# Surface-Lubricated Steel Sheet

by

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## Synopsis

*Parts of appliances made of galvanized steel sheet are cleaned after bending and pressing in order to remove oil and dirt. The use of cleaning agents 1,1,1-trichloroethane and special fluoro-hydrocarbons are prohibited by law due to their being ozone depleting substance, so much research has been done to develop alternative cleaning methods. However, the solution has not yet been found. This is why we developed lubricated steel sheets which do not require lubrication when the sheets are processed. These sheets are self-lubricated in order to use a dry press process without toxic cleaning agents. We have various lubricated steel sheets such as TOUGH-ZINC F hot dipped, TOUGH-ZINC ALLOY F hot dip alloyed, and SUMI-ZINC TJ electroplated. Moreover, TOUGH-ZINC ALLOY F, which is gray in color, enables the after-coat process to be eliminated. In this paper, we introduce the properties and suggest applications of the lubricated steel sheets in the electric appliance industries.*

## 1. Introduction

Surface-lubricated steel sheets are specialized for specific use and classified into 3 types with various pretreatments as shown in **Table 1** and **Fig. 1**. Each sheet has a lubrication layer on top for the dry process. Moreover, they achieve a clean working environment by, for in stance, not requiring a degreasing process.

## 2. Performance

### 2.1 TOUGH-ZINC F(GI-F)

**Figure 2** illustrates coating composition GI-F. GI-F, which consists of a chromate layer and high lubricate thin organic layer, is surface-lubricated steel sheet, and the substrate is galvanized steel sheet.

Table 1 Line-up of surface-lubricated steel sheet

| Products | Characteristics | Benefits |
|---|---|---|
| TOUGH-ZINC F | Excellent lubrication | No degreasing process and clean working environment |
| TOUGH-ZINC ALLOY F | Excellent design | Dark gray, no painting process |
| SUMI-ZINC TJ | Excellent conductivity | Grounding use, welding use |

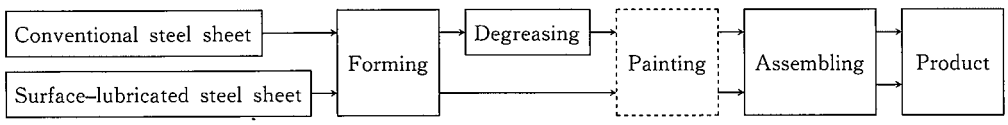



Fig. 1 Example of product process

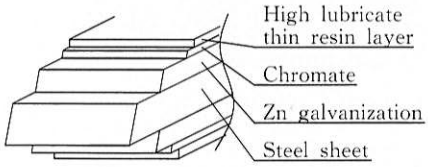



Fig. 2 Coating structure of GI-F

#### 2.1.1 Lubrication

**Figure 3** shows Bowden test method. Friction coefficient of various substitute surface is represented by means of this expression.

F (Friction force) = $\mu$ (Friction coefficient) × P (Vertical load)

Friction coefficient of GI-F, GI-K (TOUGH-ZINC K ; special chromate galvanized steel sheet), and greased GI-K are below 0.1, about 2.5 and 0.5 respectively as shown in **Fig. 4**. GI-F, which has more excellent lubrication than GI-K, possesses ability in order to dry press. Furthermore the resin layer of this sheet protects surface of galvanized layer from occurring galling.

**Photo 1** shows appearance after pressing. GI-F, which has excellent lubrication, is better forming than GI-K and greased GI-K.

