

PATENT SPECIFICATION

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(54) PROCESS OF COATING ALUMINIUM MATERIALS MOULDED BY EXTRUSION

(71) We, YOSHIDA KOGYO K.K. of 1, Kanda Izumi-cho, Chiyoda-ku, Tokyo, Japan; TOA PAINT COMPANY LIMITED, of 3—18 Takami 1-chome, Konohana-ku, Osaka, Japan; and SHIN-ETSU CHEMICAL COMPANY LIMITED, of 6—1, Otemachi 2-chome, Chiyoda-ku, Tokyo, Japan, all Japanese companies, do hereby declare the invention, for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a process for providing protective coatings on the surfaces of a material of aluminium or an aluminium-based alloy (hereinafter referred to as an aluminium material) which is moulded in shaped sections by extrusion.

In conventional procedures for providing protective coatings on the surfaces of extruded shaped sections of aluminium material, the aluminium material is extruded, cut in desired lengths and then, optionally after a thermal aging or annealing process, are cooled to room temperature and stored. All these process steps are generally conducted in the moulding plant and then the materials are moved to a surface-treating plant where the protective coating is applied, for instance by chemical oxidation, anodic oxidation, immersion coating or electrodeposition.

These processes are economically disadvantageous due to the number of separate steps that are involved, the stepwise complexity, need for large scale production facilities, difficulties in process control, and high consumption of electricity, steam, compressed air and fuels.

They also cause problems of safety or environmental pollution. Thus if aqueous coating materials are used expensive effluent treatment and disposal is needed, and also large quantities of good quality water is required. When organic coating materials

such as paints, varnishes and lacquers are used, there are often problems of fire hazards and explosion, air pollution, and damage to workers' health, and the like, for instance due to the large quantities of organic solvents that may be present in the coating materials.

Furthermore, the quality of the coating films obtained by the conventional method generally is not entirely satisfactory, due to the fact that aluminium and aluminium-based alloys have rather a poor affinity with the conventional coating materials.

In the present invention, newly extruded aluminium material is coated by applying to its surface organopolysiloxane-based material that, at the temperature of the surface, is reactive with the surface to form an adherent coating. In order for the surface to be adequately reactive it must not have cooled completely to ambient temperature after the extrusion; it must be above 250°C. The coating composition is preferably free of materials that will volatilise or decompose in the process. Preferably it consists substantially entirely of an organopolysiloxane as defined below, preferably in admixture with a di-organopolysiloxane as defined below. The coated aluminium material may be subjected to annealing at a temperature between 170 and 200°C for 2 to 6 hours in order to further improve the mechanical strengths of the coatings.

The process of the present invention has the advantage that not only can it result in reduction of costs in the production of coated aluminium materials and reduction of problems in workers' health and environmental pollution but also it can easily be conducted to yield coating films having excellent properties with respect to resistance to attack by chemicals, weather, stains, and heat as well as adhesion to the metal surface and mechanical strength.

Any aluminium material (which as defined above includes pure aluminium and

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aluminium-based alloys) that can be moulded by extrusion can be used in the invention. The extruded aluminium materials include plates, pipes, rods and wires as well as shaped sections useful for window sashes.

The aluminium materials may be extruded using an extrusion machine of a conventional type and the conditions for extrusion may also be the same as in the conventional extrusion processes. The temperature of extrusion is, for example, in the range from 500 to 580°C. The temperature of the surfaces of the newly extruded aluminium material is nearly the same as above, and then gradually falls, for instance, as the extruded material, moves on a conveyor toward the coating device. The essential requirement in the process of the present invention is that the extruded material is coated with a specific organopolysiloxane coating composition while its surface temperature is still sufficiently high to be sufficiently reactive, generally not lower than 250°C or, preferably, in the range from 350 to 550°C. Once the surface temperature of the extruded aluminium material becomes too low the coating operation will no longer exhibit a satisfactory result, even if carried out after re-heating to a temperature higher than 250°C.

It is assumed that the surface of a newly extruded aluminium material that is still very hot, e.g. at a temperature not lower than 250°C is so reactive that a strong bond can be formed between the surface and the coating composition but that this reactivity is lost on cooling too far. The coating composition must be an organopolysiloxane composition, and preferably is free of any substitutes significant quantities of materials that will decompose or volatilise. Thus organic resins, such as epoxy resins, polyester resins, polyvinyl chloride resins, methacrylic resins, polyamide resins and polyethylenes are not suitable. If such resins are used in place of the siloxane they will be found to have a relatively poor thermal stability and to be incapable of forming a strong bond with the surface of the newly extruded aluminium material kept at 250°C or above due to thermal decomposition and denaturation with coloration.

