics of VIBLESS

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

Classification	Applicable Temperature Range (°C)	Weldability	Vibration-damping Property	Adhesive Strength	
			η -max 500 Hz	Shear Adhesion (N/cm2)	T-peel Strength (N/25 mm)
Room-temperature Use	20 ～ 40	○	0.20	800	100
Intermediate-temperature Use	40 ～ 80	○	0.15	1000	140
High-temperature Use	70 ～ 100	○	0.15	1500	180

Notes •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.
① Measurement examples by means of the center-support stationary excitation method conforming to JIS G 0602
② Shear adhesive strength : Measurement examples conforming to JIS K 6850
③ T-peel strength : Measurement examples conforming to JIS K 6854
•N/cm^2 = 9.80665 × kgf/cm^2, N/25 mm = 9.80665 × kgf/25 mm

❸ 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.

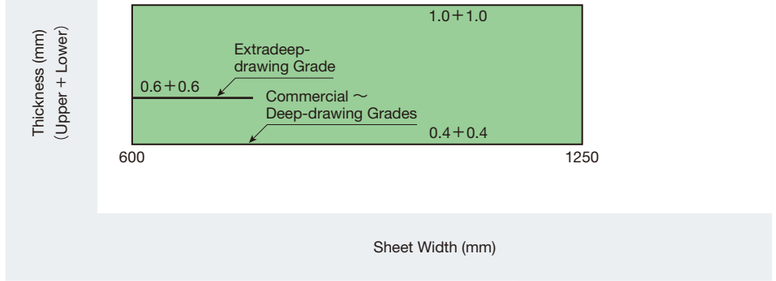
❹ Surface Treatment of VIBLESS

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

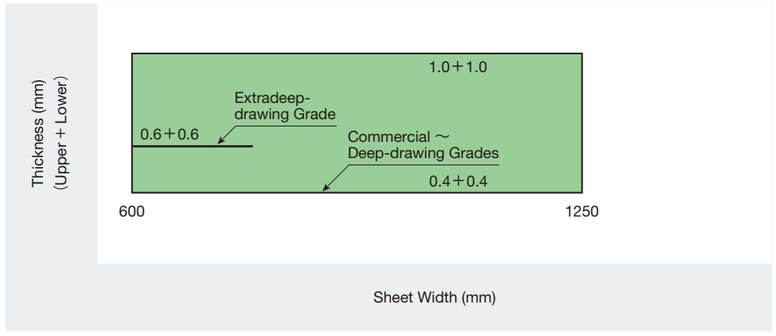
M	No Treatment
QM	High-functional Chromate-free Treatment
QB	Chromate-free Phosphate Treatment

4. Size Availability of VIBLESS

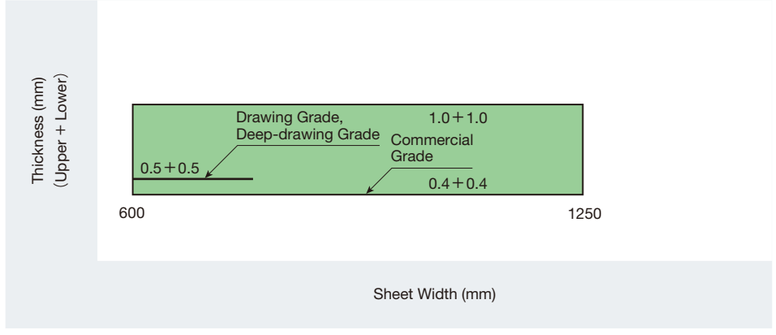
① Cold-rolled Steel Sheets



② Electrogalvanized Steel Sheets



③ Iron-Zinc Alloy-coated Steel Sheets



: Because the available size range changes depending on the kind of steel sheets and viscoelastic resins adopted, please consul concerning the details of size availability.

