ABSTRACT

The object is the provision of a pre-coated metal plate which has a high heat insulation and is excellent in workability and a coated metal article.

A pre-coated metal plate comprised of a metal sheet on one surface or on both surfaces of which at least two coating film layers are provided, said pre-coated metal plate characterized in that, among said at least two layers of coating film layers, a first coating film layer which is positioned at a lower side is a bubble-containing layer, said bubble-containing layer satisfies the following formulas: $-0.1t+57.5 \leq V \leq -0.05t+92.5$ and $50 \leq t \leq 350$, wherein V represents a volume concentration (%) as a bubble content of the bubble-containing layer, and t represents a thickness (μm) of the bubble-containing layer, a second coating film layer which is positioned at an upper side of said first coating film layers is a coating film layer which contains a melamine curing type polyester resin or isocyanate curing type polyester resin, said polyester resin has a number average molecular weight of 10000 to 23000, and said second coating film layer has a thickness of 3 to 30 μm.

CLAIMS

Claim 1

A pre-coated metal plate comprised of a metal sheet on one surface or on both surfaces of which at least two coating film layers are provided, said pre-coated metal plate characterized in that,

among said at least two layers of coating film layers, a first coating film layer which is positioned at a lower side is a bubble-containing layer,

said bubble-containing layer satisfies the following formulas:

$-0.1t+57.5 \leq V \leq -0.05t+92.5$ and

$50 \leq t \leq 350$,

wherein V represents a volume concentration (%) as a bubble content of the bubble-containing layer, and t represents a thickness (μm) of the bubble-containing layer,

a second coating film layer which is positioned at an upper side of said first coating film layers is a coating film layer which contains a melamine curing type polyester resin or isocyanate curing type polyester resin,

said polyester resin has a number average molecular weight of 10000 to 23000, and

said second coating film layer has a thickness of 3 to 30 μm.

Claim 2

A pre-coated metal plate as set forth in claim 1, characterized in that, when a total thickness of the combination of said first coating film layer and said second coating film layer is T (μm) and a size of bubbles measured in a direction vertical to the coating film surface is Rv (μm), there are 20 or more bubbles satisfying $Rv \geq 0.8T$ in a 10 mm width of any coating film cross-section.

Claim 3

A pre-coated metal plate as set forth in claim 1 or 2, characterized in that said first coating film layer and said second coating film layer respectively contain pigments of similar colors.

Claim 4

A pre-coated metal plate as set forth in any one of claims 1 to 3, characterized in that the surface of said metal sheet at the side opposite to the surface of said bubble-containing layer has a total emissivity of infrared rays of 0.50 or less in a region of a wave number of 600 to 3000 cm^{-1} which is measured at a predetermined temperature of 80°C to 200°C.

Claim 5

An electronic apparatus characterized in that a pre-coated metal plate as set forth in any one of claims 1 to 4 is used for at least part of an outer panel and in that said bubble-containing layer is positioned at an outer surface side of said outer panel.