The organopolysiloxane compositions according to the present invention can give excellent results owing to their high thermal stability without danger of thermal decomposition at temperatures above 250°C. Further, it is presumed that the effectiveness of the present method is attributable in a sense to a great affinity between the aluminium metal surface and the Si-O-Si siloxane linkages as the basic structure of the organopolysiloxanes, as is evidenced by the fact that aluminosilicate compounds, such as zeolite, are extremely stable.

Furthermore, the organopolysiloxane coat-

ing composition once applied on the surfaces of aluminium material in accordance with the process of the present invention rapidly cures and hardens, so that the subsequent handling of the coated aluminium material is quite easy. Ordinary organic resins other than the organopolysiloxane can not be applicable to coating operation in the process of the present invention since they are susceptible to decomposition and coloration.

With respect to a fluorocarbon resin which has a sufficiently high thermal stability comparable with an organopolysiloxane or a silicone resin, it should be noted that this organic resin is not suitable as a coating material for aluminium materials because of its poor adhesion to aluminium surfaces. Further with respect to an inorganic coating material, such as a low-melting glass, which has an excellent thermal stability, can not be suitable for use in place of an organopolysiloxane composition, since the coating films formed with the inorganic material usually have brittleness and poor mechanical strengths and tend to break during the course of the subsequent stretching operation.

The reason for limiting the temperature of the extruded aluminium material to be coated to between 550 and 250°C is that a temperature lower than 250°C may bring about an insufficient bond between the coatings and coated surfaces as well as a decreased curing velocity which will cause inconvenience to the subsequent handling of the coated materials, while a temperature higher than 550°C may result in an excessively high curing velocity failing to produce smoothness in the surfaces and sufficient toughness in the coatings due to the so-called over-baking.

The organopolysiloxane composition applied on the extruded aluminium materials can cure within a short period of time directly after extrusion. When the cure has not proceeded to a satisfactory extent, it can be completed by the process of heat treatment or annealing to follow. The heat treatment or annealing process is a process which is undertaken on the extruded and coated aluminium material in order to improve its mechanical strengths to a desired level.

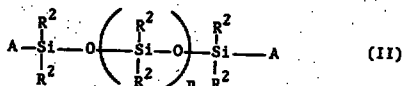
The organopolysiloxane compositions used in the process of the present invention are preferably chosen so that, in addition to forming coatings having excellent physical and chemical properties on the aluminium surfaces, they have sufficient fluidity that the composition can be applied without the use of any solvents and a sufficiently high curing velocity that the coatings cure so quickly as to facilitate subsequent handling of the coated material. Preferably the resultant coatings have moderate flexibility so that they do not rupture during any subsequent stretching process.

The organopolysiloxane composition used in the process of the present invention comprises

- (a) from 100 to 15 parts by weight or, preferably, from 70 to 15 parts by weight of an organopolysiloxane represented by the average unit formula



- where R^1 is a monovalent hydrocarbon group and a is a positive number in the range from 1.10 to 1.90 inclusive on the average, and (b) from 0 to 85 parts by weight or, preferably, from 30 to 85 parts by weight of a diorganopolysiloxane represented by the general structural formula



- where R^2 is a monovalent hydrocarbon group, A is a group selected from the class consisting of monovalent hydrocarbon groups, alkoxy groups and a hydroxy group and n is a positive integer, and having a viscosity in the range from 100 to 1,000,000 centistokes at 25°C.

- The composition may, if desired or necessary, include a small amount of curing catalysts, such as organic acid salts of cobalt, zinc, tin, lead or iron and platinum compounds.

- The monovalent hydrocarbon groups represented by symbol R^1 in formula (I) above are preferably alkyl groups, such as methyl; aryl groups, such as phenyl; and alkenyl groups, such as vinyl. It is advisable that groups R^1 in component (a) are composed of from 30 to 100 mole % or, preferably, from 30 to 80 mole % of methyl groups, from 0 to 70 mole % or, preferably, from 5 to 70 mole % of phenyl groups, and from 0 to 30 mole % of vinyl groups. It is also advantageous that component (a) is liquid at room temperature so that its blending with component (b) is easy. Component (a) may be solid at room temperature insofar as it is compatible with component (b), subject to being molten at an elevated temperature when blended.