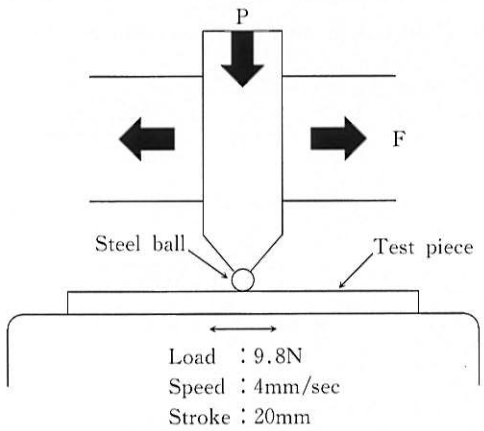



Fig. 3 Schematic diagram of Bowden test system

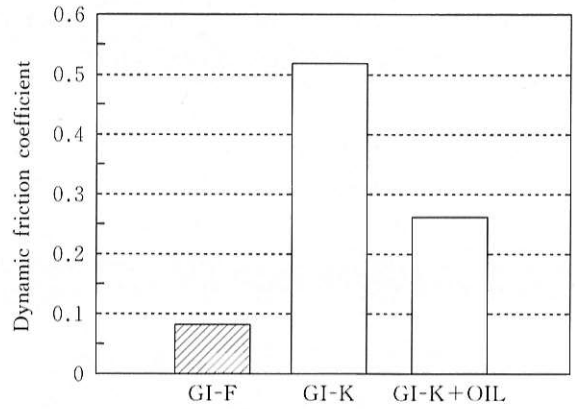



Fig. 4 Friction coefficient of GI-F

#### 2.1.2 Corrosion Resistance

**Figure 5** shows corrosion resistance for flat sheet specimens of GI-F and GI-K. White rust area was examined by SST (Salt Water Spray Test ; JIS Z-2371). Time to 5% white rust occurrence of GI-K is about 100 hours, however, that of GI-F is more than 500 hours as shown in **Fig. 5**.

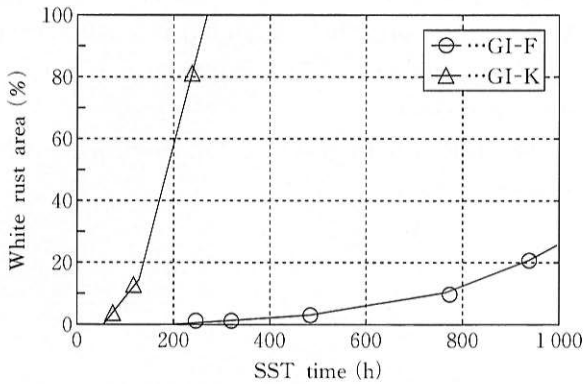



Fig. 5 Result of salt water spray test of GI-F

#### 2.1.3 Spot Weldability

**Figure 6** shows the optimum welding current range by spot welding. The GI-F resin layer on top is so thin (1$\mu$m) that the sheet has good weldability and the optimum weld current range of GI-F is as

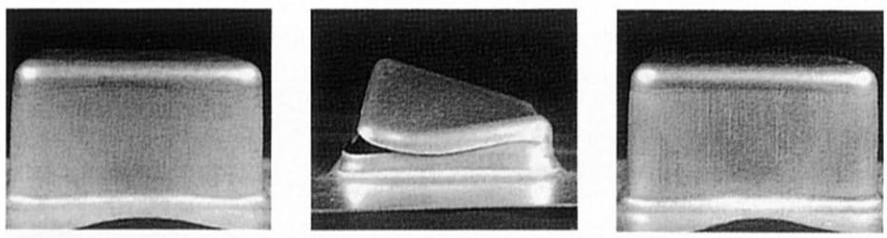



Photo 1 Appearance after drawing

wide as GI-K. However, the thin resin layer shifts the optimum welding current range to low.

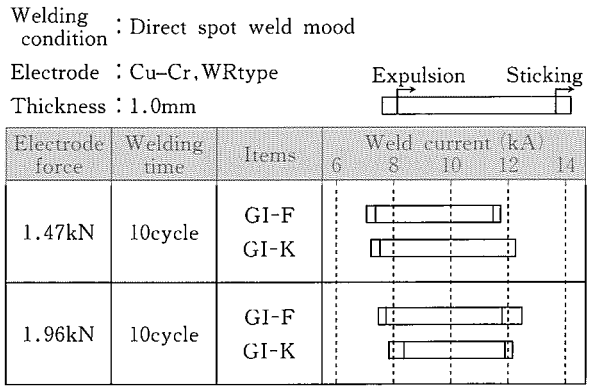



Fig. 6 Spot weldability of GI-F

#### 2.1.4 Summary of GI-F Performance

**Table 2** shows the summary of GI-F performance.

## 2.2 TOUGH-ZINC ALLOY F(GA-F)

**Figure 7** illustrates coating composition GA-F. GA-F, which consists of chromate layer and high lubricate thin organic layer(3$\mu$m), is a surface-lubricated steel sheet, and the substrate is galvanized alloy steel sheet.