5. Properties of VIBLESS

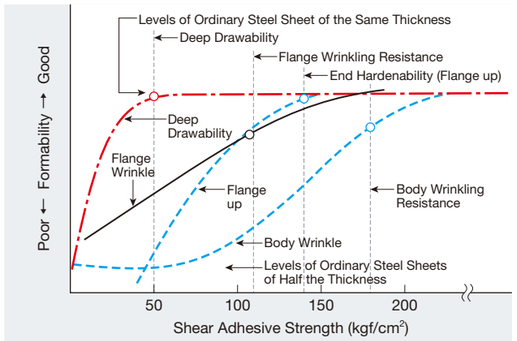
❶ Examples of Tensile Test Values (Test Piece: JIS No. 5)

Type of Base Sheet		Yield Point (N/mm^2)	Tensile Strength (N/mm^2)	Elongation (%)	$\bar{r}$ Value
Cold-rolled Steel Sheets (t = 0.8 mm) of Deep-drawing Grade		150	290	50	2.00
VIBLESS (t = 0.8 + 0.8)	For Room-temperature Use	146	283	50	2.01
	For Intermediate-temperature Use	146	285	50	2.02
	For High-temperature Use	145	285	51	2.02

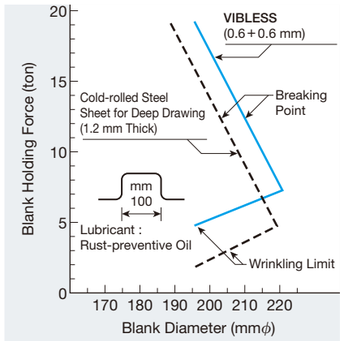
- The yield point and tensile strength of VIBLESS are slightly lower than those of the cold-rolled steel sheets used.
- The r value of VIBLESS is slightly higher than that of cold-rolled steel sheets used.

❷ Formability of VIBLESS

Relation Between Various Kinds of Formability and Shear Adhesive Strength



Relation Between Cylindrical Deep-drawing limit and Blank Holding Force

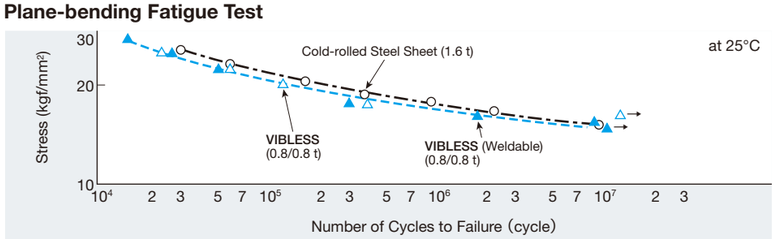


- In general, formability improves with increased adhesive strength.
- In drawing VIBLESS, apply a higher blank holding force than when working with ordinary steel sheet.
- Since the properties of VIBLESS vary with the type of the intermediate visco-elastic resin layer, please consult us before using.

❸ Fatigue Property

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

Plane-bending Fatigue Test

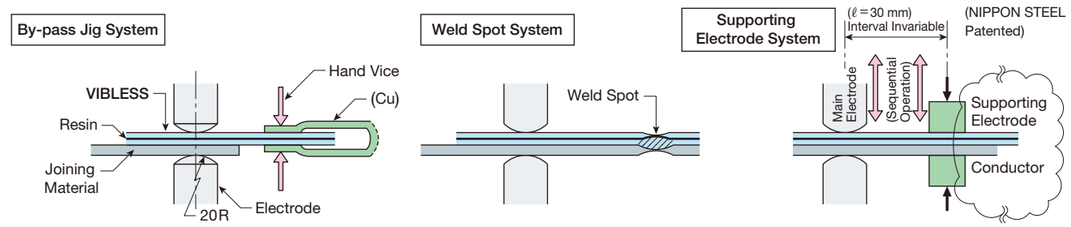


❹ Resistance Weldability

① VIBLESS (Commercial Grade)