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24 JAN 2012

Fig.1

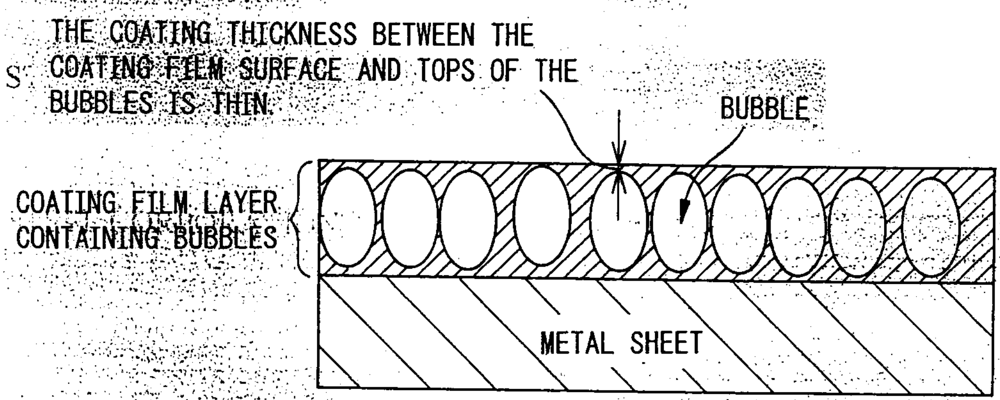

Fig.2

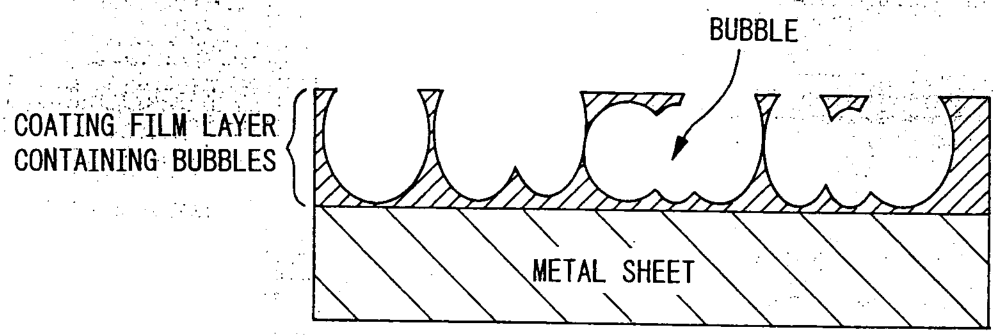

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Fig.3

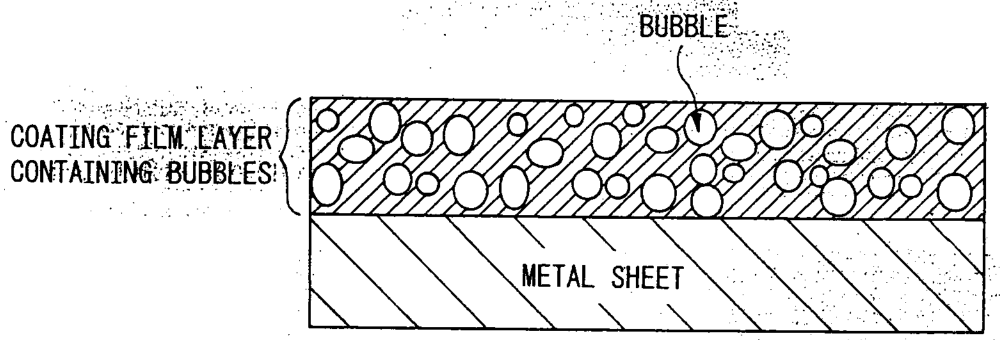

Fig.4

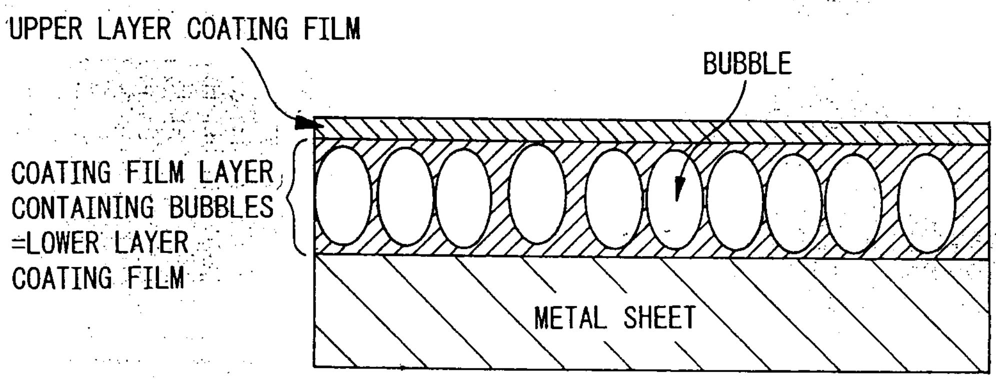

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Fig.5

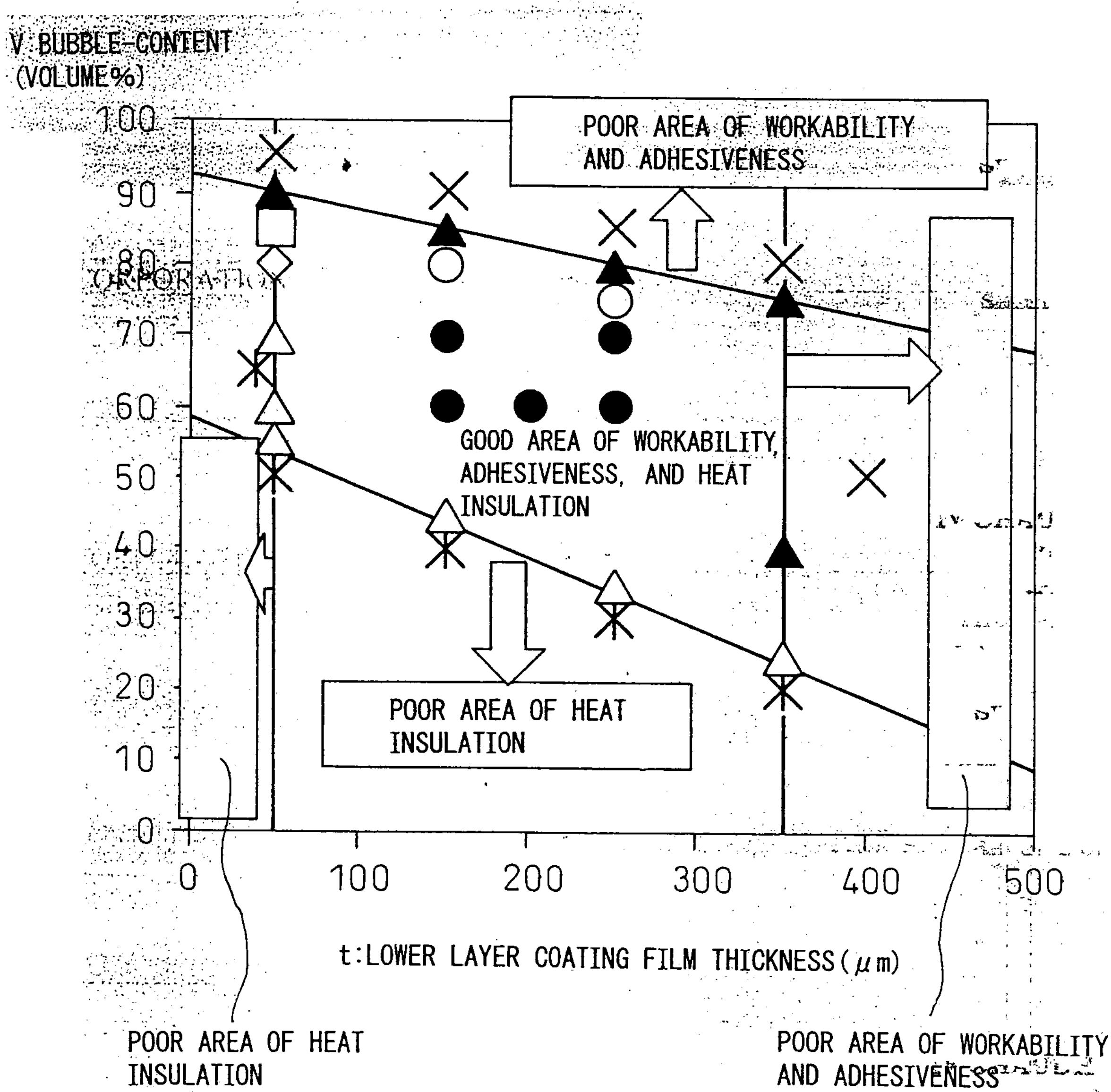

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Fig.6

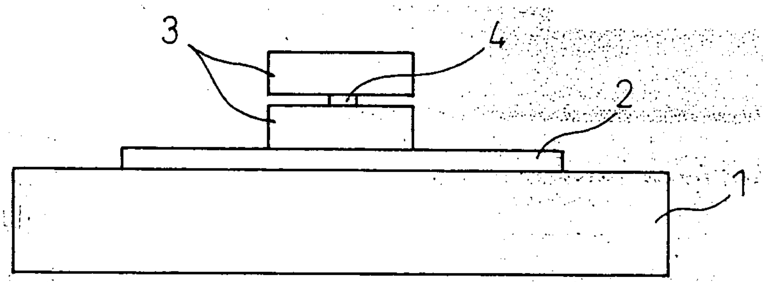

Fig.7

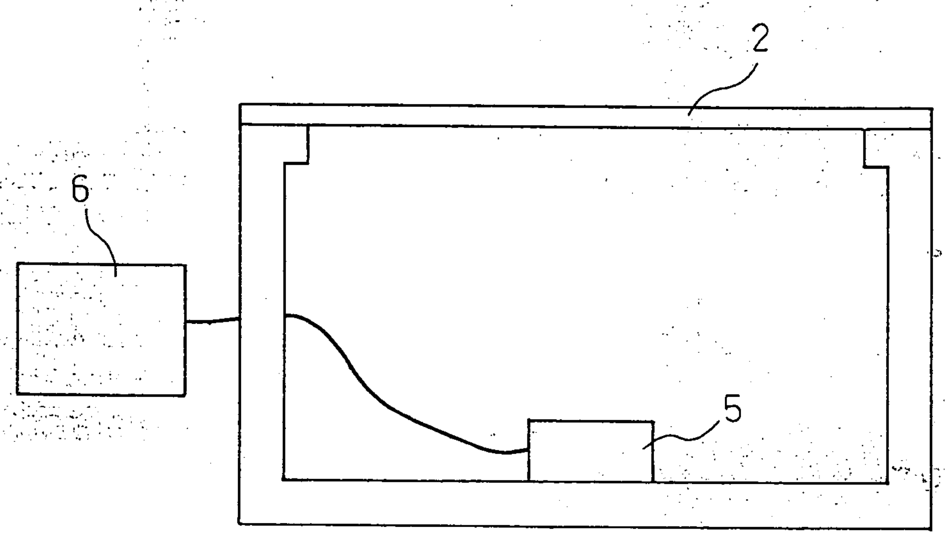

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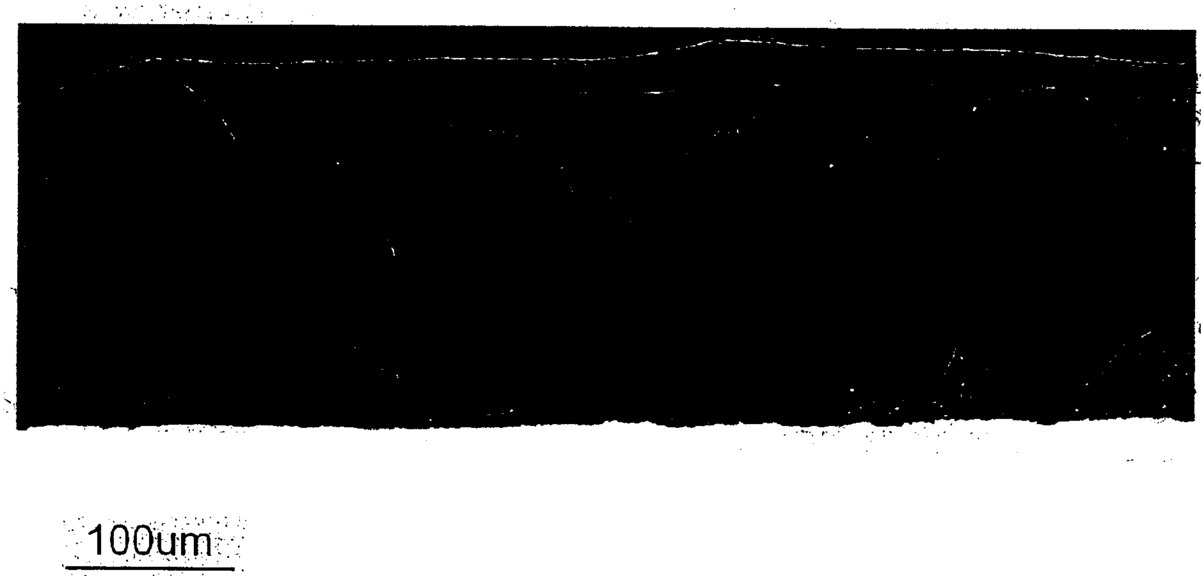
Fig.8



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DESCRIPTION

Title of Invention: Pre-coated metal plate

Technical Field

0001 The present invention relates to a pre-coated metal plate which has a high heat insulation and electronic devices which are produced at least partially using that pre-coated metal plate.

Background Art

0002 In the past, for outside panels of computers, digital household electrical appliances, and other electronic equipment, steel sheets, aluminum sheets, and other metal sheets have been used. Such metal sheets are required to be beautiful in appearance, so pre-coated metal plates are being widely used.

0003 In recent years, along with the spread of computers and the increased use of electronics in household electrical appliances etc., many motors, electronic components, and other components which act as heat sources have come to be used inside these computers and household electrical appliances. The amount of heat generated by these heat sources is increasing, so if touching the outside panels of household electrical appliances by the bare hand, there is the problem that the user will feel extreme heat or be burned.

0004 In the past, to suppress the rise in temperature of the outside panels of household electrical appliances, the practice has been to provide heat radiating openings or use a fan for forced cooling. Further, the practice has also been to use various heat radiating materials or heat insulating materials etc. However, with just these techniques, the improvement is insufficient. Further, a step of bonding a heat radiating material or heat insulating material is necessary, so this obstructs productivity and is problematic in terms of the increased cost etc. as well.

0005 Here, even if the temperature of the metal sheet itself rises, if it is made difficult for the heat of the metal sheet to be conducted to the skin contacted, extreme heat will not be felt and there will be no fear of burns. Therefore, as art for imparting heat insulation to the surface of a metal sheet for making it hard for the heat of the metal sheet to be conducted to the contacted skin, the technique of forming a coating film layer containing bubbles, which have a low heat conductivity, on the metal sheet surface is disclosed. For example, PLT 1 and PLT 2 disclose the art of coating a foamable paint, causing the paint to foam at the time of being heated to cure, and thereby cause the inclusion of bubbles. Further, PLT 3 discloses the art of coating a paint to which hollow fine particles or heat expandable particles are added to thereby introduce bubbles.

0006 Therefore, the inventors used the above PLT's 1 to 3 to form layers containing bubbles on the metal sheet, confirmed the coating film performance, and studied the application to pre-coated steel plates. As a result, they learned that the inventions of PLT's 1 and 2 were excellent in heat insulation, but were inferior in workability, in particular the drawability. Further, they learned that with the invention of PLT 3, drawing is possible, but the heat insulation is not sufficient.

0007 In the above way, in each invention, both heat insulation and workability are not satisfied. Art enabling application for pre-coated metal plates achieving both the heat insulation and workability sought for the outside panels of household electrical appliances has not yet been proposed at the present.

Citation List

Patent Literature

0008 PLT 1: Japanese Patent Publication (A) No. 2005-131830

PLT 2: Japanese Patent Publication (A) No. 2005-219354

PLT 3: Japanese Patent Publication (A) No. 2005-193533

Summary of Invention

Technical Problem

0009 The present invention, in consideration of the above situation, has as its object the provision of a pre-coated metal plate which has a high heat insulation and is excellent in workability and a coated metal article using the same.

Solution to Problem

0010 The inventors engaged in intensive studies for solving the above problem and as a result discovered that by covering one surface or both surfaces of a metal sheet with a coating film layer containing relatively large bubbles such as shown in FIG. 1, a high heat insulation can be obtained. Further, they discovered that if, as shown in FIG. 2, the size of the bubbles is too much larger than the coating film thickness, the coating film becomes poor in workability and adhesiveness and that if, as shown in FIG. 3, the size of the bubbles is too small, the coating film is poor in heat insulation. Furthermore, the inventors engaged in intensive studies and as a result discovered that, as shown in FIG. 1, a coating film layer which contains relative large bubbles becomes inferior in workability or adhesiveness when working it or when running a cross-cut test etc., since the coating thickness between the coating film surface and tops of the bubbles is thin. To solve this problem, they came up with the idea of, as shown in FIG. 4, providing a coating film layer containing bubbles as a lower layer coating film (first coating film layer) and further an upper layer coating film (second coating film layer). Furthermore, they discovered that to achieve both heat insulation and workability or adhesiveness of the pre-coated metal plate conceived of, it is possible to control the thickness of the lower layer coating film and the bubble content within a certain range shown by relations. Further, they discovered that by controlling the resin ingredients of the upper side coating film layer (second coating film layer) and, furthermore, controlling the shape and number of bubbles contained in the lower coating film layer (first coating film layer), it is possible to achieve both further heat insulation and workability or adhesiveness. The present invention was completed based on these discoveries.