This sheet is dark gray in color, therefore is used without painting.

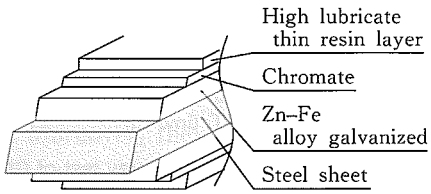



Fig. 7 Coating structure of GA-F

#### 2.2.1 Lubrication

**Figure 8** shows friction coefficients of GA-F, GI-F, GA-C, GI-K, and greased GI-K. The friction coefficient of GA-F is below 0.1, which is almost equal to GI-F. GA-F has much better lubrication than GA-C (TOUGH-ZINC ALLOY C ; special chromate galvanized alloy steel sheet), and has sufficient ability for dry press use.

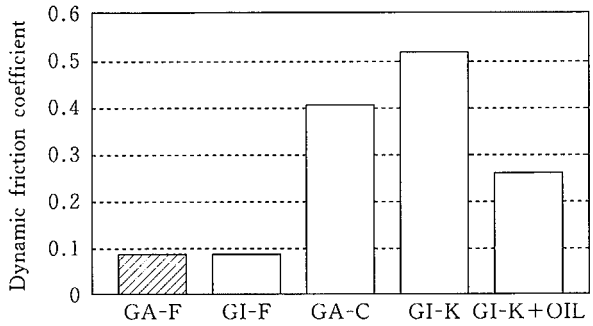



Fig. 8 Friction coefficient of GA-F

#### 2.2.2 Corrosion Resistance

The result of SST for flat sheet specimens of GA-F, GI-F, GA-C and GI-K are given in **Fig. 9**. Time to 5% white rust occurrence of GA-F, which is about 3 000 hours, is longest in these sheets.

**Figure 10** shows the case of CCT and **Photo 2** shows the appearance after 126 cycles. The CCT consists of SST, drying and humidifying. After 126 cycles, GA-C or GI-K were completely covered with red rust and exhibited relatively deep corrosion depth. With GA-F, however, no red rust was observed.

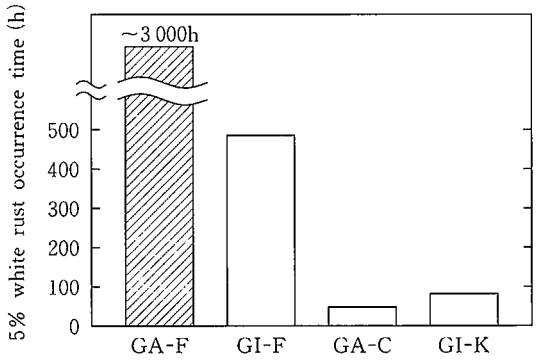



Fig. 9 Result of salt water spray test of GA-F

Table 2 Summary of GI-F performance

| Items | Material | Lubrication | Finger mark | Corrosion resistance | Weldability | Paintability | Color |
|---|---|---|---|---|---|---|---|
| GI-F | Surface-lubricated | 4 | 4 | 4 | 1 | 3 | Transparent |
| GI-L | Special chromate | 2 | 2 | 4 | 2 | 2 | Pale yellow |
| GI-K | Special chromate | 2 | 2 | 3 | 2 | 2 | Transparent |
| GI-C | Chromate | 2 | 2 | 2 | 2 | 2 | Transparent |

(Evaluation) 4:Excellent 3:Good 2:Fair 1:Poor

GA-F, which has 3$\mu$m-thick resin layer, shows better corrosion resistance than GI-F, which has 1$\mu$m-thick resin layer.