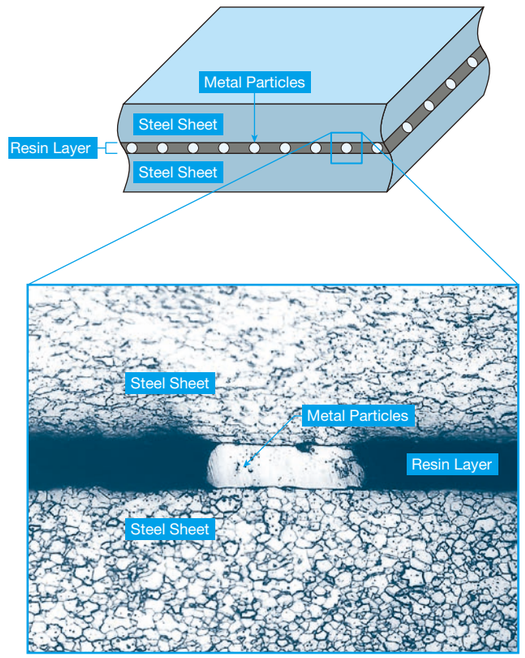
Welding of VIBLESS requires a supporting electrode system, because of the intermediate layer of nonconductive, elastic high polymer. The use of the supporting electrode system developed by NIPPON STEEL enables both spot and projection welding to be performed in a manner similar to that for cold-rolled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

Example of Current Application By By-pass Circuit



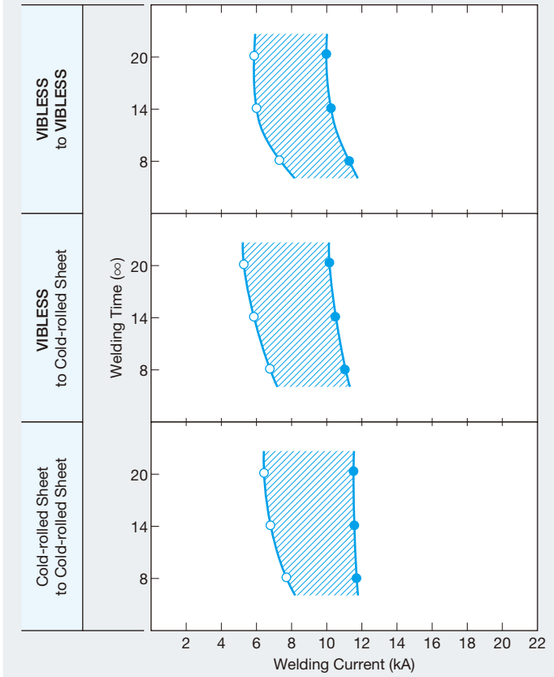
② Weldable VIBLESS

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



③ Proper Welding Region

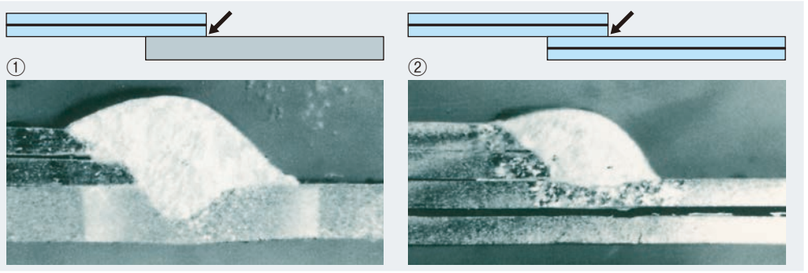
Proper Welding Conditions for Spot Welding are as Follows :



5. Properties of VIBLESS

❺ 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)



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

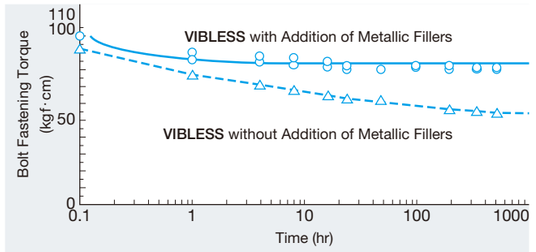
1. Test Method

- 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 • cm (9.8 N • m)
- Measurement of initial torque in the case of incremental fastening at room temperature after retaining in the prescribed time at 80 °C

2. Results

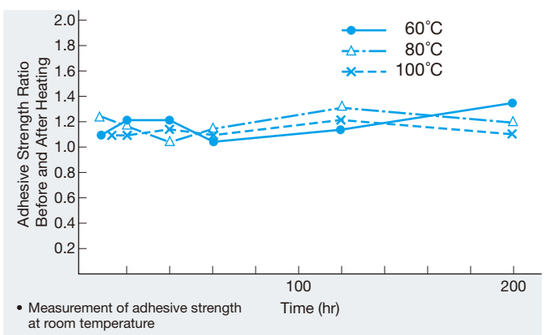
- Because of the addition of metallic fillers, maximum torque loss is about 20 % even at 80 °C.
  Further, torque loss occurs within several hours after the initial addition of filler but remains nearly constant afterwards.