0011 That is, the present invention has the following as its gist:

(1) A pre-coated metal plate comprised of a metal sheet on one surface or on both surfaces of which at least two coating film layers are provided, the pre-coated metal plate characterized in that, among the at least two layers of coating film layers, a first coating film layer which is positioned at a lower side is a bubble-containing layer, **the** bubble-containing layer has a bubble content, as a volume concentration V(%), satisfying the following formulas at the time of a thickness "t" (μm): $-0.1t+57.5 \leq V \leq -0.05t+92.5$ and $50 \leq t \leq 350$, a second coating film layer which is positioned at an upper side of the first coating film layers is a coating film layer which contains a melamine curing type polyester resin or isocyanate curing type polyester resin, the polyester resin has a number average molecular weight of 10000 to 23000, and the second coating film layer has a thickness of 3 to 30 μm.

(2) A pre-coated metal plate as set forth in (1), characterized in that, when a total thickness of the combination of the first coating film layer and the second coating film layer is T (μm) and a size of bubbles measured in a direction vertical to the coating film

surface is Rv (μm), there are 20 or more bubbles satisfying Rv≥0.8T in a 10 mm width of any coating film cross-section.

(3) A pre-coated metal plate as set forth in (1) or (2), characterized in that the first coating film layer and the second coating film layer respectively contain pigments of similar colors.

(4) A pre-coated metal plate as set forth in any one of (1) to (3), characterized in that the surface of the metal sheet at the side opposite to the surface of the bubble-containing layer has a total emissivity of infrared rays of 0.50 or less in a region of a wave number of 600 to 3000 cm^{-1} which is measured at a predetermined temperature of 80°C to 200°C.

(5) An electronic apparatus characterized in that a pre-coated metal plate as set forth in any one of (1) to (4) is used for at least part of an outer panel and in that the bubble-containing layer is positioned at an outer surface side of the outer panel.

Advantageous Effects of Invention

0012 According to the present invention, it is possible to provide a pre-coated metal plate which has a high heat insulation and is excellent in workability and a coated metal article of the same.

Brief Description of Drawings

0013 FIG. 1 is a cross-sectional view of the pre-coated metal plate on which a coating film layer having relatively large bubbles is coated.

FIG. 2 is a cross-sectional view of the pre-coated metal plate on which a coating film layer having overly large bubbles for the coating thickness is coated.

FIG. 3 is a cross-sectional view of the pre-coated metal plate on which a coating film layer having overly small bubbles for the coating thickness is coated.

FIG. 4 is a cross-sectional view of the pre-coated metal plate of the present invention.

FIG. 5 is a view showing the relationship between the bubble content of the bubble-containing layer, by volume concentration, V(%), and the coating thickness "t" (μm).

FIG. 6 is an explanatory view showing an outline of the test apparatus for measurement of rising temperature.

FIG. 7 is an explanatory view showing the contact time and the structure of a housing which is used for a test for measurement of the rising temperature.

FIG. 8 is a photograph of the cross-section of the coating film part of a pre-coated metal plate of Example No. 4 observed under an optical microscope.

Description of Embodiments

0014 Below, while referring to the attached drawings, preferred embodiments of the present invention will be explained in detail.

0015 The pre-coated metal plate according to the present invention is comprised of a base material formed by a metal sheet on one surface or both surfaces of which there are at least two layers of coating film layers. When used to express positions of the at least two layers of coating film layers of the pre-coated metal plate, "lower" means the side close to the metal sheet, while "upper" means the side far from the metal sheet. These coating film layers specifically have a multilayer structure containing at least a first coating film layer containing bubbles (hereinafter referred to as a "bubble-containing layer") and a second coating film layer containing a high molecular weight polyester resin which is laminated on the surface layer side of the first coating film layer (below, called the "topcoat layer").

0016 The bubble-containing layer is characterized in that when the bubble content of the coating film is expressed by the volume concentration V (%) and the coating thickness is expressed by "t" (μm), the relations of $-0.1t+57.5 \leq V \leq -0.05t+92.5$ and $50 \leq t \leq 350$ are satisfied. The inventors studied this and as a result discovered that by the relationship of the bubble content V (%) and coating thickness "t" (μm) of the bubble-containing layer satisfying the relations $-0.1t+57.5 \leq V$ and $t \geq 50$, it is possible to obtain a good heat insulation performance and that by satisfying the relations $V \leq -0.05t+92.5$ and $t \leq 350$, the coating film will follow deformation of the metal sheet and good workability is obtained.

0017 FIG. 5 shows the relationship between the bubble content, by volume concentration V (%), and the coating thickness "t" (μm) of the bubble-containing layer. It analyzes the relationship between the thickness of the bubble-containing layer "t" (μm) and the bubble introduction rate V (%) of examples shown below using polyurethane (i) for the binder resin of the bubble-containing layer, using Cellmic CE as the bubble-introducing agent, using carbon black as the pigment, and making the topcoat layer 15 μm (Example Nos. 4, 13 to 31, and 39 to 48) and plots the results of evaluation of heat insulation and the results of evaluation of workability and adhesiveness differentiated from each other. The meanings of the evaluation symbols in the figure are shown in the following table.

Evaluation symbol	Heat insulation	Workability and adhesiveness
●	Very good	Very good
○	Very good	Good
▲	Very good	Fair
×	Very good	Poor
□	Good	Fair
△	Fair	Very good
◇	Fair	Good
*	Poor	Very good

If viewing FIG. 5, it is learned that in the region surrounded by the bubble content range ($-0.1t+57.5 \leq V \leq -0.05t+92.5$) and the coating thickness range ($50 \leq t \leq 350$), a good evaluation is obtained in both of the heat insulation and the workability or adhesiveness.

0018 Here, the coating thickness "t" is found by cutting the coating film, embedding the piece in a resin, then polishing so as to smooth the cross-section vertical to the surface of the coating film, observing this under an optical microscope or electron microscope, observing five locations in a range of a width of 10 mm, and obtaining the average value. Further, the bubble content V is found by photographing the coating film cross-section by an electron microscope etc., placing a transparent sheet used for OHP over the top of the photograph, precisely tracing the bubble parts, then cutting out the bubble parts and other coating film parts, measuring their respective masses, and finding V from the mass ratio as the area rate=volume rate. For this bubble content V as well, the average value when observing five locations in a range of a width 10 mm is used.

0019 Further, when expressing the total thickness of the bubble-containing layer and the topcoat layer of the pre-coated metal plate combined (as explained later, when there is a further layer under the bubble-containing layer, not including the thickness of that layer positioned under it) as T (μm) and the size of the bubbles in the direction vertical to the coating film surface as Rv, if there are 20 or more bubbles satisfying ≥0.8T in a width of 10 mm of any coating film cross-section, suitable surface relief is formed at the surface, the contact area between the skin and pre-coated metal plate when using a finger etc. to touch the pre-coated metal plate can be reduced and the amount of heat which is conducted to the skin can be reduced. Furthermore, the part contacting the skin is a region where there are bubbles with low heat conductivity between the coating film surface and the steel sheet and the conduction of heat is obstructed. Further, an effect of heat insulation due to the air layer formed between the surface relief of the coating film and the skin is also obtained. Due to these synergistic effects, an excellent heat insulation is obtained, so there are preferably at least 20 bubbles satisfying≥0.8T in a width 10 mm of any coating film cross-section. Note that, the size and number of the bubbles in the bubble-containing layer are found by observing a cross-section of the coating film vertical to the surface under an optical microscope or an electron microscope and taking the average of any five locations in the range of a width of 10 mm.

0020 As the binder which is used for the bubble-containing layer, a generally known one, for example, a polyester resin, urethane resin, acryl resin, epoxy resin, melamine resin, vinyl chloride resin, etc. may be used. Further, these resins may also be either of a thermoplastic type or a heat curing type. Among these as well, a urethane resin or polyester resin with a high ductility and with a good adhesiveness with the polyester resin-based paint which is used for the topcoat layer is suitable as a binder.

0021 When applying a urethane resin or polyester resin, the glass transition temperature (Tg) of these resins is preferably -10 to 70°C. If the Tg of the urethane resin or polyester resin is less than -10°C, the film is liable to not sufficiently form. Further, if over 70°C, the coating film hardness becomes too high, so the workability is liable to deteriorate.

0022 The method of introducing bubbles into the bubble-containing layer is not particularly limited. For example, it is sufficient to coat and bake a paint to which azodicarbonamide, azobisisobutyronitrile, or another organic foam agent which decomposes while generating a gas at the time of heating etc., microcapsules or other such heat expandable particles where the solvent etc. which is sealed in the particles expands due to the baking, inorganic hollow particles, organic hollow particles, etc. are added.

0023 Furthermore, in the bubble-containing layer in the present invention, sometimes holes are formed at the coating film surface when part of the gas which is generated when forming the above-mentioned bubbles escapes from the coating film, but since a topcoat layer is provided over the bubble-containing layer, there is no detrimental effect on the performance, so this is not a particular problem.

0024 For the topcoat layer of the present invention, as the base resin, a melamine curing type polyester resin or isocyanate curing type polyester resin is used.

0025 As explained above, by controlling the bubble content, coating thickness, and size of bubbles of the bubble-containing layer, it is possible to maintain the heat insulation while securing a certain degree of workability. However, with the bubble-containing layer alone, the work performance targeted by the inventors is not satisfied. The inventors discovered that if providing, at the upper layer of the bubble-containing layer, a topcoat layer using, as the base resin, a melamine curing type polyester resin with a number average molecular weight of 10000 to 23000 or an isocyanate curing type polyester resin with a number average molecular weight of 10000 to 23000, the required excellent work performance can be obtained.

0026 The reason for making the main resin of the topcoat layer a polyester resin and, furthermore, for limiting the number average molecular weight to 10000 to 23000 is to secure workability by making a polyester resin excellent in ductility and adhesiveness as a topcoat layer, while the reason for limiting the polyester resin to a melamine curing type polyester resin or isocyanate curing type polyester resin is to obtain a coating film excellent in hardness and ductility. If the number average molecular weight of the polyester resin of the topcoat layer is less than 10000, the workability deteriorates. If the number average molecular weight of the polyester resin of the topcoat layer exceeds 23000, the workability deteriorates. Further, if the number average molecular weight of the polyester resin of the topcoat layer exceeds 23000, the coating film surface becomes too soft and the scratch resistance deteriorates, so this is made the upper limit value.