- The viscosity of the diorganopolysiloxanes as component (b) represented by formula (II) is in the range from 100 to 1,000,000 centistokes at 25°C, as defined above. Any diorganopolysiloxanes having a lower viscosity naturally contain relatively large amounts of low-boiling matter which is apt to be lost by evaporation at the high temperatures in the coating process, while any diorganopolysiloxanes having a higher viscosity may cause difficulties in blending with component (a),

although even higher viscosities are tolerable when component (a) has a sufficiently high fluidity.

The terminal groups at both chain ends of the diorganopolysiloxane as component (b) represented by symbol A are hydrocarbon groups, e.g. methyl, phenyl and vinyl groups, or may be a hydroxy group or alkoxy groups, such as methoxy and ethoxy groups. The monovalent hydrocarbon groups represented by symbols R^2 are not limited to a specific kind, but it is advisable that from 0 to 95 mole % or, preferably, from 10 to 80 mole % of the R^2 groups are alkyl groups, e.g. methyl groups; from 5 to 100 % or, preferably, from 10 to 90 mole % of the R^2 groups are aryl groups, e.g. phenyl groups; and from 0 to 50 mole % or, preferably, from 5 to 30 mole %, of the R^2 groups are alkenyl groups, e.g. vinyl groups.

The expected effect of component (b) in the organopolysiloxane composition used in the method of the present invention is to give flexibility to the coating films formed on the surface of the aluminium material molded by extrusion, but this component is not essential although it is desirable.

The methods for the preparation of components (a) and (b) are well known to those skilled in the art of silicone technology. For example, two or more kinds of organochlorosilanes are mixed together in a mixing ratio corresponding to the content of each kind of the siloxane units in the finished organopolysiloxane after co-hydrolysis and co-condensation with, optionally, organic solvents as the diluent, and the mixture is hydrolyzed and subjected to dehydration-condensation in the presence of a condensation catalyst to form siloxane linkages. When the reactions are performed with organic solvents as the diluent, the solvents are preferably removed by distillation after completion of the reactions to produce a solvent-free resin composition.

The presence of an organic solvent may be advantageous in facilitating the blending of components (a) and (b) and in adjusting the viscosity of the resulting composition suitably for application but it is preferred, if possible, not to use any organic solvents in order to avoid the problems which may be caused by the use of the organic solvents.

The process of the present invention will now be described, by way of example, with reference to the accompanying drawing which is a perspective schematic view showing the apparatus employed.

An aluminium bar 1 is continuously extruded from the die attached to an extruder machine 2, is allowed to cool in the atmosphere, and advances into a coating machine 3. At this position, the bar should still be at least 250°C, preferably between 550 and 250°C. The coating machine 3 is not limited

to any specific type, but it is preferably a machine for spray coating, for example, hot-melt airless spray coating. An electrostatic spray coating technique, in which an electric potential difference is applied between the spray gun and the aluminium bar, is advantageously employed in order to attain improved adhesion and uniformity of the coatings on the aluminium surfaces.

The organopolysiloxane coating composition is heated prior to application to a temperature of 60 to 230°C or so, variable in accordance with its nature, to have its viscosity decrease to a degree such that the spray can give uniform coating layers of the desired thickness, which is preferably in the range from 10 to 30 μm or, more preferably, from 10 to 20 μm .

The aluminium bar 1 having thus coated advances farther till its tip is caught by a puller 4 at the first position as shown in the drawing. This puller holding the aluminium bar at its tip with a certain tension in the air in order to prevent the coated surfaces from possible damages is moved to the extrusion direction by the extrusion force at the extrusion speed till one unit of extrusion in terms of bullets has been completed to form a continuous bar, for example, 30 m long. The length of the continuous bar can be controlled by the size of the bullet used.

The travelling bar is subjected to compulsory cooling, while passing under a cooling device 6 provided, for example, with a fan. During the cooling step, the organopolysiloxane coatings are cured to a substantial extent to give tackfree surfaces.

As soon as the treatment of the bullet has been completed, or the extruded bar has travelled to the maximum length with puller 4 at the tip at the second position as shown in the drawing, the bar is cut on the spot by a cutter 5 situated after coating machine 3. At the time of the cutting step, the coated bar is already cooled lower than 100°C, and there is no danger of damages on the surfaces.