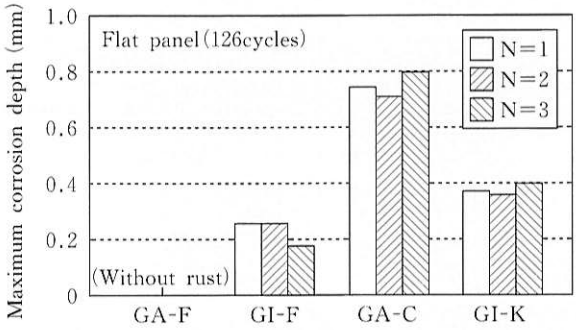



Fig. 10 Result of cyclic corrosion test of GA-F

SST (35°C×2hrs) Drying (60°C×4hrs) Humidifying (50°C,95%×2hrs)

#### 2.2.3 Summary of GA-F Performance

**Table 3** shows summary of GA-F performance.

### 2.3 SUMI-ZINC TJ(EG-TJ)

**Figure 11** illustrates coating composition EG-TJ. EG-TJ, consists of chromate layer containing resin, and the substrate is a Zn electroplated steel sheet. The surface of it is not completely covered by organic resin layer, therefore it has good electro-conductivity and is available for earthing, and moreover it has good weldability.

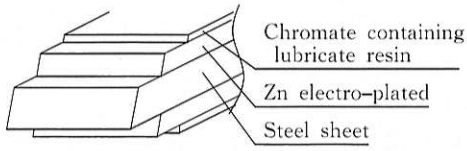



Fig. 11 Coating structure of EG-TJ

#### 2.3.1 Lubrication

**Figure 12** shows friction coefficient of EG-TJ, EG-T2J and greased EG-T. The chromate layer of EG-TJ containing resin has a friction coefficient below 0.1, yet EG-TJ has a as good lubrication as EG-T2J (SUMI-ZINC T2J; chromate layer and organic resin layer on Zn electro-plating steel sheet) and better lubrication than greased EG-T (SUMI-ZINC T ; special chromate electro-plated steel sheet), there-

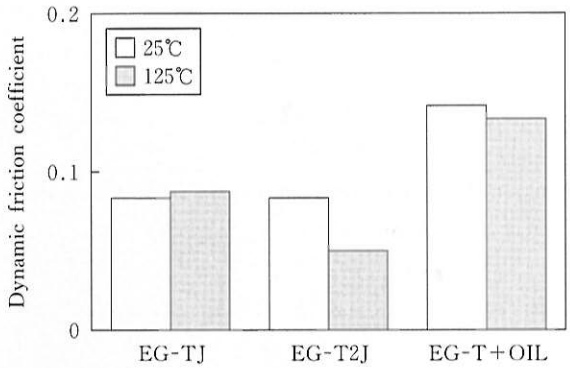



Fig. 12 Friction coefficient of EG-TJ

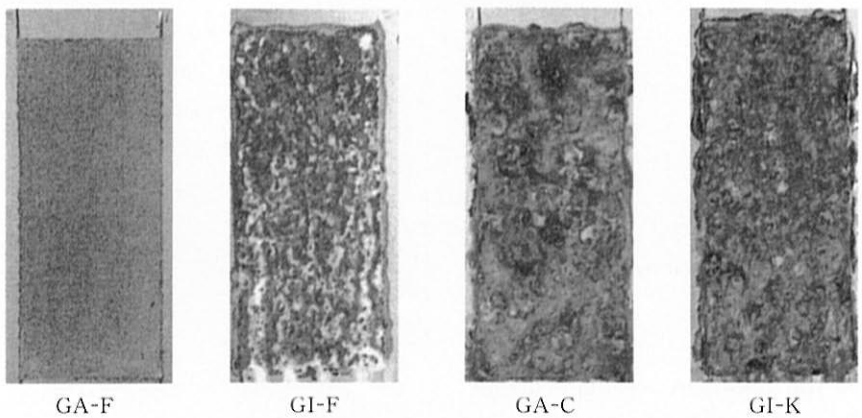



Photo 2 Appearance of test piece after 126 cycles

Table 3 Summary of GA-F performance

| Items | Material | Lubrication | Finger mark | Corrosion resistance | Weldability | Color and appearance |
|---|---|---|---|---|---|---|
| GA-F | Surface-lubricated | 4 | 4 | 4 | 1 | Gray, Moderately bright |
| GA-C | Chromate | 2 | 2 | 2 | 2 | Gray, Dull |

(Evaluation) 4:Excellent 3:Good 2:Fair 1:Poor

fore it has ability to undergo pressing without grease.