Aged Characteristics of Bolt Fastening Torque in VIBLESS (80°C After Lapse of Time)

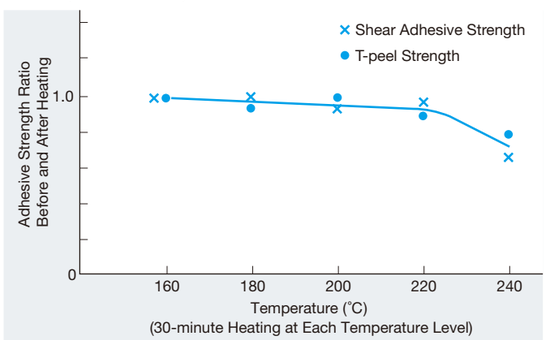


6. Heat Resistance

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



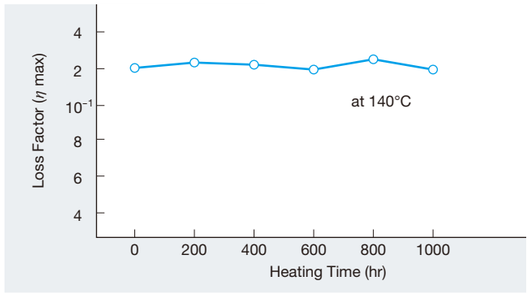
Change in Adhesive Strength Due to High-temperature Heating
(In the case of fixing the lapse of time and then changing the temperature level)



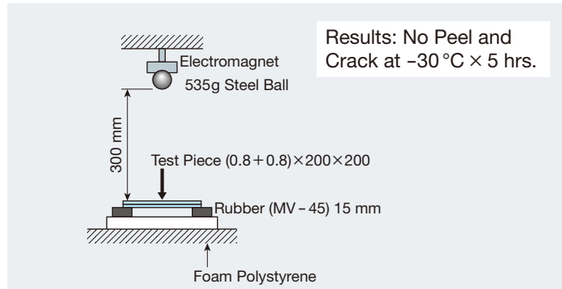
7. Durability

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)