0027 Note that, by including a melamine curing type polyester resin or isocyanate curing type polyester resin with a number average molecular weight of 10000 to 23000 in the binder resin in an amount of 80 mass% or more, an excellent effect of improvement of the workability is exhibited.

0028 The thickness of the topcoat coating film layer is preferably 3 to 30 μm. If the thickness of the topcoat coating film layer is less than 3 μm, the workability is inferior, so this is unsuitable. If the thickness of the topcoat coating film layer is over 30 μm, the layer easily bubbles at the time of coating. Further, this is unpreferable from the viewpoint of cost. Further, if the thickness of the topcoat coating film layer is over 30 μm, there is the danger of the heat insulating effect due to surface relief of the coating film surface formed by control of the shape of the bubbles and content of bubbles of the bubble-containing layer can no longer be obtained.

0029 The bubble-containing layer and topcoat layer of the present invention may, in accordance with need, have a colored pigment added to them. For the colored pigment, a generally known inorganic pigment, organic pigment, and metallic pigment may be used. For example, carbon black, titanium oxide, zinc white, naphthol red, disazo yellow, disazo pyrazolone orange, aluminum pigment, nickel pigment, etc. may be mentioned.

0030 The colored pigments which are added to the bubble-containing layer and topcoat layer are preferably similar colors. By making the bubble-containing layer and the topcoat layer similar colors, a stable color appearance is obtained and even if the topcoat layer becomes thinner due to working etc. or some cracks are formed, changes in the appearance and hue are suppressed, so this is preferred.

0031 If adding a colored pigment to the bubble-containing layer and topcoat layer of the present invention, the amount of addition is preferably 130 parts by mass or less with respect to 100 parts by mass of the binder resin solid content. If the colored pigment is over 130 parts by mass, the amount of colored pigment may become too large, the coating film may become brittle, and the workability and adhesiveness may be inferior.

0032 The bubble-containing layer and topcoat layer of the present invention may, in accordance with need, have an anti-corrosion pigment and an anti-corrosion agent both added to it. For example, strontium chromate, calcium chromate, or other generally known chrome-based anti-corrosion pigment, zinc phosphate, zinc phosphite, aluminum phosphate, aluminum phosphate, molybdate, phosphomolybdate, a mixed vanadic acid/phosphoric acid pigment, silica, a type of silica called calcium silicate to which Ca is adhered, or other generally known non-chrome-based anti-corrosion pigment and anti-corrosion agent may be used. Among the above anti-corrosion pigments and anti-corrosion agents, a non-chrome-based anti-corrosion pigment and anti-corrosion agent which does not contain the environmental load substance chromate is preferably used.

0033 If adding an anti-corrosion pigment to the bubble-containing layer and topcoat layer of the present invention, the amount of addition is preferably 10 to 130 parts by mass with respect to 100 parts by mass of the binder resin solid content. If the amount of addition of the anti-corrosion pigment is less than 10 parts by mass, the corrosion resistance may be inferior, while if the amount of addition of the anti-corrosion pigment is over 130 parts by mass, the amount of anti-corrosion pigment may become too large, the coating film may become brittle, and the workability and adhesiveness may be inferior.

0034 Further, if adding both the above colored pigment and anti-corrosion pigment to the bubble-containing layer and topcoat layer of the present invention, the upper limit of the amount of addition is preferably a total amount of the pigment of 130 parts by mass or less with respect to 100 parts by mass of the binder resin solid content. If the total amount of pigments is over 130 parts by mass, the amount of pigment may become too large, the coating film may become brittle, and the workability and adhesiveness may be inferior.

0035 Further, the bubble-containing layer and topcoat layer of the present invention may, in accordance with need, have a generally known leveling agent, pigment dispersant, etc. added. These additives are not particularly limited in type or amount of addition and may be suitably selected in accordance with need.

0036 The bubble-containing layer and topcoat layer of the present invention may be coated by a generally known coating method, for example, coated by a roll coater, roller curtain coater, ringer roll coater, spray coater, etc., then baked by a generally known paint baking oven, for example, hot air drying oven, induction heating oven, infrared heating oven, or ovens combining these. In general, production by a continuous pre-coated metal plate production facility called a "CCL (continuous coating line)" enables efficient mass production, so is more preferable. When coating by a CCL, it is preferable to coat the lower layer coating film by a roll coater or curtain coater and coat the upper layer coating film by a curtain coater. A curtain coater, unlike a roll coater, enables coating of a substrate without contact, so if coating a lower layer coating film (first coating film layer) according to the present invention, which includes bubbles formed by coating and drying for curing, with an upper layer coating film (second coating film layer) by a curtain coater, it is possible to coat it without crushing the bubbles in the lower layer coating film and also obtain a beautiful coated appearance, so this is more preferable. If coating the upper layer coating film by a roll coater, the bubbles in the lower layer coating film will end up being crushed during the coating, so the heat insulation is liable to be damaged or the appearance of the upper layer coating film is liable to become poor after coating. If using a multilayer simultaneous coating apparatus called a "slide curtain coater" to simultaneously coat the lower layer coating film before drying and the upper layer coating film by curtain coating, the drying and curing step after coating can dry and cure multiple layers simultaneously in one step, so this is preferable from the viewpoint of reducing energy consumption and production efficiency.

0037 The pre-coated metal plate of the present invention may, in accordance with need, be coated with a primer coating film layer having an anti-corrosion paint function under the bubble-containing layer. If coating the primer coating film layer, the corrosion resistance of the metal sheet is improved, so this is more preferable. As the primer coating film layer which is coated on the pre-coated metal plate of the present invention, a generally known primer coating film for a pre-coated metal plate, for example, a polyester-based primer, epoxy-based primer, urethane-based primer, etc. may be used. The curing agent of the primer coating film may be either melamine based or isocyanate based. The anti-corrosion pigment which is added to the primer coating film which is used may be a chromate-based, phosphoric acid-based, silica-based, or other generally known type, but one other than a chromate-based one has a small environmental load, so is more preferable.

0038 The primer coating film which is coated on the pre-coated metal plate of the present invention can be coated by a generally known coating method, for example, a roll coater, roller curtain coater, ringer roll coater, spray coater, etc., then baked on by a generally known paint-use baking oven, for example, a hot air drying oven, induction heating oven, infrared heating oven, or oven using these.

0039 The pre-coated metal plate of the present invention preferably has a total emissivity of infrared rays of the surface opposite to the surface having the bubble-containing layer of 0.50 or less in the region of the wave number of 600 to 3000 cm^{-1} measured at a predetermined temperature of 80°C to 200°C.

0040 When a metal sheet is struck by thermal radiation rays, the thermal radiation rays will not pass through it much at all, so the thermal radiation rays will either be reflected or absorbed. Here, when the thermal radiation rays generated from the heat generating member inside of the housing strike the inside surface of a housing outer panel, most of the incident thermal radiation rays will end up being absorbed, so the temperature of the housing outer panel will rise. According to Kirchhoff's law of thermal radiation, at a certain temperature, the absorptivity and emissivity of a body become the same (for example, Nishikawa and Fujita coauthored, "Basic Course in Mechanical Engineering: Electric Heating Engineering", p. 290, issued by Rikogaku (1983)). Therefore, the inventors researched in detail the emissivity of the surface opposite to the surface containing the bubbles. As a result, they discovered that by lowering the emissivity of the inside of a housing outer panel which covers a heat generating member, the temperature of the housing outer panel falls. That is, they discovered that by making the surface opposite to the surface having the bubble-containing layer the inside of the housing and making the total emissivity of that surface 0.50 or less, preferably 0.40 or less, in the region of a wave number of 600 to 3000 cm^{-1} measured by a temperature of 80°C to 200°C, it is possible to greatly lower the temperature of the housing outer panel.

0041 At the wave number regions of a wave number of less than 600 cm^{-1} or over 3000 cm^{-1}, the effect on the heat of housing outer panels is extremely small, so the emissivity including these wave number regions is unsuitable. By limiting the measured wave number to the 600 to 3000 cm^{-1} region, precise and efficient measurement is possible.

0042 Further, if the temperature for measurement of the emissivity is less than 80°C, the amount of radiated energy which is radiated from the coating is too small, so when measuring the emissivity, detection error easily occurs, so this is unsuitable. By measurement at a temperature of 80°C to 200°C, precise measurement is possible. Furthermore, if the measurement temperature is over 200°C, depending on the type of the coating film, the coating film is liable to thermally break down, so this is not preferable.

0043 To improve the heat reflectivity of the inside of the housing, if the metal base material itself has a high heat reflectivity, it is preferably exposed. Further, it is more preferable to plate the surface of the metal sheet by a metal with a higher heat reflectivity.

0044 As the metal material with a high heat reflectivity, aluminum, nickel, stainless steel, zinc, or other generally known metal material, alloys of the same, and metal materials plated with these may be used. If the surface at the inside of the housing is comprised of these metal sheets or plating layers exposed without being covered by a coating film, the heat reflectivity is further improved, so this is preferable. In the case of steel sheet, hot dip galvanized steel sheet, electrogalvanized steel sheet, zinc-nickel alloy plated steel sheet, hot dip galvannealed steel sheet, aluminum-plated steel sheet, aluminum-zinc alloy plated steel sheet, etc. are preferable.

0045 However, if the metal is exposed, corrosion easily occurs from there, so chemical treatment is preferably applied. However, depending on the type or amount of deposition of the chemical treatment agent, the heat reflectivity is liable to be reduced, so it is necessary to suitably select the type or amount of deposition in accordance with need.

0046 As the chemical treatment, a generally applied one can be used. Specifically, for example, zinc phosphate-based chemical treatment, chromate-free chemical treatment, coating-type chromate treatment, electrolytic chromic acid treatment, reactive chromate treatment, etc. may be used. Among these, the coating-type chromate treatment, electrolytic chromic acid treatment, and reactive chromate treatment include the environmental load substance of hexavalent chromium, so are not preferred much. Further, zinc phosphate-based chemical treatment is also liable to be inferior in workability and adhesiveness compared with other treatment. Therefore, as the chemical treatment applied to a metal material according to the present embodiment, a chromate-free treatment is preferable.