### 2.3.2 Conductivity

**Figure 13** shows the conductivity test method. The chromate layer containing resin of EG-TJ has better conductivity than EG-T2J,which is covered with resin. Surface electric resistance of EG-TJ, which is about 1Ω, is almost equivalent to greased EG-T as shown in **Fig. 14**. Therefore it is not necessary to grind the surface for grounding.

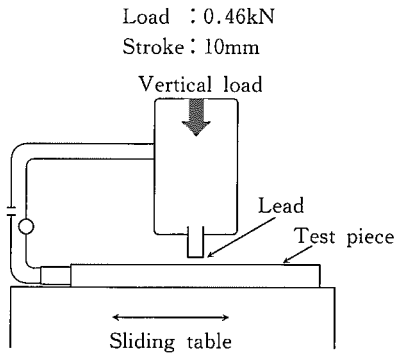



Fig. 13 Schematic diagram of conductivity test system

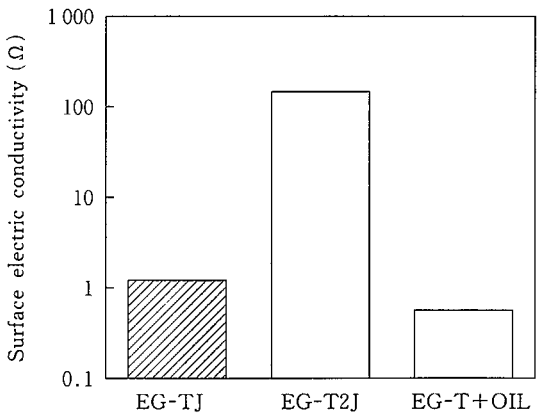



Fig. 14 Result of conductivity test

### 2.3.3 Spot Weldability

**Figure 15** shows the optimum welding current range by spot welding. Since EG-TJ is not covered, it has consecutive spot weldability as good as EG-T, therefore it is suitable for pressing parts after spot welding as shown in **Fig. 16**.

Welding condition : Direct spot weld mood
Electrode : Cu-Cr
Shape of electrode : 25φR type,pointed head 40R
Thickness : 1.0mm

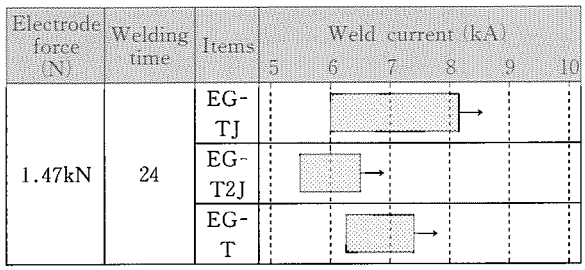



Fig. 15 Acceptable range of welding current

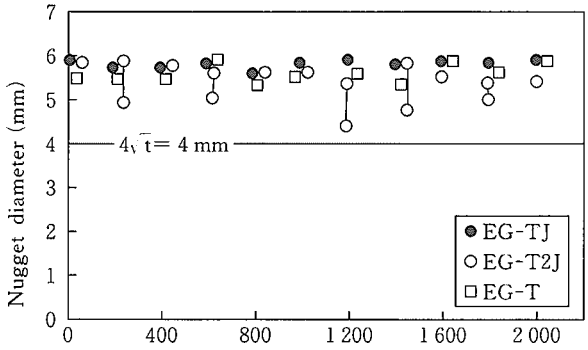



Fig. 16 Welding counts

### 2.3.4 Corrosion Resistance

**Figure 17** shows corrosion resistance for flat sheet specimens of EG-TJ, EG-T2J and EG-T. White rust area was examined by SST (JIS Z-2371). EG-TJ, which has no clear resin layer, is a little inferior in corrosion resistance to EG-T2J, however it shows more excellent corrosion resistance than EG-T1.