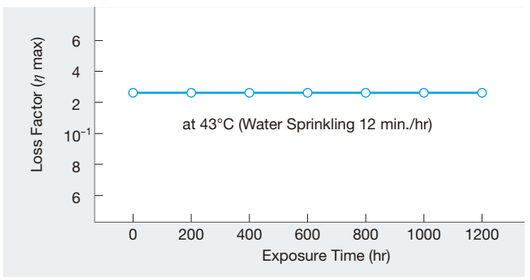
Heat-resistant Durability Test



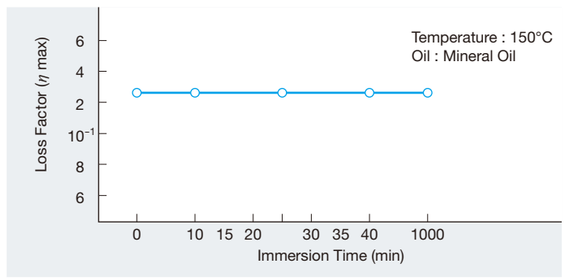
Low-temperature Resistance Test



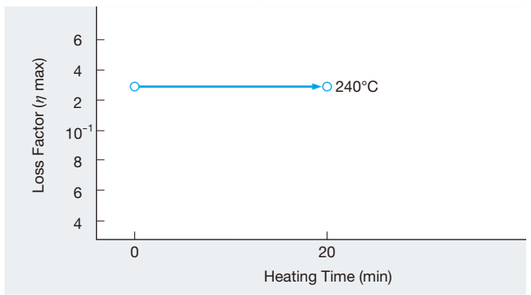
Weathering Test



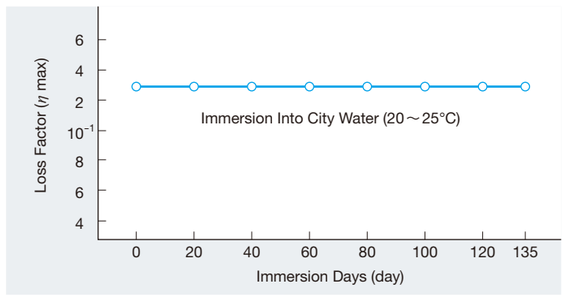
Oil Resistance Test



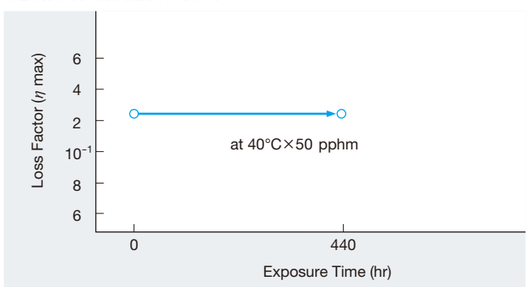
High-temperature Durability Test



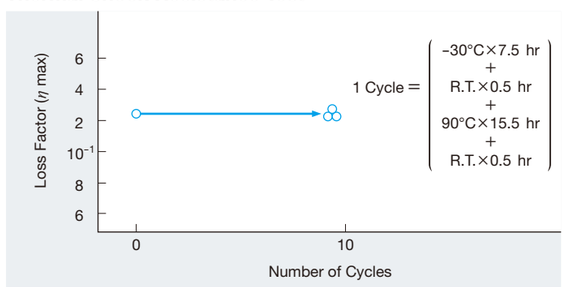
Water Resistance Test



Ozone Resistance Test



Thermal Shock Resistance Test

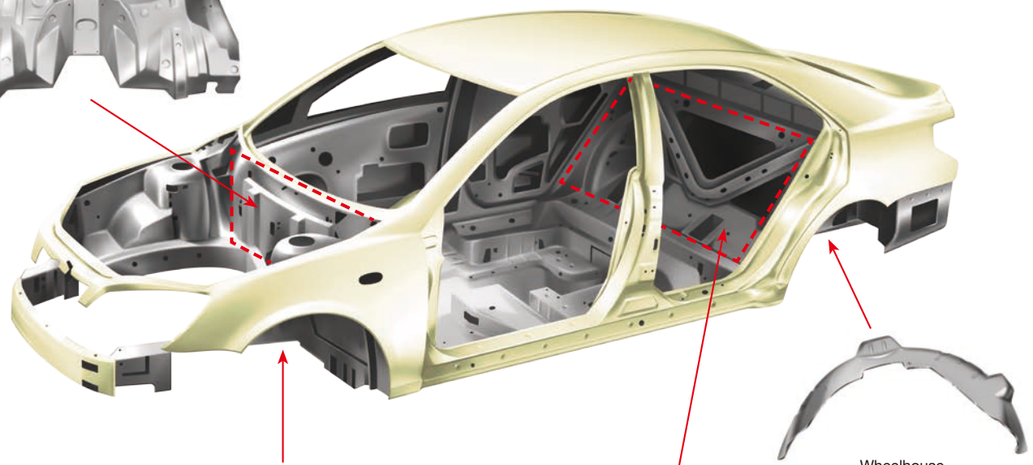


8. Typical Applications

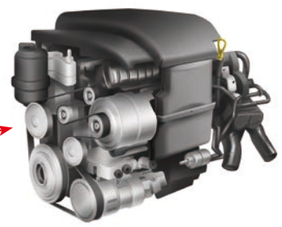
Classification	Application Examples
Automobiles	Engine oil pan (Diesel, Gasoline), Mission oil pan, Engine cover, Wheelhouse, Dash panel, Floor panel, Room partition, Seat-back center, Door panel, Roofing, Brake part, Horn parts, Belt cover, Cross members
Electrical Machines	Washing machine body, Dryer 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
Building Materials and Others	Roofing, Floor, Staircase, Shutter, Curtain rail, Shoot, Hopper and cover for industrial machinery, Various types of noise-prevention walls, Steel furniture, Air conditioner duct, Dispensing chutes of vending machines, Ship wall