The aluminium bar thus cut is released from puller 4 and taken away for other treatments and, simultaneously, the freed puller 4 is moved back to the first position to be ready for handling a new unit of extrusion.

The piece of the aluminium bar is subjected to stretching for the purpose of stress compensation, and then cut again in the desired accurate length. The aluminium bar thus treated is further subjected to annealing at 170 to 200°C for 2 to 6 hours to form a finished product having optimum strengths. During this annealing operation, any insufficient curing of the organopolysiloxane coatings can be supplemented to produce a satisfactory product with high efficiency.

By virtue of the annealing step, for example, the pencil hardness of the coatings can be improved by 2 grades, or from H to

3H which is sufficient for most coated aluminium materials.

In the case of aluminium materials conventionally coated with an organic composition, such annealing at the high temperature as in the present invention should not be undertaken due to the thermal decomposition of the coating composition.

The following Examples illustrate the process of the present invention.

The organopolysiloxanes (a—I) to (a—V) and the diorganopolysiloxanes (b—I) to (b—III) used in the examples are what were prepared by the following procedures.

Organopolysiloxane (a—I): A mixture of 5.5 moles of phenyltrichlorosilane, 2.0 moles of methylvinylchlorosilane and 2.5 moles of dimethyldichlorosilane was subjected to co-hydrolysis. The resultant co-hydrolyzate in a 40% by weight solution in toluene was polymerized by condensation in the presence of a small amount of potassium hydroxide as the alkali catalyst, followed by removal of the toluene and other volatile matter by distillation, to finally produce the organopolysiloxane having the resin structure.

Organopolysiloxane (a—II): A mixture of 2.2 moles of methyltrichlorosilane, 3.9 moles of dimethyldichlorosilane, 2.9 moles of phenyltrichlorosilane and 1.0 mole of diphenylchlorosilane was co-hydrolyzed, condensed and freed of solvent and other volatile matter in the same manner as in the preparation of organopolysiloxane (a—I) above, to produce the organopolysiloxane having the resin structure.

Organopolysiloxane (a—III): An organopolysiloxane having a small amount of residual hydroxy groups, prepared by the co-hydrolysis with a mixture of 2 moles of methyltrichlorosilane, 4 moles of dimethyldichlorosilane, 2 moles of phenyltrichlorosilane and 2 moles of diphenyldichlorosilane, was mixed with a methoxy-containing organopolysiloxane expressed by the formula $[(\text{C}_6\text{H}_5)_3(\text{CH}_3)_{0.67}\text{SiO}_{0.67}(\text{OCH}_3)]_n$ in a ratio such that equimolar amounts of the residual hydroxy groups and the methoxy-containing organopolysiloxane were attained in the organopolysiloxane mixture. The resultant mixture was subjected to co-condensation in the presence of tetrapropyl titanate as the condensation catalyst, followed by removal of volatile matter, to finally produce the organopolysiloxane having the resin structure.

Organopolysiloxane (a—IV): A mixture of 4 moles of phenyltrichlorosilane, 2.5 moles of methyltrichlorosilane, 1 mole of methylvinylchlorosilane, 2 moles of dimethyldichlorosilane and 0.5 mole of trimethylchlorosilane was co-hydrolyzed, condensed and freed of solvent and other volatile matter in the same manner as in the preparation of organopolysiloxane (a—I), to finally produce

the organopolysiloxane having the resin structure.

Organopolysiloxane (a—V): An organo-
siloxane having a small amount of residual
hydroxy groups, prepared by the co-hydrolysis
with a mixture of 2 moles of methylvinyl-
dichlorosilane, 4 moles of dimethyldichloro-
silane, 2 moles of phenyltrichlorosilane and
2 moles of diphenyldichlorosilane, was mixed
with the same methoxy-containing organo-
siloxane in the same ratio as employed in the
preparation of the organopolysiloxane
(a—III). The resultant mixture was subjected
to co-condensation, followed by removal of
volatile matter, to finally produce the organo-
polysiloxane having the resin structure.

Diorganopolysiloxane (b—I): A mixture of
3.8 moles of dimethyldichlorosilane, 3.2
moles of diphenyldichlorosilane, 2 moles of
methylvinyl-dichlorosilane and 1 mole of
trimethylchlorosilane was subjected to co-
hydrolysis and subsequently to condensation
in the presence of an alkali catalyst, followed
by removal of volatile matter, to finally
produce the diorganopolysiloxane, having
both chain ends terminated with trimethyl-
silyl groups and a viscosity of 480 centistokes
at 25°C.