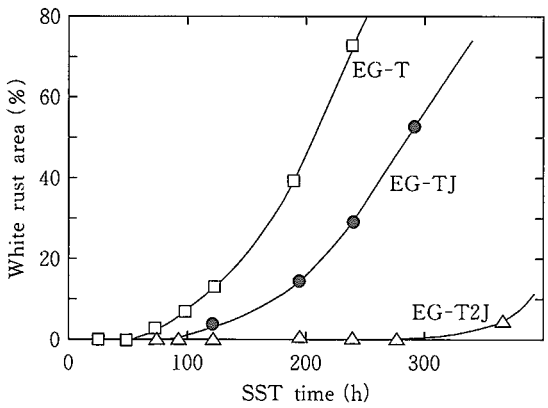



Fig. 17 Result of salt water spray test of EG-TJ

### 2.3.5 Summary of Performance

Next **Table 4** shows the summary of EG-TJ perfomance.

Table 4 Summary of EG-TJ performance

| Items | Lubrication | Conductivity | Weldability | Corrosion resistance | Color |
|---|---|---|---|---|---|
| EG-TJ | 3 | 2 | 4 | 3 | Transparent |
| EG-T2J | 4 | 2 | 2 | 4 | Pale yellow |
| EG-T | 2 | 2 | 2 | 2 | Pale yellow |

(Evaluation) 4:Excellent 3:Good 2:Fair 1:Poor

## 3. Examples of Applications (Table 5, 6)

Table 5 Examples of applications

| Appliance | TOUGH-ZINC F (GI-F) | TOUGH-ZINC ALLOY F (GA-F) | SUMI-ZINC TJ (EG-TJ) |
|---|---|---|---|
| Motor case | + | | ++ |
| Refrigerator | + | + | + |
| Washing machine, Tumble drier | + | + | + |
| Dishwasher | + | + | + |
| Microwave oven, Stove | + | + | + |
| Light | ++ | + | + |
| Air-Conditioner | ++ | + | + |
| Heater | + | + | + |
| TV set | | | + |
| Audio set | | | + |
| Electrical musical instrument | | | ++ |
| Copying machine | | | ++ |
| CD-ROM drive case | | | ++ |
| Printer | | | ++ |
| Vending machine | + | + | + |
| ATM | | | + |
| Switchboard Cubicle | | + | + |

++ : Excellent + : Suitable

Table 6 Forming processes

| Item | Process | GI-F | GA-F | EG-TJ |
|---|---|---|---|---|
| No cleaning process | (Current) Pressing(oiling) → Cleaning → Assembling<br>(New) Pressing(without oiling) → Assembling | 3 | 2 | 3 |
| No postplating process | (Current) Cold rolled steel sheet → Pressing(oiling) → Degreasing → Unichrome treatment → Assembling<br>(New) Surface-lubricated steel sheet → Pressing → Assembling | 3 | 3 | 2 |
| After-coat-less | (Current) Pressing (oiling) → Degreasing → Painting → Assembling<br>(New) Pressing → Assembling | 3 | 3 | 3 |
| Prepainted steel substitution | (Current) Prepainted steel sheet → Light pressing or rollforming<br>(New) Surface-lubricated steel sheet → Light pressing or rollforming | 1 | 3 | 1 |

(Evaluation) 3:Good, 2:Fair, 1:Poor

## 4. Available Sizes

Table 7 GI-F: available coating mass

| Symbol for coating mass on both surfaces | Z08 | Z10 | Z12 | Z18 | Z20 | Z22 | Z25 | Z27 |
|---|---|---|---|---|---|---|---|---|
| Average coating mass in triple-spot test on both surfaces | 80 | 100 | 120 | 180 | 200 | 220 | 250 | 275 |
| Minimum coating at a single spot on both surfaces | 68 | 85 | 102 | 153 | 170 | 187 | 213 | 234 |

Table 8 GA-F: available coating mass

| Symbol for coating mass on both surfaces | F06 | F08 | F10 | F12 |
|---|---|---|---|---|
| Average coating mass in triple-spot test on both surfaces | 60 | 80 | 100 | 120 |
| Minimum coating at a single spot on both surfaces | 51 | 68 | 85 | 102 |