0047 As the chromate-free chemical treatment, there are ones using an inorganic chemical treatment agent and ones using an organic chemical treatment agent, but either is acceptable. Specifically, as the chromate-free chemical treatment, for example, treatment using a silane coupling agent, zirconium compound, titanium compound, tannin or tannic acid, a resin, silica, etc. included in an aqueous solution etc. is known. It is also possible to use the known art described in Japanese Patent Publication (A) No. 53-9238, Japanese Patent Publication (A) No. 9-241576, Japanese Patent Publication (A) No. 2001-89868, Japanese Patent Publication (A) No. 2001-316845, Japanese Patent Publication (A) No. 2002-60959, Japanese Patent Publication (A) No. 2002-38280, Japanese Patent Publication (A) No. 2002-266081, Japanese Patent Publication (A) No. 2003-253464, etc. Further, for these chemical treatments, for example, the chromate treatment agent "ZM-1300AN" made by Nihon Parkerizing Co., Ltd., the chromate-free chemical treatment agent "CT-E300N" made by Nihon Parkerizing Co., Ltd., the trivalent chrome-based chemical treatment agent "Surfcoat® NRC1000" made by Nippon Paint Co., Ltd., and other commercially available chemical treatment agents may be used.

0048 The metal plate of the present invention is suitable as the outer panels of electronic apparatuses. By using the metal plate of the present invention for the outer panels of electronic apparatuses etc. so that the surface with the bubble-containing layer becomes the outer surface side, even if the outer panels of the electronic apparatuses come into direct contact with the skin, extreme heat will not be felt and, further, burns can be prevented, so this is preferable.

0049 As electronic apparatuses which use the metal plate of the present invention for at least part of the outer panels, for example, desk top PCs (personal computers), flat screen televisions, and other digital household electrical appliances and car navigation systems, car AV, and other car electronics may be mentioned. Further, the metal plate of the present invention may also be used for part of the outer panels of notebook PCs, mobile phones, and other mobile products.

Examples

0050 Next, the examples will be used to explain the present invention more specifically, but the constitution of the present invention is not limited to the following examples.

0051 (Example 1)

First, the paint used in the example will be explained in detail. In the present example, a two-layer structure of a bubble-containing layer (first coating film layer, below also called the "lower layer coating film") and a topcoat layer (second coating film layer, below also called the "upper layer coating film") was formed on the metal sheet surface in that order from the metal sheet side. The back surface of the metal sheet was uncoated or formed with back surface paint. Below, the paint ingredients used will be explained in the order of the paint for the bubble-containing layer (below, called the "lower layer paint"), the paint for the topcoat layer (below, called the "upper layer paint"), and the back surface paint.

0052 First, the lower layer paint will be explained in detail.

0053 To the polyol "Desmophen® 1150" made by Sumitomo Bayer Urethane, the block isocyanate "Desmodur® BL1100" made by Sumitomo Bayer Urethane was added to give a solid content ratio of polyol:block isocyanate = 66:34 so as to thereby prepare a clear paint (in the table, described as "Urethane (i)"). Note that, as the solvent, isophoron was used.

0054 As the base resin, the amorphous polyester resin "Vylon® 600" made by Toyobo Corporation (number average molecular weight 16000) was used. As the cross-linking agent, the butylated melamine resin "Super Beckamine® J830" made by DIC (in the table, described as "butylated melamine") was used (in the table, described as "polyester"). Note that, as the solvent, a mixture of cyclohexanone:Sorbesso 150=1:1 was used.

0055 As another base resin, the epoxy resin "EPICLON® P-439" made by DIC was used. As the cross-linking agent, the butylated melamine "Super Beckamine® J830" made by DIC was used (in the table, described as "epoxy"). Note that, as the solvent, a mixture of cyclohexanone:Sorbesso 150=1:1 was used.

0056 Further, as another base resin, the acryl resin "Acrylset® AST-5531" made by Nippon Shokubai was used. As the cross-linking agent, the butylated melamine resin "Super Beckamine® J830" made by DIC (in the table, butylated melamine) was used (in the table, described as "acryl"). Note that, as the solvent, a mixture of cyclohexanone:Sorbesso 150=1:1 was used.

0057 Next, a 1-liter four-neck flask equipped with a stirrer, thermometer, nitrogen introducing tube, and condenser was charged with anhydrous phthalic acid 100 parts by mass, neopentyl glycol 57 parts by mass, and trimethylol propane 48 parts by mass. These were stirred under nitrogen and reacted at 210°C by a condensation reaction, then the water was distilled off. Next, the result was cooled down to 100°C, then ε-caprolactone was added in 531 parts by mass, the mixture raised to 150°C, held in temperature for 3 hours, then cooled down to 100°C. Cyclohexanone 78 parts by mass was added to synthesize a polyol.

0058 To the synthesized polyol, the block isocyanate

"Sumidur® BL3175" made by Sumitomo Bayer Urethane was added to give a solid content ratio of polyol:block isocyanate=66:34 to thereby prepare a clear paint (in the table, described as "Urethane (ii)"). Note that, as the solvent, isophoron was used. The solid content concentration in the paint was suitably adjusted considering the bubble containability, coatability, and storage stability.

0059 To introduce the bubbles, the foam agent "Cellmic® CE" made by Sankyo Kasei Co., Ltd. and the hollow particles "Ganz Pearl GMH-850" made by Ganz Chemical Co., Ltd. were used.

0060 Further, as the colored pigments, for the black-based pigment, the carbon black "Tokablack® #7350" made by Tokai Carbon was used, for the white-based pigment, the titanium oxide "Tipaque White® CR-95" made by Ishihara Sangyo Kaisha and the commercially available zinc oxide were used, as the blue-based pigment, the commercially available cobalt aluminate and copper phthalocyanine were used, and as the red-based pigment, the commercially available iron oxide and mercury sulfide were used.

0061 Table 1

Paint type	Binder resin type	Amount added [parts by mass] (solid content)	Bubble-introducing agent type	Amount added [parts by mass]	Pigment	
					Type	Amount added [parts by mass]
Lower layer 1	Polyurethane (i)	100	Cellmic CE	0.3	Carbon black	15
Lower layer 2	Polyurethane (i)	100	Cellmic CE	0.5	Carbon black	15
Lower layer 3	Polyurethane (i)	100	Cellmic CE	1	Carbon black	15
Lower layer 4	Polyurethane (i)	100	Cellmic CE	2	Carbon black	15
Lower layer 5	Polyurethane (i)	100	Cellmic CE	3	Carbon black	15
Lower layer 6	Polyurethane (i)	100	Cellmic CE	4	Carbon black	15
Lower layer 7	Polyurethane (i)	100	Cellmic CE	5	Carbon black	15
Lower layer 8	Polyurethane (i)	100	Cellmic CE	10	Carbon black	15
Lower layer 9	Polyurethane (i)	100	Cellmic CE	15	Carbon black	15
Lower layer 10	Polyurethane (i)	100	Cellmic CE	20	Carbon black	15
Lower layer 11	Polyurethane (i)	100	Cellmic CE	30	Carbon black	15
Lower layer 12	Polyurethane (i)	100	Cellmic CE	40	Carbon black	15
Lower layer 13	Polyurethane (i)	100	Cellmic CE	70	Carbon black	15
Lower layer 14	Polyurethane (i)	100	Cellmic CE	140	Carbon black	15
Lower layer 15	Polyester	100	Cellmic CE	3	Carbon black	15
Lower layer 16	Acryl	100	Cellmic CE	3	Carbon black	15
Lower layer 17	Epoxy	100	Cellmic CE	3	Carbon black	15
Lower layer 18	Polyurethane (ii)	100	Cellmic CE	3	Carbon black	15
Lower layer 19	Polyurethane (i)	25	Ganz Pearl GMH-850	75	Carbon black	15
Lower layer 20	Polyurethane (i)	100	Cellmic CE	3	Titanium oxide	30
Lower layer 21	Polyurethane (i)	100	Cellmic CE	3	Cobalt aluminate	28
Lower layer 22	Polyurethane (i)	100	Cellmic CE	3	Copper phthalocyanine	12
Lower layer 23	Polyurethane (i)	100	Cellmic CE	3		
Lower layer 24	Polyurethane (i)	100	Cellmic CE	3	Zinc oxide	40
Lower layer 25	Polyurethane (i)	100	Cellmic CE	3	Iron oxide	41
Lower layer 26	Polyurethane (i)	100	Cellmic CE	3	Mercury sulfide	61

0062 Next, the upper layer paint will be explained in detail.

0063 As the base resin, amorphous polyester resins made by Toyobo Corporation, that is, "Vylon® 660" (number average molecular weight 8000), "Vylon® GK250" (number average molecular weight 10000), "Vylon® GK140" (number average molecular weight 13000), "Vylon® 240" (number average molecular weight 15000), "Vylon® 600" (number average molecular weight 16000), "Vylon® 280" (number average molecular weight 18000), "Vylon® 245" (number average molecular weight 19000), "Vylon® 103" (number average molecular weight 23000), and "Vylon® 550" (number average molecular weight 28000) were used. As the cross-linking agent, the butylated melamine resin "Super Beckamine® J830" made by DIC (in the table, described as "butylated melamine") and the isocyanate compound "Desmodur BL3175 (tradename)" made by Sumitomo Bayer Urethane (in the table, described as "HDI") were used. As the solvent, a mixture, by mass ratio, of cyclohexanone:Sorbesso 150=1:1 was used

0064 As the colored pigments, the same ones as the lower layer paint were used.

0065 Table 2

	Main resin			Cross-linking agent		Pigment	
	Type	Number average molecular weight Mn	Amount added [parts by mass] (solid content)	Type	Amount added [parts by mass] (solid content)	Type	Amount added [parts by mass] (solid content)
Upper layer 1	660	8000	100	Butylated melamine	30	Carbon black	15
Upper layer 2	GK250	10000	100	Butylated melamine	30	Carbon black	15
Upper layer 3	GK140	13000	100	Butylated melamine	30	Carbon black	15
Upper layer 4	240	15000	100	Butylated melamine	30	Carbon black	15
Upper layer 5	600	16000	100	Butylated melamine	30	Carbon black	15
Upper layer 6	280	18000	100	Butylated melamine	30	Carbon black	15
Upper layer 7	245	19000	100	Butylated melamine	30	Carbon black	15
Upper layer 8	103	23000	100	Butylated melamine	30	Carbon black	15
Upper layer 9	550	28000	100	Butylated melamine	30	Carbon black	15
Upper layer 10	600	16000	100	HDI	30	Carbon black	15
Upper layer 11	240	15000	100	Butylated melamine	30	Titanium oxide	30
Upper layer 12	240	15000	100	Butylated melamine	30	Cobalt aluminate	28
Upper layer 13	240	15000	100	Butylated melamine	30	Copper phthalocyanine	12
Upper layer 14	240	15000	100	Butylated melamine	30		
Upper layer 15	240	15000	100	Butylated melamine	30	Zinc oxide	40
Upper layer 16	240	15000	100	Butylated melamine	30	Iron oxide	41
Upper layer 17	240	15000	100	Butylated melamine	30	Mercury sulfide	61

0066 As the back surface paint, the gray color back surface paint "FL100HQ" made by Nippon Fine Coatings Inc. (in the table, described as "Back 1") and the clear color "FL100HQ" (in the table, described as "Back 2") were used.