Diorganopolysiloxane (b—II): A mixture
of 4.7 moles of octamethylcyclotetrasiloxane,
3.3 moles of octaphenylcyclotetrasiloxane, 1
mole of 1,3,5,7-tetramethyl-1,3,5,7-tetra-
vinylcyclotetrasiloxane and 2 moles of
dimethyldiethoxysilane was heated with
agitation in the presence of a small amount of
potassium hydroxide as the alkaline catalyst
to effect polymerization. The reaction mix-
ture was freed of volatile matter, to finally
produce the diorganopolysiloxane having
both chain ends terminated with dimethyl-
ethoxysilyl groups and a viscosity of 2,000
centistokes at 25°C.

Diorganopolysiloxane (b—III): A mixture
of 2.7 moles of dimethyldichlorosilane, 3.7
moles of diphenyldichlorosilane, 3 moles of
methylvinyl-dichlorosilane and 0.6 mole of
trimethylchlorosilane was subjected to co-
hydrolysis and condensation in the same
manner as in the preparation of diorgano-
polysiloxane (b—I) above, followed by
removal of volatile matter, to finally produce
the diorganopolysiloxane having both chain
ends terminated with trimethylsilyl groups
and a viscosity of 100,000 centistokes at
25°C.

Further in the examples, the various test
values or results were determined in accord-
ance with the following.

Thickness, adhesion and pencil hardness of
coating film are each determined in accord-
ance with Japanese Industrial Standard (JIS)
A 4706.

Impact strength was determined by the
duPont impact tester to be expressed in cm,
the falling distance, with 12.7 mm × 500 g.

Contact test with acid solution or with
alkali solution was conducted by keeping the
coated surface in contact with a 5% sulfuric
acid solution or with a 1% aqueous solution
of sodium hydroxide, respectively, for 48
hours and examined in accordance with JIS
A 4706, to determine whether each test piece
should pass the test.

Spraying with saline solution was evaluated
by the manner such that an aqueous salt
solution containing 5% sodium chloride and
0.026% copper(II) chloride was sprayed on
the coated surface for 48 hours, and the
state of the resulting surface was observed
and recorded by ratings in cardinal in
accordance with JIS H 8601.

Accelerated weathering was determined by
subjecting the coated surface to weathering in
accordance with JIS A 4706 for 250 hours
to be recorded with respect of discoloration,
adhesion and gloss retention of the coatings.

Appearance of the coated surface was
visually examined immediately following the
annealing step.

Examples 1 to 4 and Control A.

A bullet of aluminium-based alloy 6063
by AA Specification was continuously
extruded through a die attached to an extruder
machine at a velocity of 30 m/min. to form
a continuous bar having the same cross-
sectional shape as the die opening. The tip of
the extruding bar was held and pulled by a
puller so that it advanced afloat in the air
through a coating machine. In the coating
machine the extruding bar was spray-coated
while its surface temperature remained at
about 420°C, using an airless sprayer of hot-
melt applicator Model VII made by Nordson
Co. The bar having been coated and held by
the puller was put to compulsory cooling by
a cooler to a temperature below 100°C and
then it was cut by a cutter to form a piece
having a length approximate to what was
desired exactly.

The thus obtained piece of the coated bar
was then taken off the coating and cooling
line and then subjected to stretching for stress
compensation by means of a pair of stretchers.
The resulting piece was cut by another cutter
in the exactly desired length, and then kept
in an annealing oven at 180°C for 5 hours to
effect the annealing of the metal component
and the curing of the coating composition to
produce the finished product, which was
useful as a window sash.

In the above spray-coating procedure, the
coating composition was heated at 180 to
200°C and sprayed all over the surfaces of
the bar using four spraying rate-adjustable
nozzles positioned around at a distance of
about 25 cm from the bar.

The coating composition used in each of
Examples 1 to 4 and in the control (Control
A) was a mixture of organopolysiloxane

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(a-I) and diorganopolysiloxane (b-I) in various properties of the coatings formed on the finished product and coated surfaces, and the results are set out in the same table.