Table 9 EG-TJ available coating mass

| 10/10 ~ 40/40 |
|---|

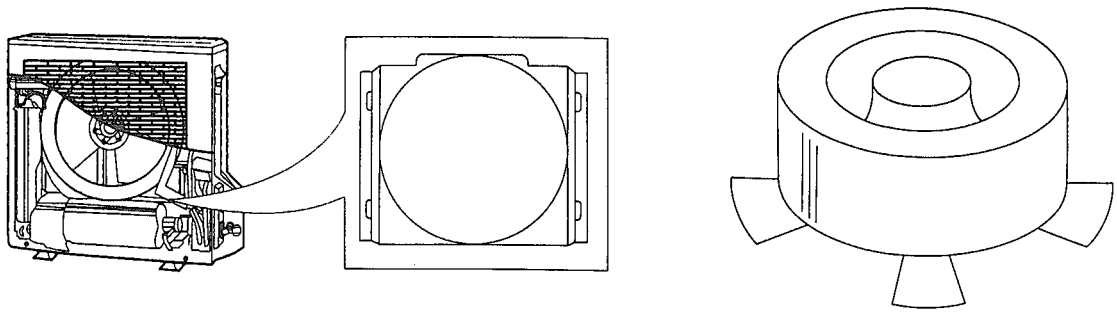
Table 10 Available sizes for GI-F, GA-F and EG-TJ

| Items | Thickness (mm) | Width (mm) |
|---|---|---|
| GI-F | 0.40(0.35) ~ 1.60(2.30) | 610 ~ 1 219(1 829) |
| GA-F | 0.40(0.35) ~ 1.60(2.30) | 610 ~ 1 219(1 829) |
| EG-TJ | 0.40(0.35) ~ 3.20 | 675 ~ 1 219(1 829) |

( ):Available upon special order

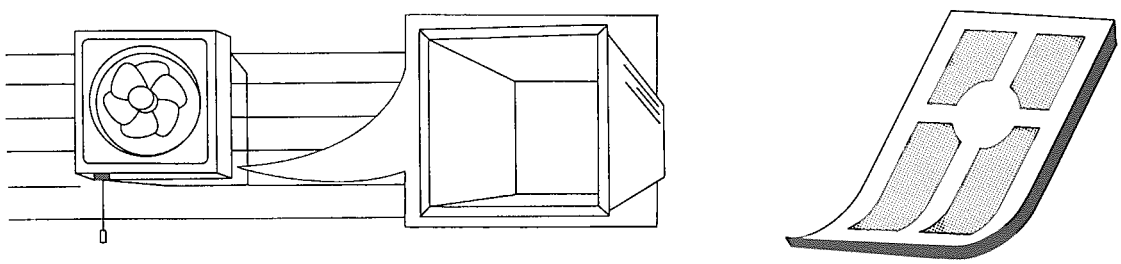
## 5. Conclusion

We have to protect the environment and working conditions, therefore we have to discontinue using special fluoro-hydrocarbons. We recommend our surface-lubricated steel sheet for electrical appliances and similar applications as an ecological material.



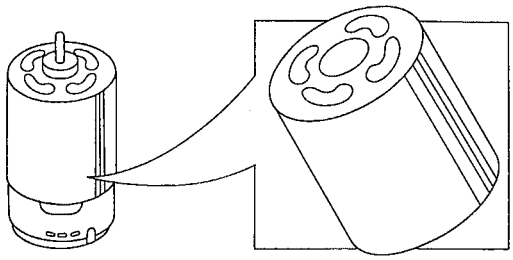
Compressor unit　　Motor case

Fig. 18 GI-F; Example applications

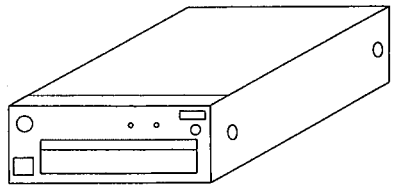


Ventilation duct　　Fan heater cover

Fig. 19 GA-F; Example applications



Motor case



CD-ROM drive case

Fig. 20 EG-TJ; Example applications

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