Chain housing

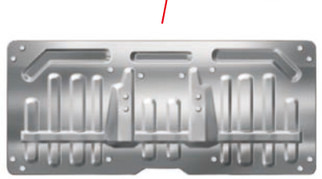
Dash panel



Wheelhouse

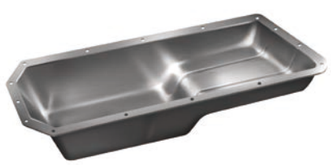


Engine belt cover

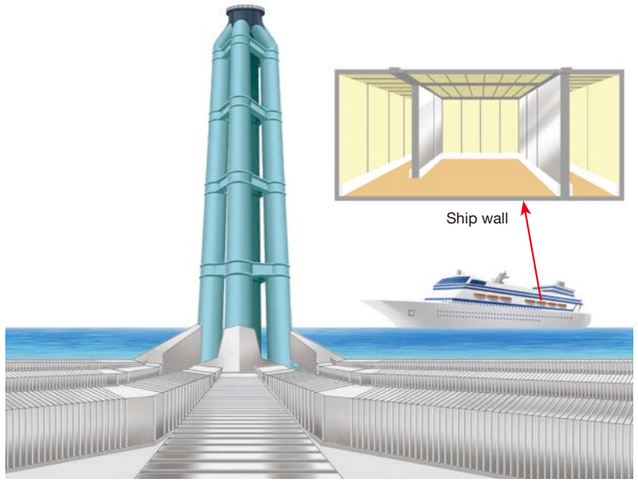


Seat-back center

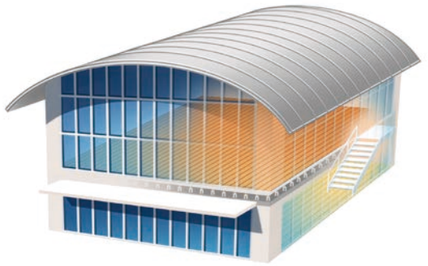
Oil pan (Gasoline)



Oil pan (Diesel)



Noise-prevention wall



Roofing, Floor, Staircase

Roofing

Curtain rail

HDD cover

Dryer drum

Washing machine body

Hopper

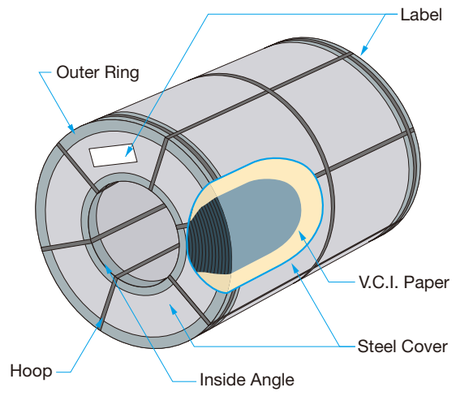
Motor base of fan heater

9. Packaging and Markings

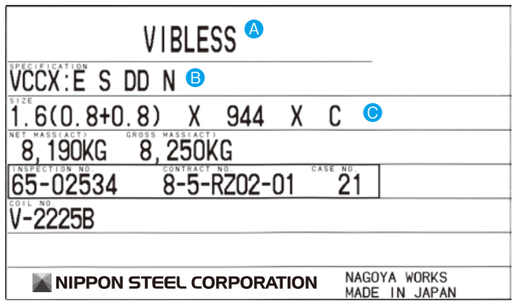
❶ Example of Packaging

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

No Steel Cover on Coil Inside and Outside
Example of V.C.I Paper or Film Packaging
[Coil]



❷ Example of Marking on Packaging Label



Item No.	Item	Markings
Ⓐ	Commodity Name	**VIBLESS**
Ⓑ	Specifications	**VEEX : J S DD M N** ① Classified Symbols ② Division of Resins ③ Symbol of Temper Grade ④ Symbol of Surface Finish (Upper and Lower Steel Sheets) ⑤ Symbol of Surface Treatment ⑥ Symbol of Oiling
Ⓒ	Dimensions	Dimensions for Ordering Thickness (Upper Sheet Thickness + Lower Sheet Thickness) × Width × Length (C. in the Case of Coil) Note : The Thickness of the Intermediate Resin Layer is not Included in the Thickness for Ordering.