0067 Below, the pre-coated metal plates which were used for the experiments in the examples will be explained in detail.

0068 Electrogalvanized steel sheet (in the table, described as "EG"), hot dip galvanized steel sheet (in the table, described as "GI"), galvannealed steel sheet (in the table, described as "GA"), stainless steel (in the table, described as "SUS"), and aluminum sheets were prepared as original sheets.

0069 Next, each prepared original sheet was sprayed and degreased by a 2 mass% concentration, 50°C aqueous solution of the alkali degreasing solution "FC-4336" made by Nihon Parkerizing Co., Ltd., rinsed, dried, then coated with the chromate-free chemical treatment agent "CT-E300N" made by Nihon Parkerizing Co., Ltd. by a roll coater and dried by a hot air oven. The drying condition of the hot air oven was made a peak temperature of the steel sheet of 60°C. The chromate-free chemical treatment agent was coated to give an amount of deposition, by total solid content, of 200 g/m^2.

0070 Next, the chemically treated metal sheet was coated on one surface by the prepared lower layer paint and on the other surface with the back surface paint by a roll coater simultaneously at the two surfaces and was dried and cured in an induction heating oven in which hot air was blown under conditions giving a peak temperature of the metal sheet of 220°C. Further, after drying and baking, the coated metal sheet was sprayed with water, wiped clean, then water cooled.

0071 Next, the lower layer paint was coated by the upper layer coating film by a roller curtain coater, then the sheet was dried and cured in an induction heating oven in which hot air was blown under conditions giving a peak temperature of the metal sheet of 230°C. Further, after drying and baking, the coated metal sheet was sprayed with water, wiped clean, then water cooled to thereby prepare a two-layer pre-coated metal plate.

0072 Below, details of the method of evaluation of the pre-coated metal plates prepared in the tests will be explained.

1. Heat Insulation

1.1. Contact Time Using Hot Plate and Measurement of Rising Temperature

Each prepared pre-coated metal plate was placed on a hot plate, which was heated to 65°C, for 120 seconds with its front surface at the top. After that, the index finger was pressed against the surface of the pre-coated metal plate by a load of 500 g. The time where contact could be maintained without feeling extreme heat was measured and the result evaluated by the following criteria. Note that, the same test was run by five persons and the average time used for the evaluation (in the table, described as "Heat Insulation (i)").

VG (very good): 10 seconds or more, G (good): 5 seconds to less than 10 seconds, F (fair): 2 seconds to less than 5 seconds, P (poor): less than 2 seconds

0073 Further, FIG. 6 shows an outline of the test apparatus for measuring the rising temperature. Each prepared pre-coated metal plate was placed on a hot plate, which was heated to 65°C, for 120 seconds with its front surface at the top. A thermocouple sandwiched between silicone rubber (thickness 3 mm, 10 mm square) was pressed against the pre-coated metal plate surface by 1 g/mm^2, the temperature was measured after 30 seconds, then the result was evaluated by the following criteria (in the table, described as "Heat Insulation (ii)"). This test simulated the heat felt by a person with the silicone rubber being deemed the skin.

VG (very good): less than 35°C, G (good): 35°C to less than 37°C, F (fair): 37°C to less than 39°C, P (poor): 39°C or more

0074 1.2. Contact Time Using Housing and Measurement of Rising Temperature

A housing shown in FIG. 7 was prepared and tested. The housing was opened at the top side. The opened side was covered by a prepared pre-coated metal plate with the back surface at the inside. In this state, the amount of heat of the heat source was made 15W. This was allowed to stand for 120 seconds. In the same way as 1.1, the surface of the pre-coated metal plate was pressed against by the index finger by a load of 500 g. The time where contact could be maintained without feeling extreme heat was measured and the result evaluated by the following criteria. Note that, the same test was run by five persons and the average time used for the evaluation (in the table, described as "Heat Insulation (iii)").

VG (very good): 10 seconds or more, G (good): 5 seconds to less than 10 seconds, F (fair): 2 seconds to less than 5 seconds, P (poor): less than 2 seconds

0075 2. Workability

The workability was evaluated by investigating the cylindrical drawability as follows. The metal plate was worked by drawing it through a mold under conditions of a punch diameter of 50 mm, a punch shoulder R of 3 mm, a die shoulder R of 3 mm, a drawing ratio of 2.0, and a BHF of 1 t and the results evaluated by the following criteria:

VG (very good): case where visually examining worked part and observing no cracks, discoloration etc. at all

G (good): case where visually examining worked part and observing no cracks, but observing discoloration

F (fair): case where visually examining worked part and observing slight cracks

P (poor): case where visually examining worked part and observing large cracks

0076 3. Adhesiveness

The adhesiveness was measured by a cross-cut tape test. Based on the method of JIS K 5600-5-6, a cross-cut tape test was run and the results evaluated by the following criteria.

VG (very good): case where no peeling at all could be observed

G (good): case where slight peeling could be observed at edges of cut pieces

F (fair): case where 80% of cut pieces remained without being peeled off

P (poor): Case where less than 80% of cut pieces remained without being peeled off

0077 4. Stain Resistance

The stain resistance was evaluated by investigating the resistance to marks by a magic marker as follows: Each prepared pre-coated metal plate was cut into a 50 mm square piece, three lines were drawn on the evaluation surface by a red color Magic Ink®, the piece was allowed to stand at 20°C in the atmosphere for 24 hours, then the lines were wiped off by ethanol. Any remaining color from the ink was visually judged and the results evaluated by the following criteria.

VG (very good): case where marks by the magic marker were erased and could not be seen any longer

G (good): case where marks by the magic marker slightly remained

F (fair): case where marks by the magic marker remained

P (poor): case where marks by the magic marker were not erased much at all

0078 5. Scratch resistance

Pencil hardness was used to measure the scratch resistance. Based on the method of JIS K 5600-5-4, the scratch resistance of the coating film was investigated by the tearing of the coating film when changing the hardness of the lead of the pencil. The maximum hardness where no tearing of the coating film could be observed was made the pencil hardness of the coating film and the results evaluated by the following criteria.

VG (very good): HB or more, G (good): B, F (fair): 2B, P (poor): 3B or less

0079 6. Measurement of Emissivity of Back Surface

Using a Fourier transform infrared spectrometer "VALOR-III" made by JASCO Corporation, the infrared emission spectrum was measured in the region of the wave number of 600 to 3000 cm^{-1} when the sheet temperature of the prepared surface treated metal plate was made 80°C. This was compared with the emission spectrum of the standard black body so as to measure the total emissivity of the surface treated metal plate. Note that, the standard black body used was an iron sheet which was spray coated with the "THI-1B Black Body Spray" sold by Tasco Japan (made Okitsumo) to a coating thickness of 30±2 μm.

0080 Tables 3 and 4 show the configurations of the pre-coated metal plates prepared in the examples and the results of evaluation of the same.

0081 Table 3

No.	Base sheet type	Lower layer paint type	Upper layer paint type	Dried coating thickness (μm) Lower layer coating film	Dried coating thickness (μm) Upper layer coating film	Bubble content (vol%)	-0.1t +57.5	-0.05t +92.5	Upper layer coating film main resin Mn	No. of bubbles satisfying Rv≥0.8T per 10 mm width cross-section	Heat insulation [1]	Heat insulation [2]	Work-ability	Adhesive-ness	Stain resis-tance	Scratch resis-tance	Remarks
1	EG	Lower layer 5	Upper layer 2	200	15	60	37.5	82.5	10000	48	VG	VG	F	VG	VG	VG	
2	EG	Lower layer 5	Upper layer 3	200	15	60	37.5	82.5	13000	48	VG	VG	G	VG	VG	VG	
3	EG	Lower layer 5	Upper layer 4	200	15	60	37.5	82.5	15000	48	VG	VG	VG	VG	VG	VG	
4	EG	Lower layer 5	Upper layer 5	200	15	60	37.5	82.5	16000	48	VG	VG	VG	VG	VG	VG	
5	EG	Lower layer 5	Upper layer 6	200	15	60	37.5	82.5	18000	48	VG	VG	VG	VG	VG	VG	
6	EG	Lower layer 5	Upper layer 7	200	15	60	37.5	82.5	19000	48	VG	VG	VG	VG	G	G	
7	EG	Lower layer 5	Upper layer 8	200	15	60	37.5	82.5	23000	48	VG	VG	VG	VG	F	F	
8	EG	Lower layer 5	Upper layer 10	200	15	60	37.5	82.5	16000	48	VG	VG	VG	VG	VG	VG	
9	EG	Lower layer 15	Upper layer 5	200	15	60	37.5	82.5	16000	48	VG	VG	VG	VG	VG	VG	
10	EG	Lower layer 16	Upper layer 5	200	15	60	37.5	82.5	16000	48	VG	VG	G	G	VG	VG	
11	EG	Lower layer 17	Upper layer 5	200	15	60	37.5	82.5	16000	48	VG	VG	G	G	VG	VG	
12	EG	Lower layer 18	Upper layer 5	200	15	60	37.5	82.5	16000	48	VG	VG	VG	VG	VG	VG	
13	EG	Lower layer 8	Upper layer 5	50	15	55	52.5	90.0	16000	21	F	F	VG	VG	VG	VG	
14	EG	Lower layer 9	Upper layer 5	50	15	60	52.5	90.0	16000	23	F	F	VG	VG	VG	VG	
15	EG	Lower layer 10	Upper layer 5	50	15	70	52.5	90.0	16000	27	F	F	VG	VG	VG	VG	
16	EG	Lower layer 11	Upper layer 5	50	15	80	52.5	90.0	16000	31	F	F	G	G	VG	G	
17	EG	Lower layer 12	Upper layer 5	50	15	85	52.5	90.0	16000	33	G	G	F	F	VG	F	
18	EG	Lower layer 13	Upper layer 5	50	15	90	52.5	90.0	16000	35	VG	VG	F	F	VG	F	Ex.
19	EG	Lower layer 5	Upper layer 5	150	15	45	42.5	85.0	16000	34	F	F	VG	VG	VG	VG	
20	EG	Lower layer 7	Upper layer 5	150	15	60	42.5	85.0	16000	45	VG	VG	VG	VG	VG	VG	
21	EG	Lower layer 8	Upper layer 5	150	15	70	42.5	85.0	16000	53	VG	VG	VG	VG	VG	VG	
22	EG	Lower layer 9	Upper layer 5	150	15	80	42.5	85.0	16000	60	VG	VG	G	G	VG	G	
23	EG	Lower layer 10	Upper layer 5	150	15	85	42.5	85.0	16000	64	VG	VG	F	F	VG	F	
24	EG	Lower layer 3	Upper layer 5	250	15	35	32.5	80.0	16000	30	F	F	VG	VG	VG	VG	
25	EG	Lower layer 4	Upper layer 5	250	15	60	32.5	80.0	16000	51	VG	VG	VG	VG	VG	VG	
26	EG	Lower layer 5	Upper layer 5	250	15	70	32.5	80.0	16000	60	VG	VG	VG	VG	VG	VG	
27	EG	Lower layer 6	Upper layer 5	250	15	75	32.5	80.0	16000	64	VG	VG	G	G	VG	G	
28	EG	Lower layer 7	Upper layer 5	250	15	80	32.5	80.0	16000	68	VG	VG	F	F	VG	G	
29	EG	Lower layer 2	Upper layer 5	350	15	25	22.5	75.0	16000	23	F	F	VG	VG	VG	VG	
30	EG	Lower layer 3	Upper layer 5	350	15	40	22.5	75.0	16000	36	VG	VG	F	F	VG	VG	
31	EG	Lower layer 4	Upper layer 5	350	15	75	22.5	75.0	16000	68	VG	VG	F	F	VG	G	
32	EG	Lower layer 5	Upper layer 5	200	3	60	37.5	82.5	16000	59	VG	VG	F	F	VG	F	
33	EG	Lower layer 5	Upper layer 5	200	5	60	37.5	82.5	16000	58	VG	VG	G	G	VG	G	
34	EG	Lower layer 5	Upper layer 5	200	10	60	37.5	82.5	16000	56	VG	VG	VG	VG	VG	VG	
35	EG	Lower layer 5	Upper layer 5	200	20	60	37.5	82.5	16000	54	VG	VG	VG	VG	VG	VG	
36	EG	Lower layer 5	Upper layer 5	200	30	60	37.5	82.5	16000	36	VG	VG	VG	VG	VG	VG	