TABLE I

Example	Control A	1	2	3	4
Organopolysiloxane (a-I) (%)	10	20	30	40	50
Diorganopolysiloxane (b-I) (wt%)	90	80	70	60	50
Thickness of coating film, μm	15	16	15	15	16
Adhesion of coating film	100/100	100/100	100/100	100/100	91/100
Pencil hardness	H	3H	3H	3H	4H
Impact strength, minimum	40 cm	50 cm	50 cm	50 cm	40 cm
Contact test with acid solution	Passing	Passing	Passing	Passing	Passing
Contact test with alkali solution	Passing	Passing	Passing	Passing	Passing
Spraying with saline solution	10	10	10	10	10
Accelerated weathering	Discoloration	None	None	None	None
	Adhesion	100/100	100/100	100/100	100/100
	Gloss retention	>95%	>95%	>95%	>95%
Appearance of coated surface	Smooth	Smooth	Smooth	Smooth	Smooth

Example 5.
The same procedures of coating, cooling, stretching and annealing as in Examples 1 to 4 were repeated, using the same coating composition as in Example 2 except that the surface temperature of the extruded aluminium bar at the entrance of the coating machine was about 270°C instead of 420°C. The results of the tests performed of the thus coated material are set out in Table II (following Example 6).

that the surface temperature of the extruded aluminium bar at the entrance of the coating machine was about 230°C and 570°C respectively instead of 270°C. The results of the tests are set out also in Table II.

Example 6.
The same procedure as in Example 5 was carried out except that the surface temperature of the extruded aluminium bar at the entrance of the coating machine was about 420°C instead of 270°C, and the coating technique was electro-static coating with spray nozzles of 60 kilovolt. The results of the tests are set out in Table II.

Controls B and C.

By way of comparison, the same procedure as in Example 5 above was repeated except

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TABLE II

Example		5	Control B	Control C	6
Thickness of coating film, μm		15	15	15	17
Adhesion of coating film		100/100	100/100	100/100	100/100
Pencil hardness		2H	H	3H	3H
Impact strength test with 50 cm falling distance		Passing	Passing	Fouling*	Passing
Contact test with acid solution		Passing	Passing	Passing	Passing
Contact test with alkali solution		Passing	Fouling**	Passing	Passing
Spraying with saline solution		10	9	10	10
Accelerated weathering	Discoloration	None	None	None	None
	Adhesion	100/100	100/100	100/100	100/100
	Gloss retention	95.8%	94.6%	95.2%	95.6%
Appearance of coated surfaces		Smooth	Smooth	Less smooth	Smooth

Notes: * Fouling due to peeling occurring to protruded parts, though recessed parts were found unpeeling.

** Fouling due to the occurrence of slight blisters.

Examples 7 to 10 and Controls D, E and F.

The same procedure of coating, cooling, stretching and annealing as in Examples 1 to 4 were repeated with the exception of the formulation of the coating compositions and

the surface temperature of the extruded aluminium bar at the entrance of the coating machine both as indicated in Table III. The results of the tests are set out in the same table.

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TABLE III

Example	7	8	Control D	9	Control E	Control F	10
Formulation of coating composition, % by weight	(a-I): 30 (a-II): 10 (b-I): 60	(a-I): 30 (a-V): 10 (b-I): 60	(a-III): 100	(a-I): 30 (b-IV): 70	(a-IV): 30 (b-III): 70	(a-IV): 30 (b-I): 70	(a-IV): 30 (a-II): 10 (b-I): 60
Surface temperature, °C	520	470	570	450	560	230	280
Thickness of coating film, μm	15	15	15	15	15	15	15
Adhesion of coating film	100/100	100/100	100/100	100/100	100/100	100/100	100/100
Pencil hardness	2H	2H	2H	2H	3H	H-2H	H-2H
Impact strength, minimum	50 cm	50 cm	40 cm	50 cm	40 cm	50 cm	50 cm
Contact test with acid solution	Passing	Passing	Passing	Passing	Passing	Passing	Passing
Contact test with alkali solution	Passing	Passing	Passing	Passing	Passing	Passing	Passing
Spraying with saline solution	10	10	9.0	10	10	9.0	9.0
Accelerated weathering	Discoloration	None	None	None	None	None	None
	Adhesion	100/100	100/100	100/100	100/100	100/100	100/100
	Gloss retention	>95%	>95%	>95%	>95%	>95%	>95%
Appearance of coated surface	Smooth	Smooth	Less smooth	Smooth	Less smooth	Less smooth	Smooth