Division	General	Weldable
Room-temperature Use	J	G
Intermediate-temperature Use	Q	I
High-temperature Use	K	E

H : Heavy Oiling
L : Light Oiling
N : Normal Oiling
X : Nonoiling

M : Nontreatment
QM: High-functional Chromate-free Treatment
QB : Chromate-free Phosphate Treatment

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:

❶ Shearing/Cutting

(1) Shearing and blanking: Adjust the clearance to half that for ordinary steel sheet.
Adoption of clearances similar to that of ordinary steel sheet is likely to cause large burring.
(2) For fusion-cutting, select the methods characterized by a small beam diameter, such as laser beam cutting.
In plasma cutting, slight unevenness occurs on the cut surface.
Since gas cutting is likely to cause burning and evaporation of the visco-elastic resin, which would make normal cutting difficult, gas cutting should be avoided.

❷ Forming

(1) Because VIBLESS is more likely to wrinkle during drawing than ordinary steel sheets, higher blanking force should be adopted (refer to 5-(2) Formability of VIBLESS). In particular, in drawing parts for which forming is difficult, the plastic flowing 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:
① Materials: To differentiate thickness between the upper and lower steel sheets (however, this lessens the vibration-damping effect).
② Design: To adopt a larger bending radius
③ Fabrication: To extend the die width (ten times or more the sheet thickness is desirable). V-cutting (refer to 5-(3) Bendability) and other methods can be applied. Further, since large spring back is likely to occur, there are cases where adjustment of the bending angles is required.
(3) An excessively small bending flange width results in the misalignment of the upper and lower steel sheets. Thus, sufficient flange width should be adopted.
(4) Roll-forming involves increased spring back, thus necessitating adjustment. In general, the greater the number of rolls, the better the forming finish.
(5) Punching is more advantageous than drilling. In applying either of these methods, care should be taken to avoid peeling off the visco-elastic resin layer, which is caused by hooking the upper sheet of VIBLESS during blanking. Further, punching or drilling should be done after fabrication.

❸ Joining

(1) Resistance welding: The provision of a bypass circuit is required for the commercial grade (refer to paragraph 5-(5) 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-(6) Arc Welding). There is also a method by which arc welding is performed after the visco-elastic resin has been removed by burning.
(3) Caulking: Even if the upper and lower sheets are misaligned, there should be no problem
(4) Screw-fastening: Screws compatible with the upper and lower steel sheets should be used.

❹ Painting

(1) For a high-temperature baking finish (180℃ or higher), the thermosetting resin type is essential, so please consult us prior to the application.
(2) The application of usual degreasing or chemical treatments poses no problem.

❺ Galvanizing at Fabricators' Shop

(1) Electrogalvanizing: 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.