No.	Base sheet type	Lower layer paint type	Upper layer paint type	Dried coating thickness (μm): Lower layer coating film	Dried coating thickness (μm): Upper layer coating film	Bubble content (vol%)	-0.1t +57.5	-0.05t +92.5	Upper layer coating film main resin Mn	No. of bubbles satisfying Rv≥0.8T per 10 mm width cross-section	Heat insulation [1]	Heat insulation [2]	Work-ability	Adhesive-ness	Stain resis-tance	Scratch resis-tance	Remarks
37	EG	Lower layer 5	Upper layer 1	200	15	60	37.5	82.5	8000	48	VG	VG	P	VG	VG	VG	Comp. ex.
38	EG	Lower layer 5	Upper layer 9	200	15	60	37.5	82.5	28000	48	VG	VG	VG	VG	P	P	
39	EG	Lower layer 8	Upper layer 5	50	15	50	52.5	90.0	16000	19	P	P	VG	VG	VG	VG	
40	EG	Lower layer 14	Upper layer 5	50	15	95	52.5	90.0	16000	36	VG	VG	P	P	VG	P	
41	EG	Lower layer 4	Upper layer 5	150	15	40	42.5	85.0	16000	30	P	P	VG	VG	VG	VG	
42	EG	Lower layer 11	Upper layer 5	150	15	90	42.5	85.0	16000	68	VG	VG	P	P	VG	F	
43	EG	Lower layer 2	Upper layer 5	250	15	30	32.5	80.0	16000	26	P	P	VG	VG	VG	VG	
44	EG	Lower layer 8	Upper layer 5	250	15	85	32.5	80.0	16000	72	VG	VG	P	P	VG	F	
45	EG	Lower layer 1	Upper layer 5	350	15	20	22.5	75.0	16000	18	P	P	VG	VG	VG	VG	
46	EG	Lower layer 5	Upper layer 5	350	15	80	22.5	75.0	16000	72	VG	VG	P	P	VG	G	
47	EG	Lower layer 10	Upper layer 5	40	15	65	53.5	90.5	16000	24	P	P	VG	VG	VG	VG	
48	EG	Lower layer 3	Upper layer 5	400	15	50	17.5	72.5	16000	46	VG	VG	P	P	VG	VG	
49	EG	Lower layer 5	None	200		60	37.5	82.5	16000	64	VG	VG	P	P	F	P	
50	EG	Lower layer 5	Upper layer 5	200	1	60	37.5	82.5	16000	63	VG	VG	P	P	G	P	
51	EG	Lower layer 5	Upper layer 5	200	35	60	37.5	82.5	16000	32	G	G	G	G	VG	VG	

0082 Table 4

No.	Base sheet type	Lower layer paint type	Upper layer paint type	Dried coating thickness (μm)		Bubble content (vol%)	-0.1t +57.5	-0.05t +92.5	Upper layer coating film main resin Mn	No. of bubbles satisfying Rv≥0.8T per 10 mm width cross-section	Heat insulation		Work-ability	Adhesive-ness	Stain resis-tance	Scratch resis-tance	Remarks
				Lower layer coating film	Upper layer coating film						[1]	[2]					
52	EG	Lower layer 5	Upper layer 5	50	15	90	52.5	90.0	16000	35	VG	VG	F	F	VG	F	Ex.
53	EG	Lower layer 5	Upper layer 5	50	20	90	52.5	90.0	16000	20	VG	VG	F	F	VG	F	
54	EG	Lower layer 5	Upper layer 5	50	25	90	52.5	90.0	16000	8	G	G	F	F	VG	F	
55	EG	Lower layer 3	Upper layer 5	350	15	40	22.5	75.0	16000	36	VG	VG	F	F	VG	VG	
56	EG	Lower layer 19	Upper layer 5	350	15	40	22.5	75.0	16000	0	G	G	F	F	VG	VG	

0083 Table 5

No.	Base sheet type	Lower layer paint type	Upper layer paint type	Dried coating thickness (μm)		Bubble content (vol%)	-0.1t +57.5	-0.05t +92.5	Upper layer coating film main resin Mn	No. of bubbles satisfying Rv≥0.8T per 10 mm width cross-section	Heat insulation		Work-ability	Adhesive-ness	Stain resis-tance	Scratch resis-tance	Remarks
				Lower layer coating film	Upper layer coating film						[1]	[2]					
57	EG	Lower layer 5	Upper layer 4	200	15	60	37.5	82.5	15000	48	VG	VG	VG	VG	VG	VG	Ex.
58	EG	Lower layer 20	Upper layer 11	200	15	60	37.5	82.5	15000	48	VG	VG	VG	VG	VG	VG	
59	EG	Lower layer 21	Upper layer 12	200	15	60	37.5	82.5	15000	48	VG	VG	VG	VG	VG	VG	
60	EG	Lower layer 22	Upper layer 13	200	15	60	37.5	82.5	15000	48	VG	VG	VG	VG	VG	VG	
61	EG	Lower layer 23	Upper layer 14	200	15	60	37.5	82.5	15000	48	VG	VG	VG	VG	VG	VG	
62	EG	Lower layer 21	Upper layer 13	200	15	60	37.5	82.5	15000	48	VG	VG	VG	VG	VG	VG	
63	EG	Lower layer 22	Upper layer 12	200	15	60	37.5	82.5	15000	48	VG	VG	VG	VG	VG	VG	
64	EG	Lower layer 20	Upper layer 4	200	15	60	37.5	82.5	15000	48	VG	VG	G	VG	VG	VG	
65	EG	Lower layer 21	Upper layer 4	200	15	60	37.5	82.5	15000	48	VG	VG	G	VG	VG	VG	
66	EG	Lower layer 5	Upper layer 11	200	15	60	37.5	82.5	15000	48	VG	VG	G	VG	VG	VG	
67	EG	Lower layer 21	Upper layer 11	200	15	60	37.5	82.5	15000	48	VG	VG	G	VG	VG	VG	
68	EG	Lower layer 20	Upper layer 15	200	15	60	37.5	82.5	15000	48	VG	VG	VG	VG	VG	VG	
69	EG	Lower layer 24	Upper layer 11	200	15	60	37.5	82.5	15000	48	VG	VG	VG	VG	VG	VG	
70	EG	Lower layer 25	Upper layer 17	200	15	60	37.5	82.5	15000	48	VG	VG	VG	VG	VG	VG	
71	EG	Lower layer 26	Upper layer 16	200	15	60	37.5	82.5	15000	48	VG	VG	VG	VG	VG	VG	
72	EG	Lower layer 25	Upper layer 4	200	15	60	37.5	82.5	15000	48	VG	VG	G	VG	VG	VG	
73	EG	Lower layer 25	Upper layer 11	200	15	60	37.5	82.5	15000	48	VG	VG	G	VG	VG	VG	
74	EG	Lower layer 25	Upper layer 12	200	15	60	37.5	82.5	15000	48	VG	VG	G	VG	VG	VG	

0084 Table 6

No.	Base sheet type	Lower layer paint type	Upper layer paint type	Back surface paint type	Dried coating thickness (μm)			Bubble content (vol%)	-0.1t +57.5	-0.05t +92.5	Upper layer coating film main resin Mn	No. of bubbles satisfying Rv≥0.8T per 10 mm width cross-section	Emissivity of back surface	Heat insulation				Workability	Adhesiveness	Stain resistance	Scratch resistance	Remarks
					Lower layer coating film	Upper layer coating film	Back surface coating film							[1]	[2]	[3]	[4]					
75	EG	Lower layer 5	Upper layer 5	Back 1	200	15	5	60	37.5	82.5	16000	48	0.65	VG	VG	F	F	VG	VG	VG	VG	Ex.
76	EG	Lower layer 5	Upper layer 5	Back 2	200	15	5	60	37.5	82.5	16000	48	0.60	VG	VG	F	F	VG	VG	VG	VG	
77	EG	Lower layer 5	Upper layer 5	Back 2	200	15	4	60	37.5	82.5	16000	48	0.55	VG	VG	F	F	VG	VG	VG	VG	
78	EG	Lower layer 5	Upper layer 5	Back 2	200	15	3	60	37.5	82.5	16000	48	0.50	VG	VG	G	G	VG	VG	VG	VG	
79	EG	Lower layer 5	Upper layer 5	Back 2	200	15	2	60	37.5	82.5	16000	48	0.40	VG	VG	VG	G	VG	VG	VG	VG	
80	EG	Lower layer 5	Upper layer 5	Back 2	200	15	1	60	37.5	82.5	16000	48	0.30	VG	VG	VG	VG	VG	VG	VG	VG	
81	EG	Lower layer 5	Upper layer 5	Back 2	200	15	0.5	60	37.5	82.5	16000	48	0.25	VG	VG	VG	VG	VG	VG	VG	VG	
82	EG	Lower layer 5	Upper layer 5	None	200	15		60	37.5	82.5	16000	48	0.20	VG	VG	VG	VG	VG	VG	VG	VG	
83	GI	Lower layer 5	Upper layer 5	None	200	15		60	37.5	82.5	16000	48	0.20	VG	VG	VG	VG	VG	VG	VG	VG	
84	SUS	Lower layer 5	Upper layer 5	None	200	15		60	37.5	82.5	16000	48	0.15	VG	VG	VG	VG	VG	VG	VG	VG	
85	aluminum	Lower layer 5	Upper layer 5	None	200	15		60	37.5	82.5	16000	48	0.05	VG	VG	VG	VG	VG	VG	VG	VG	
86	EG	Lower layer 4	Upper layer 5	Back 2	150	15	0.5	40	42.5	85.0	16000	30	0.25	P	P	P	P	VG	VG	VG	VG	Comp. ex.

0085 Below, the results of evaluation will be described in detail.

0086 (1) Effects of Molecular Weight of Upper Layer Coating film

The molecular weight of the upper layer coating film is shown in Example Nos. 1 to 12 and Comparative Example Nos. 37 and 38.

0087 The pre-coated metal plates according to the examples of the present invention had excellent heat insulation, workability, adhesiveness, stain resistance, and scratch resistance.

0088 The sample with a molecular weight of the upper layer coating film of 10000 (No. 1) tended to drop slightly in workability, while the sample with a molecular weight of the upper layer coating film of 23000 (No. 7) tended to drop slightly in stain resistance and scratch resistance, so the molecular weight of the upper layer coating film is more preferably 13000 to 19000. The sample with a molecular weight of less than 10000 (No. 37) is inferior in workability, so is unsuitable. The sample with a molecular weight of the upper layer coating film of over 23000 (No. 38) is inferior in stain resistance and scratch resistance, so is unsuitable.

0089 (2) Relationship of Concentration of Bubble Content and Thickness of Lower Layer Coating Film

The relationship of the concentration of the bubble content and the thickness of the lower layer coating film is shown in Example Nos. 13 to 31 and in Comparative Example Nos. 39 to 48.

0090 The pre-coated metal plates according to the examples of the present invention had excellent heat insulation, workability, adhesiveness, stain resistance, and scratch resistance.

0091 The samples with a relationship between the concentration of bubble content V volume (%) and coating thickness "t" (μm) of $V<-0.1t+57.5$ (Nos. 39, 41, 43, and 45) are inferior in heat insulation, while the samples with V>-0.05t+92.5 (Nos. 40, 42, 44, and 46) are inferior in workability and adhesiveness, so are unsuitable. Further, the sample with a coating thickness of less than 50 μm (No. 47) is inferior in heat insulation, while the sample with a coating thickness of over 350 μm (No. 48) is inferior in workability and adhesiveness, so are unsuitable.

0092 (3) Effects of Thickness of Upper Layer Coating Film

The effects of thickness of the upper layer coating film are shown in Example Nos. 32 to 36 and in Comparative Example Nos. 49 to 51.

0093 The pre-coated metal plates according to the examples of the present invention had excellent heat insulation, workability, adhesiveness, stain resistance, and scratch resistance.

0094 The sample with a thickness of the upper layer coating film of 3 μm (No. 32) tended to fall slightly in workability, adhesiveness, and scratch resistance, while the sample with a thickness of the upper layer coating film of 30 μm (No. 36) tended to be slightly high in cost, so the thickness of the upper layer coating film is more preferably 5 to 25 μm. Further, the sample with no upper layer coating film (No. 49) and the sample with a thickness of the upper layer coating film of less than 3 μm (No. 50) are inferior in workability, adhesiveness, and scratch resistance, while the sample with a thickness of the upper layer coating film of over 30 μm (No. 51) is high in cost, so these are unsuitable.

0095 (4) Relationship Between Bubble Size and Total Thickness

The relationship between the bubble size and the total thickness is shown in Example Nos. 52 to 56.

0096 Samples with less than 20 bubbles with a relationship between the bubble size Rv (μm) measured in the direction vertical to the coating film surface and the total thickness T (μm) of the lower layer coating film and the upper layer coating film combined satisfying Rv≥0.8T in a with of 10 mm width of any coating film cross-section (Nos. 54 and 56) tend to slightly fall in heat insulation, so it is learned that the number of bubbles satisfying Rv≥0.8T in 10 mm width of any cross-section be 20 or more.

0097 (5) Effects of Colored Pigments of Lower Layer Coating Film and Upper Layer Coating Film

The effects of the pigments of the lower layer coating film and the upper layer coating film are shown in Example Nos. 57 to 74. Samples with the same colored pigments of the lower layer coating film and the upper layer coating film (Nos. 57 to 60), samples with no colored pigments contained in the lower layer coating film and the upper layer coating film (No. 61), and samples with colored pigments of the lower layer coating film and the upper layer coating film of the similar colors (Nos. 62, 63, and 68 to 71) are superior in workability, while samples with colored pigments of the lower layer coating film and the upper layer coating film of not the similar colors (Nos. 64 to 67 and 72 to 74) exhibit some discoloration at the worked parts when observed visually, so are liable to fall in workability, therefore it is preferable that the pigments of the lower layer coating film and the upper layer coating film be of the similar colors.

0098 (6) Effects of Emissivity of Back Surface

The effects of the emissivity of the back surface are shown in Example Nos. 58 to 68 and in Comparative Example No. 69.

0099 The lower the emissivity of the back surface, the better the heat insulation tends to be. It is learned that an emissivity of the back surface of 0.50 or less is suitable. Further, it is learned that even if emissivity of the back surface is low, a sample with a surface outside of the scope of the present invention (No. 79) is inferior in heat insulation.

0100 (Example 2)

The pre-coated metal plates of Example No. 73 and Comparative Example No. 79 of Table 6 were used as back panels of flat screen television sets with the insides forming the back surfaces. Images were displayed, then after 2 hours, the back panels were touched by the index finger and time during which contact could be maintained was measured. Note that, the same test was carried out by five test persons. Further, as a comparison, electrogalvanized steel sheet was worked into the shape of a back panel, then was press bonded with the foamed polyethylene sheet "Foam Ace® SN-500" made by Furukawa Electric.

0101 The test persons were able to maintain contact with No. 73 for 1 minute or more, but could only maintain contact with No. 79 for 5 seconds or less. Further, they could maintain contact with the samples with foamed polyethylene sheet bonded to them for 1 minute or more, but bonding requires time and the appearance is also impaired, so this is unsuitable.

0102 (Example 3)

The pre-coated metal plate of No. 4 of Table 3 was prepared by coating the lower layer paint by a roll coater, drying and curing by an induction heating oven in which hot air was blown, then water cooling, coating the upper layer coating film by a roller curtain coater, drying and curing by an induction heating oven in which hot air was blown, then water cooling, but a sample the same as this may also be prepared by a different coating method. A pre-coated metal plate which was prepared by coating the lower layer coating film by a roller curtain coater, drying and curing, then coating the upper layer coating film by a roller curtain coater was used as No. 87. No. 87 was prepared under exactly the same conditions as No. 4 except for the coating method. Further, a pre-coated metal plate which was prepared by simultaneously applying the lower layer coating film, and the upper layer coating film by a multilayer simultaneous coating apparatus called a "slide curtain coater", then simultaneously drying and curing the layers of coatings by an induction heating oven in which hot air was blown under conditions giving a peak temperature of the metal sheet of 230°C and water cooling was used as No. 88. The pre-coated metal plate of No. 88 was prepared under exactly the same conditions as No. 4 except for simultaneously coating the upper layer coating film and the lower layer coating film by a slide curtain coater and simultaneously baking them. Furthermore, a pre-coated metal plate which was prepared by coating the lower layer coating film by a roller curtain coater, drying and curing, then coating upper layer coating film by a roll coater was used as No. 89. No. 89 was prepared under exactly the same conditions as No. 4 except for the coating method.

0103 The prepared pre-coated metal plate were evaluated for heat insulation, workability, adhesiveness, stain resistance, and scratch resistance as described in (Example 1). No. 87 and No. 88 gave results of evaluation completely the same as the results of evaluation and testing of No. 4 described in Table 3, but No. 89 had "fair" results of evaluation of [1] and [2] of the heat insulation, that is, results somewhat lower than No. 4. It is presumed when coating the upper layer coating by a roll coater, the bubbles in the lower layer coating film ended up being crushed by the coating roll and therefore the heat insulation was inferior. Further, Nos. 4, 87, and 88 were beautiful in coated appearance, but No. 89 had a patchy appearance of the upper layer coating film. It was also presumed that when coating by a roll coater, the lower layer coating film was coated while being crushed by the coating roll, so surface relief formed at the foundation and therefore the finish of the upper layer coating film became patchy. From these results as well, it is learned that the upper layer coating film of the present invention is preferably coated by a curtain coater.

0104 Note that, a photograph of a cross-section of a coating film part of the pre-coated metal plate of Example No. 4 observed by an optical microscope is shown in FIG. 8.

0105 Above, preferred embodiments of the present invention were explained with reference to the drawings, but the present invention is not limited to these embodiments needless to say. A person skilled in the art clearly can conceive of various changes or modifications within the scope described in the claims. These naturally are also understood to fall under the technical scope of the present invention.

Reference Signs List

0106 1 hot plate

2 pre-coated metal plate

3 silicone rubber

4 thermocouple

5 heat source

6 temperature controller