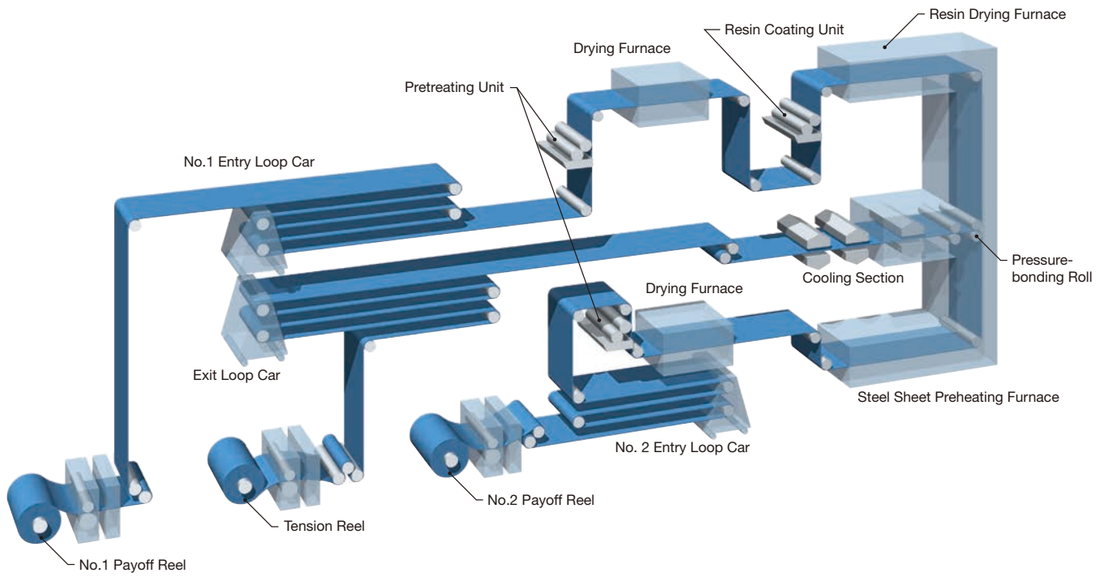
❻ Treatment at Fabricators' Shops

(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.

References

VIBLESS Production Line

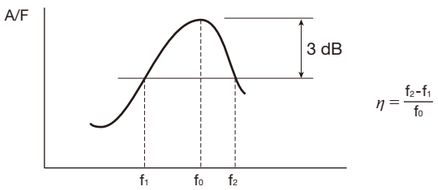
Layout of Coil Production Line



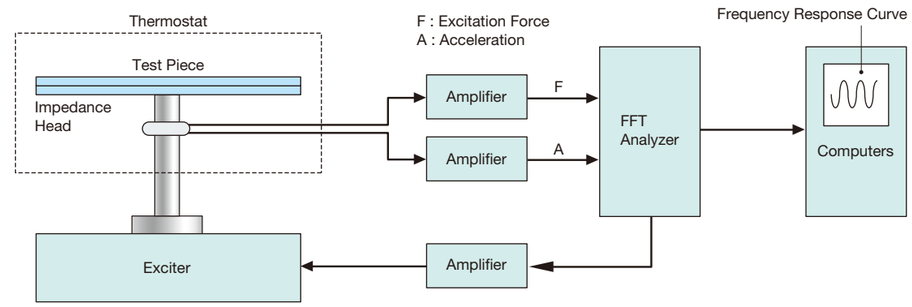
● NIPPON STEEL operates a VIBLESS production line exclusively for cut-sheet manufacture, in addition to the coil production line.

Methods for Measuring Vibration-damping Capacity

Methods for Measuring Vibration-damping Capacity, Loss Factor η

Measuring Method	Principle of Measurement
Center-support Stationary Excitation Method **(Refer to the Figure Below)**	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.  $\eta = \frac{f_2 - f_1}{f_0}$

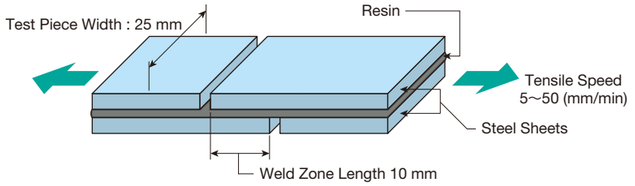
Center-support Stationary Excitation Method



Test Piece Width : 25 mm,
Length : 300 mm

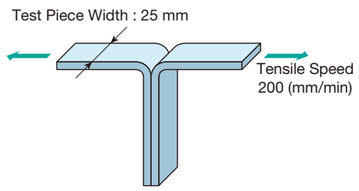
Methods for Measuring Adhesive Strength

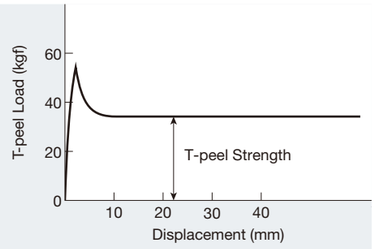
❶ Shear Adhesive Strength



Room temperature
Shear adhesive strength is obtained by calculating strength per 1 cm² of area.

❷ T-peel Strength





Room Temperature

MEMO